Expansion of Anfield Stadium for
Liverpool Football Club

Environmental Statement, Volume 2: Technical Appendices (Part 3)

B4/5

Expansion of Anfield Stadium for Liverpool Football Club

Environmental Statement,
Volume 2: Technical Appendices (Part 3)

May 2014

Liverpool Football Club and Athletic Grounds

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Issue and revision record

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Appendices

Appendix Title **Page**

1. Light Pollution

1.1 Lighting Assessment

Expansion of Anfield Stadium for Liverpool Football Club

Lighting Impact Assessment

May 2014

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Contents

Executive Summary

This report provides an obtrusive light assessment for the proposed re-development works at Liverpool Football Club. The assessment includes Sky Glow, Luminous Intensity, Light Intrusion onto Windows and Building Luminance.

The Design of the Public Realm Lighting and the Architectural Feature lighting was carried out by iGuzzini and SKM.

The Pitch floodlighting design for was carried out by Mott MacDonald Ltd.

The results from the above designs were compared against the Institute of Lighting Professionals (ILP) Guidance for Reduction of Obtrusive Light (GN01:2011), as summarised below:

Table 1.1: ILP Guidance for Reduction of Obtrusive Light

Environmental Zone	Sky Glow ULR (Max %)	Light Intrusion (into Windows) Ev (Lux)		Luminaire Intensity (Candelas)		Building Luminance Pre-curfew
		Pre-curfew	Post-curfew	Pre-curfew	Post-curfew	Average, L (cd/m2)
E3	5.0	6*	2	10,000	1,000	10

* As amended by LCC.

Table 1.2: Summary of Findings

ILP Guidance	Guidance Criteria		Calculated Performance Worst Case		Comment
	Pre Curfew	Post Curfew	Pre Curfew	Post Curfew	
Light Intrusion onto windows	6 lux	2 lux	35.2 lux	33.5 lux	Remedial Action Recommended
Luminous Intensity	10,000 cd	2,000 cd	26,204 cd	26,204 cd	Remedial Action Recommended
Sky Glow	5% Max		5.46%		Remedial Action Recommended
Building Luminance	10 cd/m2 Average		0.2 cd/m2 Average		Design Considered Satisfactory

1 Introduction

1.1 Overview

Mott MacDonald Ltd has been commissioned by Liverpool Football Club and Athletics Grounds Ltd to undertake an Environmental Impact Assessment (EIA) for the proposed expansion of the existing stadium located in Anfield, Liverpool. An Environmental Statement (ES) has been produced following the EIA process and is submitted to Liverpool City Council (LCC) as the Local Planning Authority (LPA) in support of the planning application for the scheme.

This report is provided as a lighting impact assessment to supplement the Townscape, Landscape and Visual Amenity Impact Assessment (TLVIA) which in turn forms part of the Environmental Statement (ES).

In line with LCC's local requirements, this lighting assessment provides details of external lighting (including a layout plan with a lux contour diagram showing luminance levels both within and in the immediate vicinity of the site and a schedule of equipment in the design) and the proposed hours when the lighting would be switched on.

The purpose of this report is to assess the lighting conditions of the area directly surrounding the stadium. Firstly a baseline condition is established on a non-match day where all of the stadium lighting is switched off except for the security lighting which remains on at all times. We then directly compare this to a match day situation where all lighting for the stadium is switched on.

This will give an accurate representation of how the stadium visually affects the surrounding area in its current state. With the use of a 3D model and the lighting proposals from the stadium designers a direct comparison of how the stadiums proposed development will affect the base line conditions, match day and non-match day will then be made.

The report has been divided into two separate phases due to the nature of the planning application.

Phase 1– Full planning application including a lighting design for the parking and soft landscaping, floodlighting designs for the football pitch within the proposed Main Stand expansion stadium and the architectural lighting design to illuminate the stadium facade.

Phase 2– Outline planning application. This report will suggest the environmental zone and associated light pollution limits for the future expansion of the Anfield Road Stand.

