

BRE Client Report

Daylight and sunlight assessment for 43-47 Piccadilly Gardens, Manchester

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Executive Summary

It is proposed to redevelop 43-47 Piccadilly Gardens to provide a ten storey building for retail and office use. BRE have been requested to assess the impact of the proposals on daylight and sunlight received by existing flats at Chatsworth House on Lever Street. This report presents the results of the assessment. A previous version of the design was assessed in BRE Report P112610-1000, dated 4 June 2018.

Guidance on the loss of light to existing buildings following construction of new development nearby is given in BRE Report 'Site layout planning for daylight and sunlight: a guide to good practice'. This report is widely used by local authorities to help determine planning applications.

The windows on the south east and south west elevations of Chatsworth House which would have a view of the development were assessed using the protocol required by Manchester City Council. All windows were to be first assessed using vertical sky component (VSC) followed by assessment of average daylight factor (ADF) for any failures, followed by assessment of no-sky line for any average daylight factor failures. Sunlight was assessed using the standard procedure in the BRE Report.

Nine windows in total, five on the first floor, three on the second and one on the third, would have a loss of VSC outside the guidelines. However, six of these are secondary windows which would not be covered by the BRE guidelines.

The other three are located one on each floor over the first to third floors. In each case, they serve Flat 2 living room and are one of three main windows serving the room. The guidelines permit averaging of results for windows of equal size. Where this is carried out, the mean loss of daylight over the three main windows would be within the BRE guidelines in each case.

Loss of daylight, as measured by the VSC, would therefore be within the guidelines for Chatsworth House overall, and ADF and no-sky line calculations were not required.

All of the living rooms would continue to have a main window which receives the recommended amount of sunlight, both year round and in the winter months. Loss of sunlight would therefore be within the BRE guidelines.



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1 Introduction

1.1 Proposal

It is proposed to redevelop 43-47 Piccadilly Gardens to provide a ten storey building for retail and office use.

BRE have been requested to assess the impact of the proposals on daylight and sunlight received by existing flats at Chatsworth House on Lever Street. This report presents the results of the assessment. The report was prepared for Trafalgar Leisure Ltd.

The site is outlined in red in Figure 1 below. Chatsworth House is outlined in green. There are commercial uses on the ground floor, with the lowest floor of flats on the first floor.

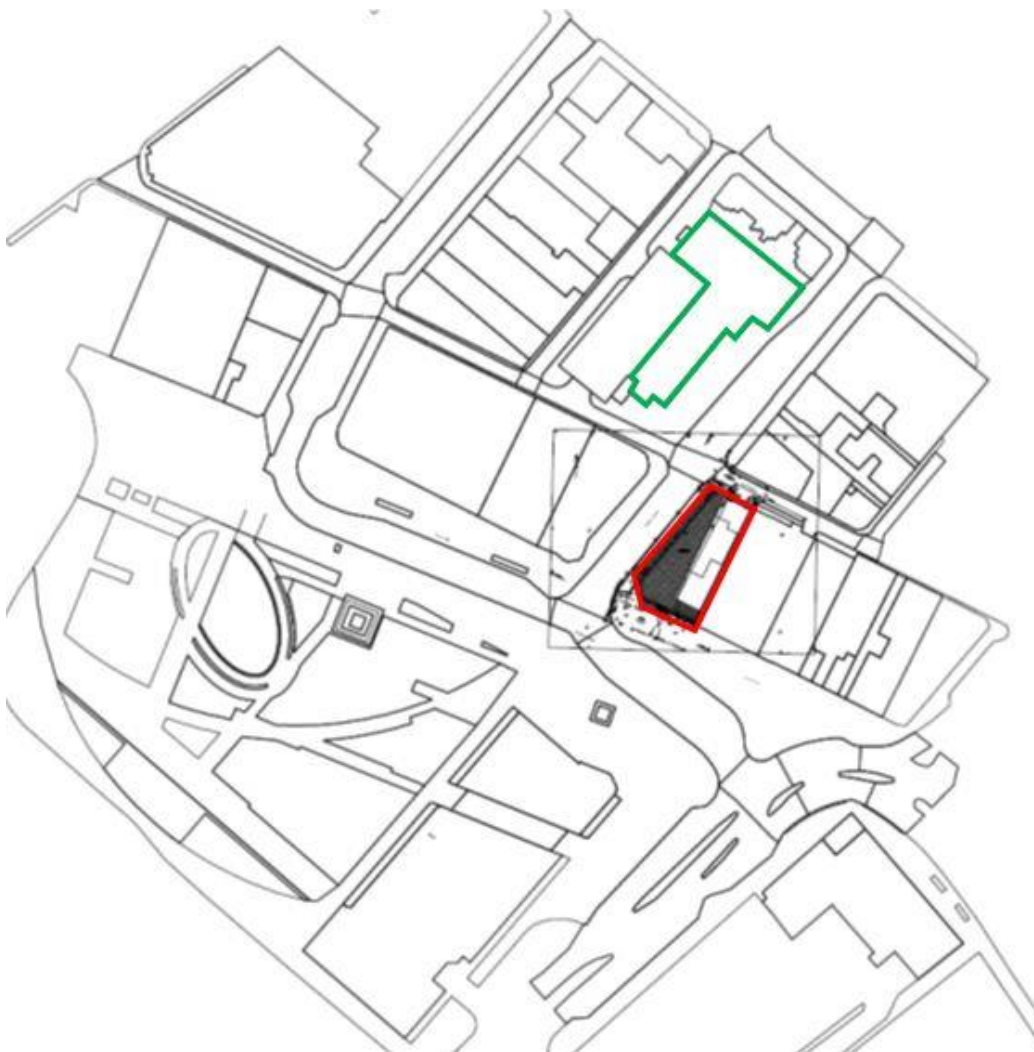


Figure 1 Location of 43-47 Piccadilly Gardens and Chatsworth House. Based on drawing 2074_PS_SP_01_500.