2 Site Description

2.1 Scheme Background

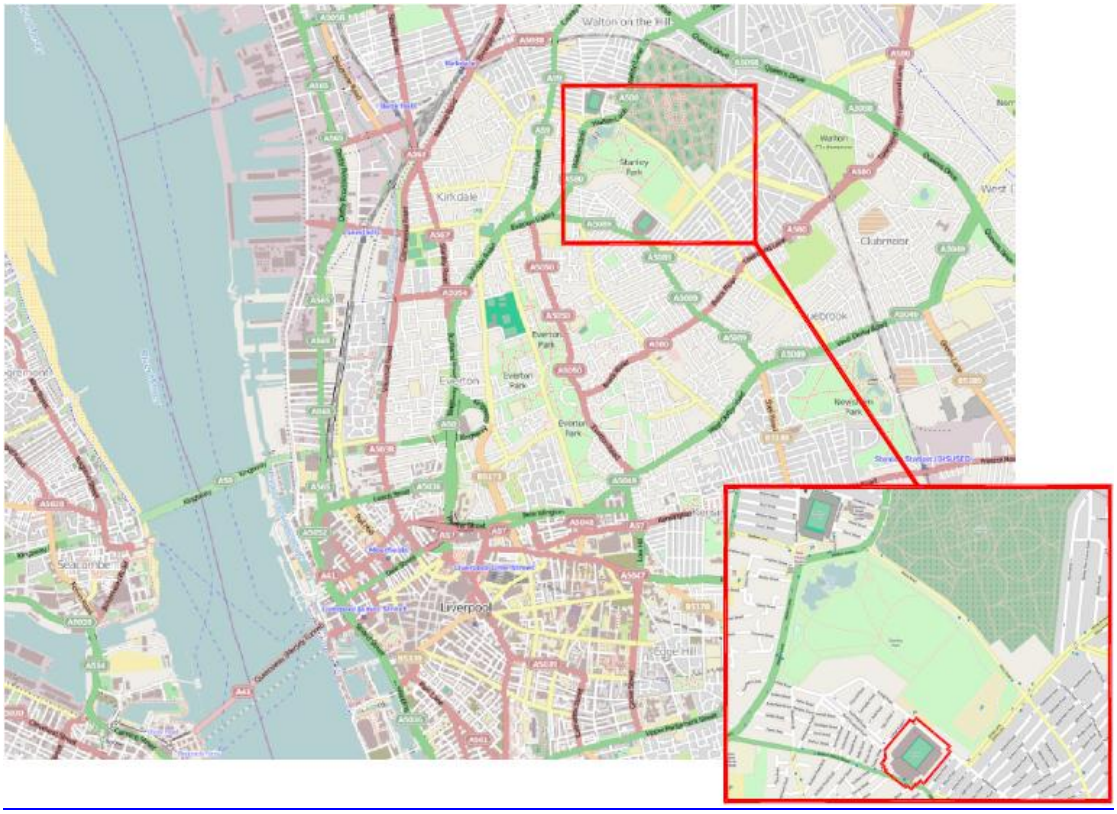
The Anfield Stadium Expansion is recognised as a key project in the wider Anfield Spatial Regeneration Framework (SRF) being developed by LCC for the purpose of delivering comprehensive and sustainable regeneration of the Anfield area. The SRF aims to bring together current and new proposals in a coordinated and comprehensive manner as a means to deliver lasting social, economic, and environmental regeneration.

2.2 Description of the Proposed Works

2.2.1 Site Location

The location of the site is shown in Figure 2.1 below.

Figure 2.1: Site Location Plan



Source: Mott MacDonald, 2014

2.2.2 Expansion of Stadium

The proposals to expand the Liverpool Football Club (LFC) stadium are based around a long term vision to expand the Main Stand and Anfield Road stand to give an increase in the total seated capacity to circa 58,700 spectators.

2.2.3 Regeneration

Along with increasing the capacity of the stadium, the aspirations of LFC are to enhance both the spectator experience at the Anfield Stadium and provide a catalyst to long-term investment benefiting the regeneration of the Anfield / Breckfield area.