The calculations in this report are based on a Sketchup model provided by Trafalgar Leisure Ltd corresponding to the following drawings of the project:

- Elevations in 2074_PA_ELE_01 Rev 01 to 2074_PS_ELE_04, all Rev 01
- Floor plans in 2074_PA_GA_00 to 2074_PA_GA_14, all Rev 01 except 2074_PA_GA_03 Rev 02
- Site plans in 2074_PA_SP_01 and 2074_PA_SP_02, both Rev 01

The model included obstructions to daylight and sunlight presented by other buildings in the vicinity. The existing scenario was the cleared site.

The window positions and room dimensions in Chatsworth House were obtained from drawings of Chatsworth House by Michael Hyde and Associates, dated 10-01-2001.

A previous version of the proposals was analysed in BRE Report P112610-1000, dated 4 June 2018.

2 Methodology

2.1 Loss of light to existing dwellings

Guidance on the loss of light to existing buildings following construction of new development nearby is given in BRE Report 'Site layout planning for daylight and sunlight: a guide to good practice'¹. This report is widely used by local authorities to help determine planning applications. The assessment has been carried out with reference to the current, second edition of the report, which was published in October 2011.

The guidelines in the Report are intended to apply to rooms in adjoining dwellings where daylight is required, including living rooms, kitchens and bedrooms. Windows to bathrooms, toilets, storerooms, circulation areas and garages need not be analysed. The guidelines may also be applied to any existing non-domestic building where the occupants have a reasonable expectation of daylight; this would normally include schools, hospitals, hotels and hostels, small workshops and some offices.

Only main windows are covered by the numerical criteria suggested in the BRE guidelines. If a secondary window serving a room has a loss of daylight or sunlight outside the BRE guidelines but the main window does not, the overall loss would be within the BRE guidelines.

To assess the impact on the amount of diffuse daylighting entering existing buildings, the Report first recommends the measurement or calculation of obstruction angle. This is the angle to the horizontal subtended by the new development at the centre of the lowest window in each affected window wall, in a plane perpendicular to it. If this angle is less than 25° for the whole of the development, then the new building would not have a substantial effect on the diffuse skylight (or sunlight) enjoyed by the existing building.

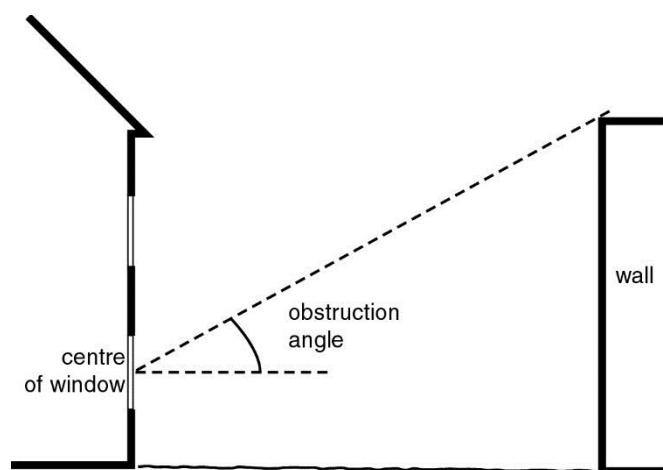


Figure 2 Example of obstruction angle

2.2 Vertical sky component

Where the obstruction angle exceeds 25°, a calculation is needed to assess the impact on the amount of diffuse daylighting entering existing buildings. The BRE Report recommends the calculation of the vertical



sky component. This is the ratio of the direct sky illuminance falling on the outside of a window, to the simultaneous horizontal illuminance under an unobstructed sky. The standard CIE Overcast Sky² is used and the ratio is usually expressed as a percentage. The maximum value is almost 40% for a completely unobstructed vertical wall. The vertical sky component on a window is a good measure of the amount of daylight entering it.

In this case, vertical sky component was calculated for all the windows. A BRE computer program was used to calculate it, which has the same basis as the skylight indicators in the BRE Report.

The BRE Report sets out the following two guidelines for vertical sky component:

- a) Where the vertical sky component at the centre of the existing window exceeds 27% with the new development in place, then enough sky light should still be reaching the existing window.
- b) Where the vertical sky component with the new development is both less than 27% **and** less than 0.8 times its former value, then the area lit by the window is likely to appear more gloomy, and electric lighting will be needed for more of the time.

In the case of a floor-to-ceiling window such as a patio door, a point 1.6m above ground (or balcony level for an upper storey) is used instead of the centre of the window.

The BRE Report states that its own numerical guidelines 'should be interpreted flexibly since natural lighting is only one of many factors in site layout design. In special circumstances the developer or planning authority may wish to use different target values. For example in a historic city centre a higher degree of obstruction may be unavoidable if new developments are to match the height and proportions of existing buildings'.

The guidance is advisory in nature and is intended to assist with good design. There is no formal requirement to comply with the advice it contains.

2.3 Average daylight factor

Guidance on daylight to new dwellings, including numerical target values, is given in BS8206 Part 2:2008 Lighting for Buildings, Code of Practice for Daylighting². The BRE Report refers to these values and provides additional guidance. It is normally recommended for assessment of daylight provision to new dwellings rather than loss of daylight to existing dwellings.

Average daylight factor (ADF) is defined in the standard as the ratio of total daylight flux incident on a reference area to total area of reference area, expressed as a percentage of outdoor illuminance on a horizontal plane due to an unobstructed hemisphere of sky of assumed or known luminance distribution.

It acts as a measure of the amount of daylight within the interior of a room. It depends on the room and window dimensions, the reflectances of interior surfaces and the type of glass, as well as the obstructions outside. By comparison, the vertical sky component (VSC) depends only on obstruction.

For housing, BS8206 Part 2 recommends minimum values of ADF of 2.0% for kitchens, 1.5% for living rooms and 1% for bedrooms.

In accordance with guidance from Manchester City Council, ADF calculations would be carried out for rooms where the windows in question had not achieved the levels recommended for vertical sky component. In the event, this test was not needed due to the result of the first test.

2.4 Daylight distribution

The BRE report gives guidance on the distribution of light in existing buildings. Where room layouts are known, the impact on the daylight distribution in the existing building can be found by plotting the 'no sky line' in each of the main rooms. The no sky line divides points on the working plane (0.85m high in



houses) which can and cannot see the sky. Areas beyond the no-sky line, since they receive no direct daylight, usually look dark and gloomy compared to the rest of the room, however bright it is outside.

If, following construction of a new development, the no sky line moves so that the area of the existing room which does receive direct skylight is reduced to less than 0.8 times its former value this will be noticeable to the occupants and more of the room will appear poorly lit.

In accordance with guidance from Manchester City Council, daylight distribution calculations would be carried out for rooms where the windows in question had not achieved the levels recommended for average daylight factor. However, in the event, this test was not required due to the results of the first test.

2.5 Loss of sunlight to existing dwellings

The BRE Report recommends that loss of sunlight should be checked for main living rooms of dwellings, and conservatories, if they have a window facing within 90° of due south.

According to the BRE Report, if the centre of the window can receive more than one quarter of annual probable sunlight hours, including at least 5% of annual probable sunlight hours in the winter months between 21 September and 21 March, then the room should still receive enough sunlight. If the window already receives less than this, a reduction to less than 0.8 times its current value and a reduction of more than 4% of annual probable sunlight hours over the year may lead to the room it serves appearing colder and less cheerful and pleasant.

All of the windows which serve living rooms were analysed for loss of sunlight as they face within 90° of due south.

2.6 Relevant Local guidance

For our previous report, Manchester City Council specified an assessment protocol to be used for daylight. This comprises a hierarchy of assessment tests as follows:

- Loss of vertical sky component to windows
- Changes to average daylight factor within the rooms
- Changes to the no-sky line within the rooms.

Any failures of the first test would lead to assessment using the second. A failure of the second test would lead to assessment using the third. We have continued this approach for the updated scheme.



3 Windows and rooms analysed for loss of light

The windows and rooms analysed for loss of daylight are shown in Figure 3 below. These are the rooms which would have a view of the proposed development. The northernmost end of the building has not been analysed as that room also has main windows facing away from the development.

Each room has a series of window numbers associated with it. The room layouts and the centre points of the windows are the same on each floor, but the windows have slightly differing widths on alternating floors.

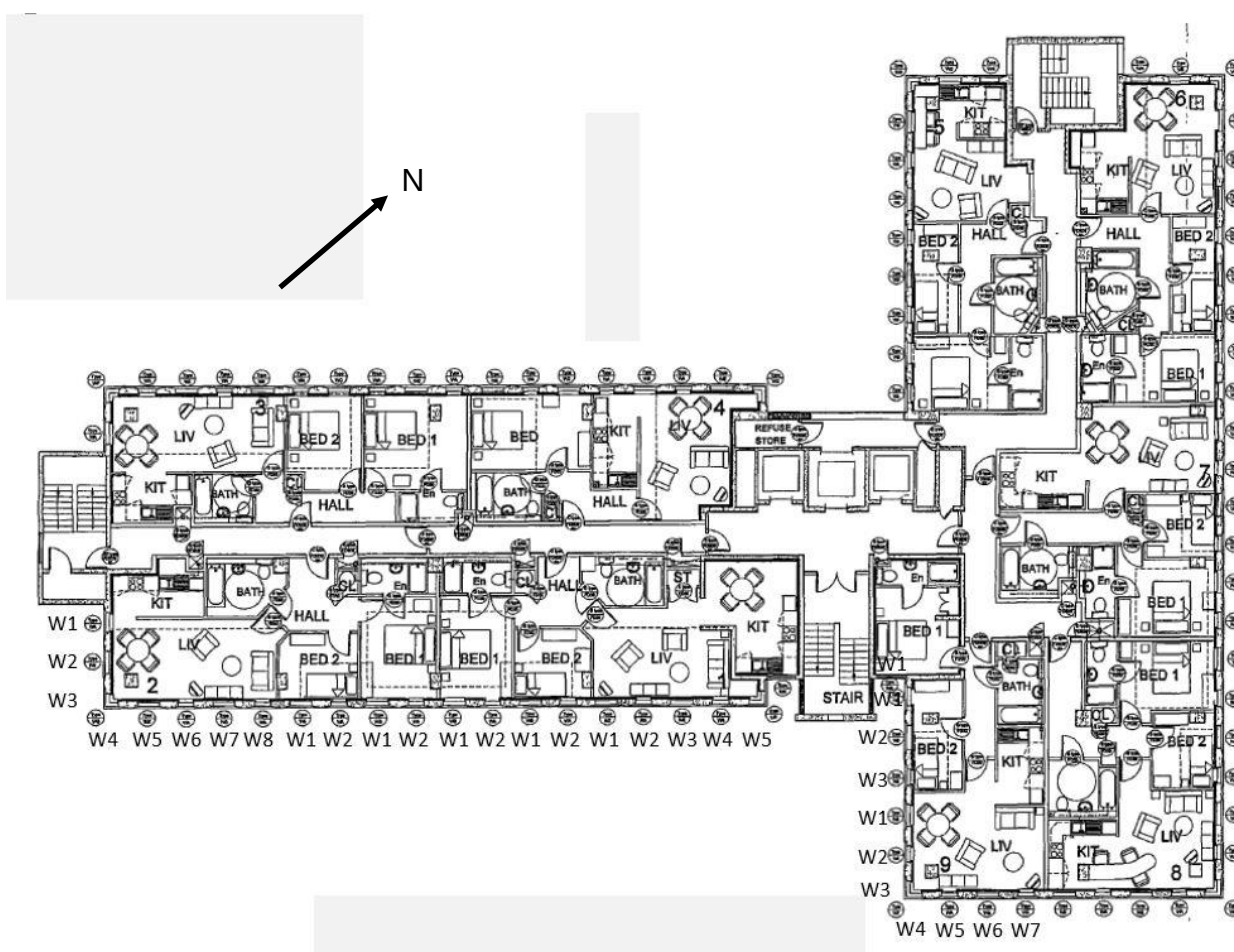


Figure 3 Window positions at Chatsworth House, using the floor plan for levels 2/4/6.