2.2.4 Scheme Phasing

The scheme comprises of two consecutive phases, both of which will be covered in this report, albeit to different levels of assessment. The first phase is to erect a new Main Stand to the rear of the existing stand and high quality public realm around the stadium. The available designs are consistent with a RIBA Stage ‘D - design development’ stage for this phase, and so detailed assessments of the potential impacts are included in this report. The second phase is to redevelop the Anfield Road Stand. This new stand will also be constructed to the rear of the existing stand with the immediate area to the north being landscaped. At the time of writing this report the planning application for Phase 2 is an outline planning application which does not require any detailed design. The purpose of including Phase 2 in this report will be to suggest the environmental zone and light pollution limits for the future detailed design.

3 Method of Assessment

3.1 Scope of Assessment

Due to the requirement for external lighting around the stadium the architectural feature lighting and the (Phase1) proposals for new floodlighting the pitch it was considered necessary to ensure that the planning application was supported by a Lighting Impact Assessment Report which would include match day and non-match day night time surveys.

A baseline condition was established on a non-match day where all of the stadium lighting is switched off except for the security lighting which remains on at all times. This situation was then directly compared to a match day situation where all lighting for the stadium is switched on to give an accurate representation of how the stadium affects the surrounding area in its current state. With the use of a 3D model and the proposed lighting design a direct comparison of how the stadiums proposed development will affect the base line conditions, match day and non-match day was made.

An assessment was carried out at key survey viewpoint locations which have been summarised in Table 3.3.

The Institution of Lighting Professionals (ILP) has provided a guidance note on the reduction of obtrusive light, GN01:2011. This document forms the basis for the lighting analysis carried out within this report. It should however be noted that this can only be assessed against Phase 1 for the full planning application as phase 2 has not been designed with enough detail at this outline planning stage.

The assessment of potentially significant lighting effects on ecological species (in particular sensitive bat species) is not included within the scope of this report. Further information can be found within ES Volume 1 Chapter 16 Ecology which provides detailed baseline data, evaluation of ecological features, discussion of effects and impacts, and mitigation measures for protected sites, species and habitats of value for nature conservation within the footprint of the proposed LFC expansion scheme and the immediate surrounding area.

3.2 Methodology for Baseline Assessment

The baseline assessment for the existing lighting conditions has been carried out, using the guidance produced by the ILP (Institution of Lighting Professionals) ILP – Guidance Note PLG 04, Guidance on Undertaking Environmental Lighting Impact Assessments.

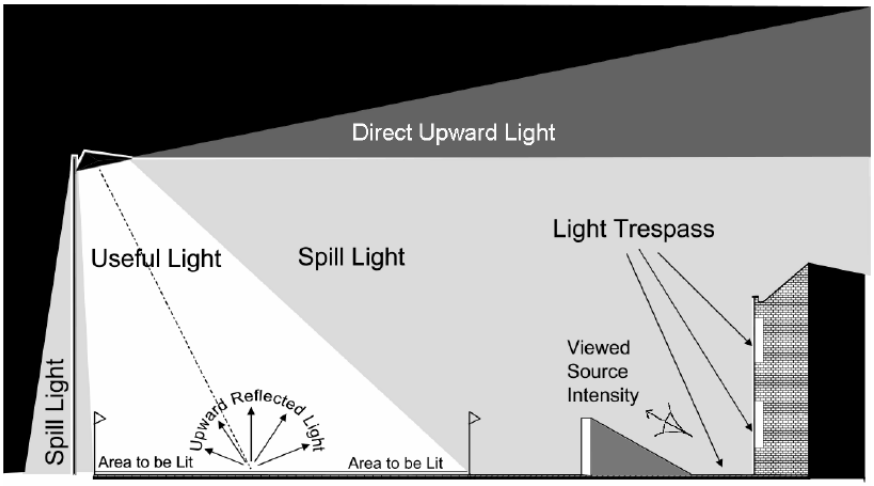
3.2.1 Obtrusive Light

Obtrusive Light Limitation Design Guidance

Light intensity and distribution needs to be carefully considered during the design process to ensure that direct upward light is minimised, and light distribution cut-offs from luminaries do not result in severe lighting contrast on light receiving surfaces such as floors and walls. Luminaries, lamps, optics and

equipment should be specified and located to minimise any direct upward light component in order to reduce light pollution. In addition light trespass and spill light will need to be minimised through design.