4 Loss of daylight calculations

4.1 Vertical sky component (VSC)

A summary of vertical sky component results for Chatsworth House is provided below in Table 1. The full set of results are shown in Appendix A.

Table 1 Summary of vertical sky component results at Chatsworth House

Floor	No. of windows analysed	No. of VSC results within the BRE guidelines	No. of VSC results outside the BRE guidelines
1	32	27	5 (4 secondary windows)
2	32	29	3 (2 secondary windows)
3	32	31	1
4	32	32	0
5	32	32	0
6	32	32	0
7	32	32	0

In order to achieve the recommendations in BRE Report 'Site layout planning for daylight and sunlight: a guide to good practice', a window should retain a vertical sky component of at least 27%, or where it is lower, a ratio of after/before of 0.8 or more.

Nine windows in total, five on the first floor, three on the second and one on the third, would have a loss of daylight outside the guidelines. The ratios in question were between 0.71 and 0.79.

The widths of the windows in Chatsworth House alternate in a checkerboard effect, so that rooms with more than one window have a mixture of wider and narrower windows. Where this is the case, the narrower windows would be classed as secondary windows, which are not covered by the BRE guidelines.

All five windows which would be outside the guidelines on the first floor, W1, W2, W3 and W4 and W5, serve the living room of Flat 2. Of these, W2, W3, W4 and W5 would be classed as secondary windows. W1 would be classed as a main window.

On the second floor, two of the windows, W1, and W4 would be classed as secondary windows. W2 would be classed as a main window.

On the third floor, the single window which would be outside the guidelines would be classed as a main window.

The guidelines permit averaging of results for windows of equal size. If the mean of the VSCs for the three large windows serving the room are considered, the results shown in Table 2 are obtained:



Table 2 Mean VSCs for Flat 2 living room, first to third floors

Floor	Room	Large windows	Mean VSC before	Mean VSC after	Ratio of after/before
1	Flat 2 Liv	W1, W6, W7	24.5	19.7	0.80
2	Flat 2 Liv	W2, W5, W7	29.0	23.6	0.81
3	Flat 2 Liv	W1, W6, W7	29.1	24.4	0.84

The mean loss of daylight to the main windows of the room on each floor would be within the BRE guidelines, and therefore loss of daylight would be within the guidelines overall.

Loss of daylight would therefore be within the BRE guidelines for all of the rooms assessed.



5 Loss of sunlight calculations

All of the living room windows face within 90° of due south and therefore have a reasonable expectation of sunlight. Loss of sunlight has been analysed for all of them, although as noted above, not all of them are main windows. A summary of the analysis results is shown in Table 3 below. The full set of results is provided in Appendix B.

Table 3 Summary of APSH results for Chatsworth House living rooms

Floor	No. of rooms analysed	Rooms continuing to receive recommended level of APSH	Rooms continuing to receive recommended level of APSH in winter months
1	3	3	3
2	3	3	3
3	3	3	3
4	3	3	3
5	3	3	3
6	3	3	3
7	3	3	3

In order to achieve the recommendations in BRE Report 'Site layout planning for daylight and sunlight: a guide to good practice', a main living room window should retain 25% or more of available annual probable sunlight hours (APSH), or where it is lower, a ratio of after/before of 0.8 or more. This should include 5% or more of available sunlight hours in the winter months.

All of the living rooms would have a main window which continues to receive at least the recommended amount of sunlight, both year round and in the winter months.

Loss of sunlight would therefore be within the BRE guidelines in all cases.



6 Conclusions

Loss of daylight and sunlight to Chatsworth House as a result of the proposed development at 43-47 Piccadilly Gardens has been analysed. The windows on the south east and south west elevations which would have a view of the development were assessed.

The methodology required by Manchester City Council for daylight has been used, where all windows are first assessed using vertical sky component, followed by assessment of average daylight factor for any failures, followed by assessment of no-sky line for any average daylight factor failures.

Loss of daylight to the windows at Chatsworth House would be within the BRE guidelines overall. Nine windows with results outside the guidelines were either secondary windows or the room as a whole would pass using the results for all of the main windows serving the room.

ADF and no-sky line calculations were therefore not required.

All of the living rooms would continue to have a main window which receives the recommended amount of sunlight, both year round and in the winter months. Loss of sunlight would therefore be within the BRE guidelines.



7 References

1. BRE, BR209 Site Layout Planning for Daylight and Sunlight: A guide to good practice, 2011
2. Commission Internationale de L'Eclairage (International Commission on Illumination), CIE Standard 011/E:2003 Spatial distribution of daylight - CIE standard overcast sky and clear sky
3. BS8206 Part 2:2008 Lighting for Buildings, Code of Practice for Daylighting



Appendix A Vertical sky component results

First floor

Window	Floor	VSC before %	VSC after %	Ratio after/before
Flat 2 Liv	W1	13.0	9.2	0.71
	W2	17.6	13.2	0.75
	W3	20.5	15.5	0.76
	W4	30.4	23.6	0.78
	W5	30.4	24.1	0.79
	W6	30.4	24.5	0.81
	W7	30.3	24.8	0.82
	W8	30.2	25.0	0.83
Flat 2 Bed 2	W1	30.0	25.2	0.84
	W2	29.7	25.3	0.85
Flat 2 Bed 1	W1	29.4	25.3	0.86
	W2	29.0	25.3	0.87
Flat 1 Bed 1	W1	28.6	25.1	0.88
	W2	28.1	24.8	0.88
Flat 1 Bed 2	W1	27.4	24.4	0.89
	W2	26.8	24.0	0.90
Flat 1 liv	W1	26.0	23.4	0.90
	W2	25.1	22.7	0.91
	W3	24.1	22.0	0.91
	W4	23.1	21.1	0.91
	W5	21.9	20.0	0.91
Flat 9 Bed 1	W1	9.2	9.2	1.00
Flat 9 Bed 2	W1	8.4	7.2	0.86
	W2	17.9	15.4	0.86
	W3	19.0	16.4	0.86
Flat 9 Liv	W1	20.0	17.4	0.87
	W2	20.9	18.2	0.87
	W3	21.8	19.1	0.88
	W4	20.3	19.2	0.95
	W5	19.8	18.8	0.95
	W6	19.4	18.5	0.95
	W7	18.9	18.1	0.96



Second floor

Window	Floor	VSC before %	VSC after %	Ratio after/before
Flat 2 Liv	W1	15.8	11.8	0.75
	W2	21.6	17.0	0.79
	W3	24.9	19.9	0.80
	W4	32.8	26.1	0.79
	W5	32.7	26.5	0.81
	W6	32.7	26.9	0.82
	W7	32.6	27.2	0.83
	W8	32.4	27.4	0.85
Flat 2 Bed 2	W1	32.2	27.5	0.85
	W2	31.9	27.6	0.87
Flat 2 Bed 1	W1	31.6	27.7	0.88
	W2	31.3	27.7	0.88
Flat 1 Bed 1	W1	30.9	27.5	0.89
	W2	30.4	27.3	0.90
Flat 1 Bed 2	W1	29.8	26.9	0.90
	W2	29.2	26.6	0.91
Flat 1 liv	W1	28.5	26.0	0.91
	W2	27.6	25.3	0.92
	W3	26.6	24.5	0.92
	W4	25.5	23.6	0.92
	W5	24.2	22.4	0.93
Flat 9 Bed 1	W1	10.5	10.5	1.00
Flat 9 Bed 2	W1	9.0	7.9	0.87
	W2	19.0	16.7	0.88
	W3	20.3	17.9	0.88
Flat 9 Liv	W1	21.6	19.2	0.89
	W2	22.7	20.2	0.89
	W3	23.8	21.3	0.89
	W4	23.8	22.8	0.96
	W5	23.1	22.2	0.96
	W6	22.6	21.7	0.96
	W7	22.0	21.2	0.96



Third floor

Window	Floor	VSC before %	VSC after %	Ratio after/before
Flat 2 Liv	W1	18.7	14.7	0.79
	W2	25.4	21.1	0.83
	W3	29.0	24.3	0.84
	W4	34.7	28.2	0.81
	W5	34.6	28.6	0.83
	W6	34.5	28.9	0.84
	W7	34.4	29.3	0.85
	W8	34.2	29.5	0.86
Flat 2 Bed 2	W1	34.1	29.6	0.87
	W2	33.8	29.8	0.88
Flat 2 Bed 1	W1	33.6	29.9	0.89
	W2	33.3	29.9	0.90
Flat 1 Bed 1	W1	33.0	29.8	0.90
	W2	32.6	29.7	0.91
Flat 1 Bed 2	W1	32.0	29.3	0.92
	W2	31.6	29.1	0.92
Flat 1 liv	W1	30.9	28.6	0.93
	W2	30.1	28.0	0.93
	W3	29.1	27.2	0.93
	W4	28.0	26.3	0.94
	W5	26.6	25.0	0.94
Flat 9 Bed 1	W1	11.5	11.5	1.00
Flat 9 Bed 2	W1	9.5	8.4	0.89
	W2	20.0	17.9	0.89
	W3	21.6	19.4	0.90
Flat 9 Liv	W1	23.1	20.9	0.91
	W2	24.5	22.2	0.91
	W3	25.8	23.5	0.91
	W4	27.4	26.5	0.97
	W5	26.6	25.8	0.97
	W6	26.0	25.2	0.97
	W7	25.2	24.5	0.97



Fourth floor

Window	Floor	VSC before %	VSC after %	Ratio after/before
Flat 2 Liv	W1	20.0	16.4	0.82
	W2	27.8	23.9	0.86
	W3	31.8	27.5	0.86
	W4	36.3	30.3	0.83
	W5	36.2	30.7	0.85
	W6	36.2	31.0	0.86
	W7	36.0	31.3	0.87
	W8	35.9	31.5	0.88
Flat 2 Bed 2	W1	35.8	31.7	0.89
	W2	35.6	31.9	0.90
Flat 2 Bed 1	W1	35.4	32.0	0.90
	W2	35.2	32.1	0.91
Flat 1 Bed 1	W1	34.9	32.0	0.92
	W2	34.6	32.0	0.92
Flat 1 Bed 2	W1	34.1	31.7	0.93
	W2	33.7	31.5	0.93
Flat 1 liv	W1	33.2	31.1	0.94
	W2	32.4	30.6	0.94
	W3	31.5	29.8	0.95
	W4	30.4	28.8	0.95
	W5	28.9	27.4	0.95
Flat 9 Bed 1	W1	12.3	12.3	1.00
Flat 9 Bed 2	W1	9.9	9.0	0.90
	W2	20.9	19.0	0.91
	W3	22.8	20.9	0.92
Flat 9 Liv	W1	24.7	22.7	0.92
	W2	26.3	24.3	0.92
	W3	27.8	25.8	0.93
	W4	30.7	29.8	0.97
	W5	29.9	29.1	0.97
	W6	29.3	28.6	0.98
	W7	28.6	28.0	0.98