Figure 3.1: Types of Obtrusive Light



Source: ILP Guidance Notes for the Reduction of Obtrusive Light (2011)

3.2.2 Environmental Zone Classification for Liverpool Football Club

To assess the levels of obtrusive light an appraisal was carried out to classify the site in terms of its 'Environmental Zone' which equates to the district brightness of the surroundings, see Table 3.1 for environment zone information.

In the case of a site being between two possible environmental zones, ILP guidance recommends that the most difficult environmental zone of the two options to achieve is assigned for assessment purposes. In this case it could be argued that the site lies between an E3 and E4 zone. Therefore in line with ILP guidance, we have applied E3.

Table 3.1: Environmental Zones

Zone	Surrounding	Lighting Environment	Examples
E0	Protected	Dark	UNESCO Starlight Reserves, IDA Dark Sky Parks
E1	Natural	Intrinsically dark areas	National Parks, Areas of Outstanding Natural Beauty etc.
E2	Rural	Low District Brightness	Village or relatively dark outer suburban locations
E3	Suburban	Medium district brightness	Small town centres or suburban locations
E4	Urban	High district brightness	Town/city centres with high levels of night time activity

Source: ILP guidance notes for the reduction of obtrusive light – 2011

3.2.3 Obtrusive Light Limitations

It can be seen from Table 3.2 below that a lighting installation located in an area deemed to be more sensitive will understandably equate to greater constraints with regards to obtrusive light. Based on our appraisal, see below for maximum levels of obtrusive light associated with an E3 Zone.

Table 3.2: Obtrusive Light Limitations (ILP guidance notes for the reduction of obtrusive light 2011)

Environmental Zone	Sky Glow ULR (Max %)	Light Intrusion (into Windows) Ev (Lux)		Luminaire Intensity I (Candelas)		Building Luminance Pre-curfew
		Pre-curfew	Post-curfew	Pre-curfew	Post-curfew	Average, L (cd/m2)
E0	0	0	0	0	0	0
E1	0	2	0	2,500	0	0
E2	2.5	5	1	7,500	500	5
E3	5.0	6	2	10,000	1,000	10
E4	15	25	5	25,000	2,5000	25

Source: ILP guidance notes for the reduction of obtrusive light - 2011

Curfew: The time after which more stringent requirements (for control of obtrusive light) will apply; often a condition of use of lighting by the local planning authority. If not otherwise stated – 23:00 hours is suggested by the ILP.

3.2.4 Lighting Restrictions

LCC Environmental Health Officer, Mr Ian Rushforth has confirmed* that the light restrictions highlighted in table 3.2 are correct and can be applied for this development. Mr Rushforth has also confirmed that 23:00hrs is the curfew time, after which the more stringent requirements for control of obtrusive light, highlighted in table 3.2, will apply. Mr Rushforth requested that the pre-curfew limit for light intrusion (into windows) should be lowered to 6 Lux as opposed to the limit of 10 Lux set by the ILP increasing the stringency of requirements.

* Confirmation of Mr Rushforth' s requests can be found in Appendix G.

3.3 Summary of Key Survey Viewpoint Locations

A desk study was executed using the existing infrastructure information available. To carry out an effective night survey the area around the stadium was assessed and 41 key survey viewpoint locations were identified. These points span the streets that could logically be affected by the proposed phase one lighting. The key survey viewpoint locations have been illustrated in Appendix B and as listed in Table 3.3.