Fifth floor

Window	Floor	VSC before %	VSC after %	Ratio after/before
Flat 2 Liv	W1	20.5	17.4	0.85
	W2	28.9	25.5	0.88
	W3	33.1	29.4	0.89
	W4	37.7	32.3	0.86
	W5	37.6	32.7	0.87
	W6	37.6	33.0	0.88
	W7	37.5	33.3	0.89
	W8	37.4	33.5	0.90
Flat 2 Bed 2	W1	37.3	33.7	0.90
	W2	37.1	33.9	0.91
Flat 2 Bed 1	W1	37.0	34.0	0.92
	W2	36.9	34.1	0.93
Flat 1 Bed 1	W1	36.7	34.1	0.93
	W2	36.4	34.1	0.94
Flat 1 Bed 2	W1	36.0	33.9	0.94
	W2	35.7	33.8	0.95
Flat 1 liv	W1	35.2	33.4	0.95
	W2	34.6	33.0	0.95
	W3	33.7	32.3	0.96
	W4	32.7	31.3	0.96
	W5	31.0	29.8	0.96
Flat 9 Bed 1	W1	12.8	12.8	1.00
Flat 9 Bed 2	W1	10.3	9.4	0.92
	W2	21.7	20.1	0.93
	W3	24.2	22.6	0.93
Flat 9 Liv	W1	26.5	24.8	0.94
	W2	28.4	26.7	0.94
	W3	30.0	28.3	0.94
	W4	33.8	33.1	0.98
	W5	33.3	32.6	0.98
	W6	32.9	32.3	0.98
	W7	32.4	31.9	0.98



Sixth floor

Window	Floor	VSC before %	VSC after %	Ratio after/before
Flat 2 Liv	W1	20.8	18.3	0.88
	W2	29.5	26.8	0.91
	W3	34.0	31.0	0.91
	W4	38.8	34.4	0.89
	W5	38.7	34.8	0.90
	W6	38.7	35.0	0.90
	W7	38.7	35.3	0.91
	W8	38.6	35.5	0.92
Flat 2 Bed 2	W1	38.6	35.7	0.93
	W2	38.5	35.9	0.93
Flat 2 Bed 1	W1	38.4	36.0	0.94
	W2	38.3	36.1	0.94
Flat 1 Bed 1	W1	38.2	36.2	0.95
	W2	38.0	36.2	0.95
Flat 1 Bed 2	W1	37.8	36.1	0.96
	W2	37.6	36.0	0.96
Flat 1 liv	W1	37.2	35.8	0.96
	W2	36.8	35.5	0.96
	W3	36.1	34.9	0.97
	W4	35.2	34.1	0.97
	W5	33.5	32.5	0.97
Flat 9 Bed 1	W1	13.6	13.6	1.00
Flat 9 Bed 2	W1	10.6	9.9	0.93
	W2	22.6	21.4	0.94
	W3	26.0	24.7	0.95
Flat 9 Liv	W1	28.8	27.5	0.95
	W2	31.0	29.6	0.96
	W3	32.5	31.2	0.96
	W4	36.9	36.4	0.98
	W5	36.7	36.2	0.99
	W6	36.5	36.0	0.99
	W7	36.3	35.8	0.99



Seventh floor

Window	Floor	VSC before %	VSC after %	Ratio after/before
Flat 2 Liv	W1	21.0	19.3	0.92
	W2	30.0	28.1	0.94
	W3	34.6	32.5	0.94
	W4	39.5	36.4	0.92
	W5	39.5	36.6	0.93
	W6	39.5	36.8	0.93
	W7	39.5	37.0	0.94
	W8	39.5	37.2	0.94
Flat 2 Bed 2	W1	39.5	37.4	0.95
	W2	39.4	37.6	0.95
Flat 2 Bed 1	W1	39.4	37.7	0.96
	W2	39.4	37.8	0.96
Flat 1 Bed 1	W1	39.4	37.9	0.96
	W2	39.3	38.0	0.97
Flat 1 Bed 2	W1	39.2	38.0	0.97
	W2	39.1	38.0	0.97
Flat 1 liv	W1	39.0	37.9	0.97
	W2	38.7	37.8	0.98
	W3	38.3	37.5	0.98
	W4	37.7	37.0	0.98
	W5	36.3	35.6	0.98
Flat 9 Bed 1	W1	15.4	15.4	1.00
Flat 9 Bed 2	W1	11.2	10.7	0.96
	W2	24.1	23.2	0.96
	W3	28.7	27.7	0.97
Flat 9 Liv	W1	31.8	30.8	0.97
	W2	33.7	32.7	0.97
	W3	35.0	34.0	0.97
	W4	39.5	39.1	0.99
	W5	39.5	39.2	0.99
	W6	39.5	39.2	0.99
	W7	39.5	39.2	0.99



Appendix B Annual probable sunlight hours results

First floor

Room	Window	Annual probable sunlight hours				Ratio after/before	
		Before		After		All year %	Winter %
		All year %	Winter %	All year %	Winter %		
Flat 2 Liv	W1	36	11	26	2	0.71	0.22
	W2	44	11	32	2	0.74	0.18
	W3	48	12	35	2	0.74	0.19
	W4	55	14	43	5	0.78	0.37
	W5	56	15	43	6	0.78	0.38
	W6	56	16	45	7	0.80	0.41
	W7	57	16	46	7	0.81	0.45
	W8	57	17	46	8	0.82	0.49
Flat 1 liv	W1	54	19	47	12	0.87	0.63
	W2	53	18	46	12	0.87	0.63
	W3	52	18	46	12	0.88	0.67
	W4	51	18	46	12	0.89	0.69
	W5	51	18	45	12	0.89	0.68
Flat 9 Liv	W1	45	17	40	12	0.89	0.71
	W2	45	16	40	11	0.89	0.70
	W3	46	15	41	11	0.91	0.72
	W4	41	13	36	9	0.89	0.68
	W5	40	13	36	9	0.90	0.70
	W6	39	13	35	9	0.90	0.69
	W7	39	13	35	9	0.90	0.69



Second floor

Room	Window	Annual probable sunlight hours				Ratio after/before	
		Before		After		All year %	Winter %
		All year %	Winter %	All year %	Winter %		
Flat 2 Liv	W1	42	16	30	6	0.73	0.37
	W2	51	16	39	6	0.76	0.38
	W3	56	17	43	6	0.77	0.37
	W4	61	19	48	8	0.79	0.44
	W5	62	20	49	9	0.80	0.47
	W6	62	21	50	10	0.81	0.49
	W7	62	21	51	11	0.82	0.52
	W8	62	21	51	11	0.83	0.55
Flat 1 liv	W1	59	21	53	15	0.89	0.70
	W2	58	21	52	15	0.89	0.70
	W3	58	21	52	15	0.90	0.73
	W4	57	21	52	16	0.91	0.75
	W5	56	21	51	15	0.91	0.75
Flat 9 Liv	W1	49	20	45	16	0.92	0.80
	W2	50	20	45	16	0.91	0.78
	W3	50	20	47	16	0.92	0.80
	W4	48	18	44	14	0.92	0.80
	W5	47	17	43	14	0.92	0.79
	W6	46	17	43	13	0.92	0.80
	W7	46	16	42	13	0.92	0.79



Third floor

Room	Window	Annual probable sunlight hours				Ratio after/before	
		Before		After		All year	Winter
		All year	Winter	All year	Winter		
		%	%	%	%	%	%
Flat 2 Liv	W1	47	21	36	11	0.77	0.50
	W2	57	22	45	12	0.80	0.52
	W3	62	23	50	11	0.80	0.49
	W4	67	23	55	12	0.82	0.52
	W5	67	23	55	12	0.82	0.52
	W6	67	23	56	13	0.83	0.55
	W7	67	23	56	13	0.84	0.57
	W8	67	24	57	14	0.86	0.59
Flat 1 liv	W1	65	24	59	18	0.92	0.77
	W2	64	24	59	18	0.91	0.77
	W3	63	23	58	18	0.92	0.78
	W4	62	24	58	19	0.92	0.80
	W5	61	23	56	19	0.93	0.81
Flat 9 Liv	W1	53	23	49	20	0.94	0.86
	W2	54	23	50	20	0.93	0.84
	W3	56	23	53	20	0.94	0.87
	W4	55	21	52	18	0.94	0.86
	W5	54	21	51	18	0.94	0.85
	W6	54	19	51	17	0.95	0.85
	W7	53	18	50	15	0.94	0.84



Fourth floor

Room	Window	Annual probable sunlight hours				Ratio after/before	
		Before		After		All year %	Winter %
		All year %	Winter %	All year %	Winter %		
Flat 2 Liv	W1	49	23	39	13	0.79	0.56
	W2	59	25	49	15	0.82	0.58
	W3	65	25	54	14	0.82	0.55
	W4	71	25	60	14	0.84	0.55
	W5	71	25	60	14	0.85	0.57
	W6	71	25	61	15	0.86	0.59
	W7	71	25	61	16	0.87	0.62
	W8	71	25	62	16	0.88	0.65
Flat 1 liv	W1	68	25	64	20	0.93	0.81
	W2	67	25	63	20	0.93	0.81
	W3	66	25	62	20	0.93	0.82
	W4	64	24	61	20	0.94	0.84
	W5	63	24	59	21	0.94	0.85
Flat 9 Liv	W1	55	24	52	21	0.95	0.88
	W2	57	24	54	21	0.95	0.88
	W3	58	24	55	21	0.95	0.89
	W4	62	22	60	19	0.96	0.89
	W5	61	21	59	18	0.96	0.88
	W6	60	19	58	17	0.96	0.88
	W7	60	18	57	16	0.96	0.87



Fifth floor

Room	Window	Annual probable sunlight hours				Ratio after/before	
		Before		After		All year %	Winter %
		All year %	Winter %	All year %	Winter %		
Flat 2 Liv	W1	49	23	41	15	0.83	0.65
	W2	60	26	52	17	0.86	0.66
	W3	66	26	56	16	0.85	0.63
	W4	73	26	63	16	0.87	0.63
	W5	73	26	64	17	0.88	0.66
	W6	73	26	64	17	0.89	0.67
	W7	73	26	65	18	0.90	0.70
	W8	73	26	66	19	0.90	0.73
Flat 1 liv	W1	70	25	67	22	0.95	0.86
	W2	69	25	66	22	0.95	0.86
	W3	68	25	65	22	0.95	0.88
	W4	66	25	64	22	0.96	0.90
	W5	64	25	62	22	0.96	0.90
Flat 9 Liv	W1	57	24	55	22	0.96	0.92
	W2	59	24	56	22	0.96	0.91
	W3	60	25	58	23	0.97	0.92
	W4	68	22	66	21	0.97	0.92
	W5	67	21	65	20	0.97	0.92
	W6	66	21	65	19	0.97	0.91
	W7	66	20	64	18	0.97	0.91



Sixth floor

Room	Window	Annual probable sunlight hours				Ratio after/before	
		Before		After		All year %	Winter %
		All year %	Winter %	All year %	Winter %		
Flat 2 Liv	W1	49	24	43	18	0.88	0.74
	W2	60	26	54	20	0.89	0.75
	W3	66	26	59	19	0.89	0.72
	W4	74	26	67	19	0.90	0.72
	W5	74	26	67	19	0.91	0.75
	W6	74	26	68	20	0.92	0.77
	W7	74	26	69	21	0.93	0.80
	W8	74	26	69	21	0.93	0.80
Flat 1 liv	W1	72	26	70	24	0.97	0.93
	W2	71	26	69	24	0.98	0.93
	W3	70	26	68	24	0.97	0.93
	W4	68	26	66	24	0.98	0.95
	W5	66	26	65	24	0.98	0.96
Flat 9 Liv	W1	60	25	59	24	0.98	0.96
	W2	62	25	61	24	0.98	0.96
	W3	64	25	63	24	0.98	0.96
	W4	72	24	71	23	0.98	0.95
	W5	72	24	71	23	0.99	0.96
	W6	71	23	70	22	0.99	0.96
	W7	71	23	70	22	0.99	0.97