Table 3.3: Key Lit Survey Viewpoint Locations Summary

Survey Viewpoint Location No	Drawing Reference No	Description of Location
1	317415-EIA-002	Walton Breck Road - Outside property no: 220
2		Walton Breck Road - Outside property no: 214
3		Walton Breck Road - Outside property no: 208
4		Walton Breck Road - Christ Church Building
5	317415-EIA-001	Walton Breck Road - Outside property no: 194
6		Walton Breck Road - Outside property no: 182
7		Walton Breck Road - Outside property no: 178/176
8		Walton Breck Road - Outside property no: 172
9		Walton Breck Road - Outside property no: 168
10		Walton Breck Road - Outside property no: 162
11		Walton Breck Road - Outside property no:160
12		Walton Breck Road - Outside property no: 152
13		Walton Breck Road - Outside property no: 144
14		Gilman Street - Outside property no: 1
15		Gilman Street - Outside property no: 17/19
16		Gilman Street - Outside property no: 35/37
17		Baltic Street - Outside property no: 1
18		Baltic Street - Outside property no: 19/21
19		Baltic Street - Outside property no: 39/41 currently demolished
20		Rockfield Road - Beside property no: 53
21		Alroy Road - Outside property no: 20
22		Alroy Road - Outside property no: 12/10
23		Alroy Road - Outside property no: 4
24		Anfield Road - Beside property no: 144
25		Anfield Road - Outside property no:45
26		Anfield Road/Mill Lane junction - Beside property no:46
27		Stanley Park - Next to substation on Mill Lane
28		Stanley Park location 1
29		Stanley Park location 2

Survey Viewpoint Location No	Drawing Reference No	Description of Location
30	317415-EIA-002	Stanley Park location 3
31		Anfield Road - Outside property no:73/71
32		Anfield Road - Beside property no:250
33		North West Car Park - Inside stadium boundary location 1
34		North West Car Park - Inside stadium boundary location 2
35		North West Car Park - Inside stadium boundary location 3
36		North West Car Park - Inside stadium boundary location 4
37		North West Car Park - Inside stadium boundary location 5
38		Skerries Road - Outside property no:30
39		Skerries Road - Outside property no:20
40		Skerries Road - Outside property no:8
41		Walton Breck Road - Beside property no:271

Source: Mott MacDonald Ltd

3.4 Description of Day and Night-Time Site Visit Procedures

Usually to carry out an environmental impact assessment for lighting, a site visit would be arranged for the area to be surveyed over 2 or 3 evenings. This would give the flexibility to ensure good weather conditions and the most accurate readings on a light meter. However once Mott MacDonald was commissioned to carry out the EIA, there was already a limited time for completion. Due to the nature of football stadium lighting we would have to find a date within the project timeframe that contained an evening football match with full floodlighting. This did however provide only one evening to get every result we required for full stadium lighting.

Day-time and night-time surveys were therefore undertaken on the 3rd of April for non-match day conditions and on the 4th of April for full match day conditions, to determine the current baseline lighting and the types of lighting installations present on-site and in the immediate vicinity of the stadium.

During the daytime survey the weather conditions were generally misty, giving way to heavy cloud conditions and the occasional light shower. The rain cleared for the night time non-match day survey however it was still misty at times with wet ground conditions.

Figure 3.2: Daytime Weather conditions

Source: Mott MacDonald Ltd.

The night time survey for match day was undertaken with good visibility, no rain and dry ground conditions; however cloud cover was such that the moon and stars were not visible.

Figure 3.3: Night-time Weather Conditions

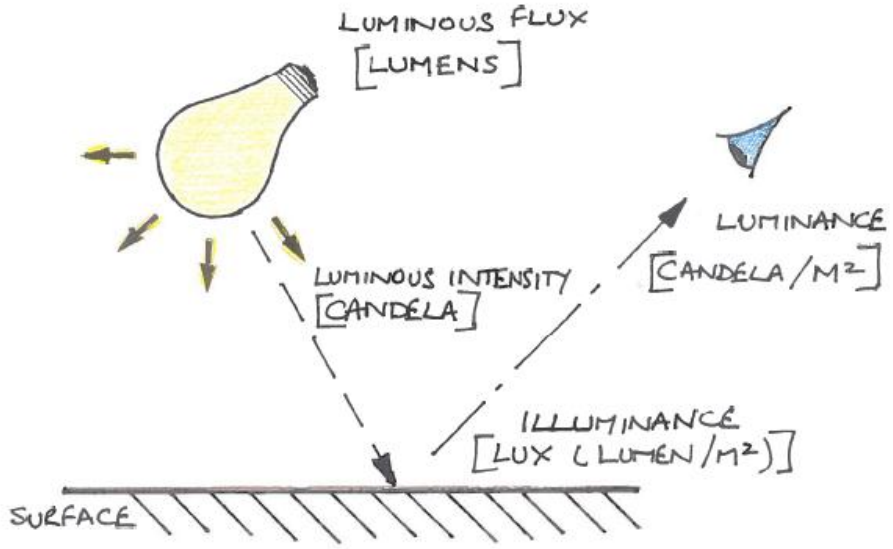
Source: Mott MacDonald Ltd.

Readings of Illuminance, to establish light spill, were taken from predetermined survey viewpoint locations, which, are provided in Appendix B shown on drawings 317415-EIA-001 and 317415-EIA-002 with details of reading available in Appendix E.

Figure 3.4 is shown to provide an explanation of Illuminance and how this differs from Luminance. To summarise Illuminance is the measurement of the amount of light falling on a surface whereas Luminance is an indicator of how bright the surface will appear from a given observe position.

The locations were determined during the desk study and confirmed during the day-time survey. In particular, properties in close proximity to the site were evaluated in terms of their direct and intermittent views towards the site and whether existing screening prevented any existing views.

Figure 3.4: Luminance and Illuminance



Source: Mott MacDonald Ltd.

The Illuminance readings were taken between 21:00hrs to 23:00hrs to establish the existing ambient lighting conditions on which to base the lighting assessment. Due to the heavy cloud cover on both survey days 21:00hrs was considered to be full night conditions.

At the key survey viewpoint locations, two horizontal readings of Illuminance were taken with the front of the light meter pointed towards the stadium. One reading was taken at ground level and an additional reading taken at a height of 1.5m above ground level.

3.5 Equipment Utilised

A TES 1330A Heavy Duty hand held Light Meter (Serial Number X031/R8) was utilised for all on site light readings in lux. The hand held meter is maintained and calibrated in accordance with the manufacturers' instructions, the Certificate of Calibration can be found in Appendix F. Readings of illuminance were recorded at the locations described in Table 3.3.

The camera utilised for the site photos was a Canon 550d, a tripod was used for longer exposure shots associated with night time photography, to provide increased stability.

3.6 Assessment of Effects and Determining of Significance

The proposed development will have varying levels of significance and these have been assessed based on the scale of change experienced by each identified key receptor. The level of change is assessed on a scale of minor, moderate or major in terms of whether the changes have a positive, neutral or negative effect.

To determine the scale of the change in lighting levels at each key receptor, the following criteria have been utilised:

- The obtrusive light limitations detailed in Table 3.2;
- Type of lighting that will be in use during the construction and operational phases;
- The anticipated duration of artificial lighting during the hours of darkness;
- The distance between the proposed lighting installation and the key receptor;
- Type of view (e.g. direct, intermittent or constrained); and
- Existing and proposed screening from the proposed development.

The level of change evaluated from the criteria above is assessed using the matrix outlined in Table 3.4 below. Levels that are either moderate or above are considered to be a significant effect. Note that significant effects can be either beneficial or adverse.

Table 3.4: Evaluation Table

Nature	Ref	Level	Description	Remedial Needs
Positive	1	Major/substantial beneficial effects	Significant improvement in night environment and/or reductions in glare, spill light and sky glow.	No remedial / mitigation measures required
	2	Moderate beneficial effects	Noticeable improvements in night environment and/or reductions in glare, spill light and sky glow etc.	
	3	Minor beneficial effects	Slight improvement in night environment and/or reductions in glare, spill light and sky glow etc.	
Neutral	4	None/negligible	No significant effect or overall effects balancing out.	
Negative	5	Minor adverse effects	Slight increase in visibility of site, glare, and sky glow etc.	Develop appropriate levels and type of mitigation
	6	Moderate adverse effects	Noticeable increase in visibility of site, glare and sky glow etc.	
	7	Major adverse effects	Significant problems with increase in visibility of site, glare, and sky glow etc.	

Source: ILP Professional Lighting Guide 04

4 Baseline Conditions

The baseline conditions presented below are those surveyed and documented during the day and night time surveys in April 2014.