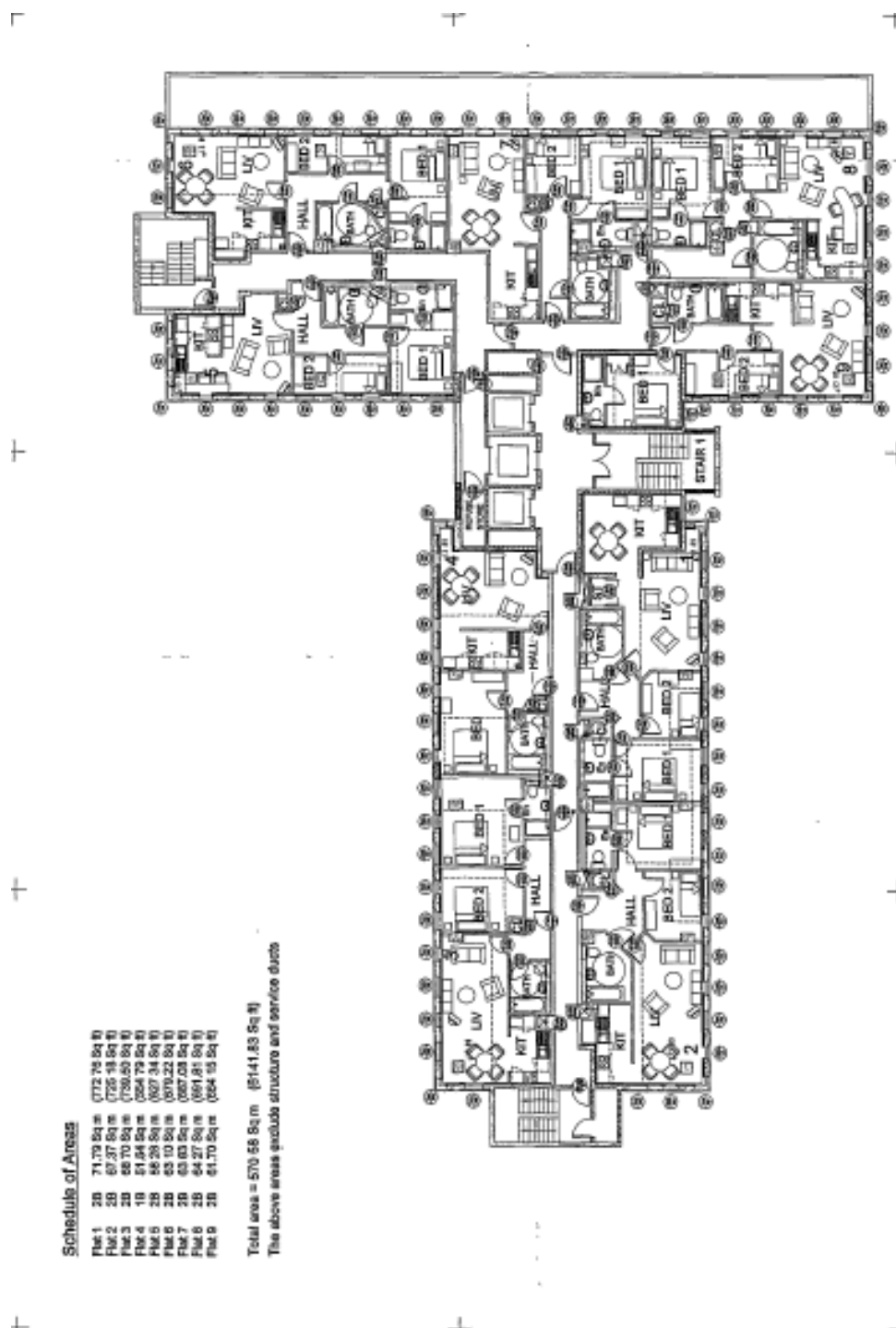


Seventh floor

Room	Window	Annual probable sunlight hours				Ratio after/before	
		Before		After		All year %	Winter %
		All year %	Winter %	All year %	Winter %		
Flat 2 Liv	W1	49	24	46	21	0.94	0.87
	W2	60	26	57	22	0.94	0.86
	W3	66	26	62	22	0.94	0.85
	W4	74	26	70	22	0.95	0.85
	W5	74	26	71	23	0.95	0.87
	W6	74	26	71	23	0.96	0.87
	W7	74	26	72	24	0.97	0.90
	W8	74	26	72	24	0.97	0.91
Flat 1 liv	W1	73	26	73	26	1.00	1.00
	W2	73	26	73	26	1.00	1.00
	W3	72	26	72	26	1.00	1.00
	W4	71	26	71	26	1.00	1.00
	W5	70	26	70	26	1.00	1.00
Flat 9 Liv	W1	62	25	62	25	1.00	1.00
	W2	65	26	65	26	1.00	1.00
	W3	67	26	67	26	1.00	1.00
	W4	75	26	75	26	1.00	1.00
	W5	75	26	75	26	1.00	1.00
	W6	75	26	75	26	1.00	1.00
	W7	75	26	75	26	1.00	1.00

Appendix C Floor plans for Chatsworth House

Floor plan for floors 1, 3, 5 and 7 of Chatsworth House. Taken from drawing by Michael Hyde and Associates Ltd. Not shown to scale.





Floor plan for floors 2, 4 and 6 of Chatsworth House. Taken from drawing by Michael Hyde and Associates Ltd. Not shown to scale.