The following descriptions provide a summary of the assessed conditions for both of the scenarios match day and non-match day. For a comprehensive overview reference should be made to:

- Appendix B.1 & B.2 – Survey Viewpoint Locations Plan including Photograph locations, 317415-EIA-001 & 317415-EIA-002;
- Appendix C.1 - Photo Sheets; and
- Appendix E.1 & E.2 - Onsite Assessment Lux Readings for match day and non-match day.

The site has been classified with an environmental zone of E3 which relates to low district brightness, rural area and equates to a village or relatively dark outer suburban location. Justification of the classification of the appropriate environmental zone can be found in Section 3.2. The associated obtrusive light limitations can be found in Table 3.2.

Light readings in lux can be obstructed by trees, vegetation, and street furniture however in this case the most prevalent issue was parked vehicles. We took a number of Lux readings at fixed points on the non-match day (as indicated on drawing numbers 317415-EIA-001 & 002) then the next evening we took readings in the same locations for the match-day base line. If, on the second evening light was blocked by a parked vehicle then the reading could have been adversely affected.

From the daytime survey it was apparent that there were no trees surrounding the site that we considered to be evergreen. There is an existing tree belt along the boundary of Stanley Park and Anfield Road car park that is deciduous (loses all foliage in autumn and winter). We therefore have not taken in to account any shielding effects from these trees, to create a worst case scenario; this is because in autumn and winter these deciduous trees would not have any leaves and no shielding effects from the lighting scheme. At this stage, no information regarding the type and size of the proposed trees has been provided therefore we have been unable to include this in our assessment.

The full results tables are in Appendix E; the non-match day survey results are in Appendix E.1, and the match day survey results in Appendix E.2.

Table 4.1: Non Match Day

Survey Viewpoint Location No	Time of reading	Lux level on the ground	Lux level at 1.5m
1	09:19	16.1	14.5
2	09:21	28.5	32.6
3	09:22	75.6	86
4	09:24	10	10.7
5	09:24	30.1	30.5

Table 4.2: Match Day

Survey Viewpoint Location No	Time of reading	Lux level on the ground	Lux level at 1.5m
1	09:01	14.6	13
2	09:02	36	33
3	09:03	75	87
4	09:04	10.1	10.7
5	09:05	30	28.2

4.1 Walton Breck Road Survey Viewpoint Location No's: 1 – 13 & 41

Walton Breck Road is an A class road situated to the south of the stadium. From observations, this road seemed the busiest of those surveyed. There are a number of businesses along the road close to the stadium including a public house, church, cafés and fast food outlets. There is a wide footway on the northern side of Walton Breck Road and a relatively narrow footway on the southern side. Both sides of the road have double yellow lines. There are no trees or planting of any significance in the area near to the stadium.

There is existing highway lighting on Walton Breck Road in the form of lighting columns which are approximately 10 metres in height. The luminaires incorporate low pressure sodium lamps which are classed as a monochromatic light source providing negligible colour recognition properties. The system of lighting appears to be operated by the local highway authority and as such will be to a standard of lighting appropriate for a traffic route.

There are significant existing views of the stadium.

*When the stadium lighting is operational there is a significant amount of light falling on the advertising hoarding and The Park Public House as can be seen in Figures 4.1 and 4.2

From reviewing the Illuminance readings details in section 4.1.1 and 4.1.2, the difference in the non-match day and match day Illuminance of the majority of readings are negligible. Comparing the match and non-match day readings at survey viewpoint location no's: 2 and 12 there is an increase in Illuminance during match day however adjacent readings do not show any significant increase.

We have noted an anomaly with the readings taken at survey viewpoint location no's: 6 and 9, where the non-match day readings have increased compared to the match day readings. From our experience using light meters, we have attributed this to the slight variation in weather conditions between the non-match day and match day surveys. As the survey was conducted after rain/shower, cars, buildings and ground surfaces held higher reflectance values due to them being wet/damp which increases the amount of light being reflected from the existing street lighting onto the light meter.

4.1.1 Non-Match Day Illuminance Results

Table 4.3 is summary of the measured levels of Illuminance for Walton Breck Road for survey viewpoint location no's: 1 to 13 for a non-match day.

Table 4.3: Walton Breck Road Illuminance Results

Survey Viewpoint Location No	Measured at Ground Level (lux)	Measured at 1.5m Above Ground Level (lux)
1	16.1	14.5
2	28.5	32.6
3	75.6	86.0
4	10.0	10.7
5	30.1	30.5
6	27.3	59.0
7	5.0	5.0
8	6.5	5.6
9	24.3	29.6
10	11.0	10.0
11	9.5	8.1
12	16.6	19.3
13	6.5	6.7

Source: Mott MacDonald Ltd.

4.1.2 Match Day Illuminance Results

Table 4.4 is summary of the measured levels of Illuminance for Walton Breck Road for survey viewpoint location numbers 1 to 13 for a match day.

Table 4.4: Walton Breck Road Illuminance Results

Survey Viewpoint Location No	Measured at Ground Level (lux)	Measured at 1.5m Above Ground Level (lux)
1	14.6	13
2	36	33
3	75	87
4	10.1	10.7
5	30	28.2
6	27.4	48.2
7	5.1	4.5

Survey Viewpoint Location No	Measured at Ground Level (lux)	Measured at 1.5m Above Ground Level (lux)
8	7	6.5
9	15.5	18.1
10	11	10.1
11	9.1	8.5
12	21.2	26.1
13	6.5	6.1

4.1.3 Site Survey Photo Comparison

Figure 4.1: Walton Breck Road With Stadium Lights Off

Source: Mott MacDonald Ltd.

Figure 4.2: Walton Breck Road With Stadium Lights On

Source: Mott MacDonald Ltd.

4.2 Gilman Street Survey Viewpoint Location No's: 14 – 16

Gilman Street is located to the west of the stadium and has a row of small 2-storey terraced houses on the west side and an area on the east side which is grassed with planting. Restricted parking is allowed on the west side of Gilman Street but there are double yellow lines for the length of the east side. The road allows 2-way traffic and incorporates traffic calming measures at 2 locations within the area surveyed.

Photos were taken both facing down Gilman Street shown in Figures 4.3 and 4.4. There are also photos taken from Gilman Street looking over the grassed area towards the stadium which shows significant existing views of the stadium.

Gilman Street has relatively narrow footways on both sides and is sparsely lit with 3 lighting columns of approximately 6 metres in height. The luminaires incorporate low pressure sodium lamps which are classed as a monochromatic light source providing negligible colour recognition properties. The system of lighting appears to be operated by the local highway authority and as such will be to a standard of lighting appropriate for a residential road.

From reviewing the Illuminance readings details in section 4.2.1 and 4.2.2, the non-match day readings have significantly increased compared to the match day readings. Survey viewpoint location reading no's: 14 and 16 can be attributed to the readings being taken later in evening when the existing highway lighting,

which is in close proximity, have been operational for longer and therefore at increased intensity. Survey viewpoint location no: 15 reading which is not positioned in close proximity to the existing street lighting, illustrates a significant increase in lux levels both at ground level and at 1.5 metres above ground level which can be attributed to the increase of stadium building illuminators.

It is noted that all of the properties in the area between Gilman Street and Pulford Street are now vacant. They have been acquired by LCC and are due to be cleared during the 3rd quarter of 2014 to make way for commercial / residential development in accordance with the Anfield Strategic Regeneration Framework.

4.2.1 Non-Match Day Illuminance Results

Table 4.5 is summary of the measured levels of Illuminance for Gilman Street for the survey viewpoint location numbers 14 to 15 for a non-match day.

Table 4.5: Gilman Street Illuminance Results

Survey Viewpoint Location No	Measured at Ground Level (lux)	Measured at 1.5m Above Ground Level (lux)
14	26.4	35.9
15	3.5	3.6
16	20.2	26

4.2.2 Match Day Illuminance Results

Table 4.6 is summary of the measured levels of Illuminance for Gilman Street for Receptor numbers 14 to 15 for a match day.

Table 4.6: Gilman Street Illuminance Results

Survey Viewpoint Location No	Measured at Ground Level (lux)	Measured at 1.5m Above Ground Level (lux)
14	7.3	6.5
15	9.1	8.5
16	5	4.5

4.2.3 Site Survey Photo Comparison

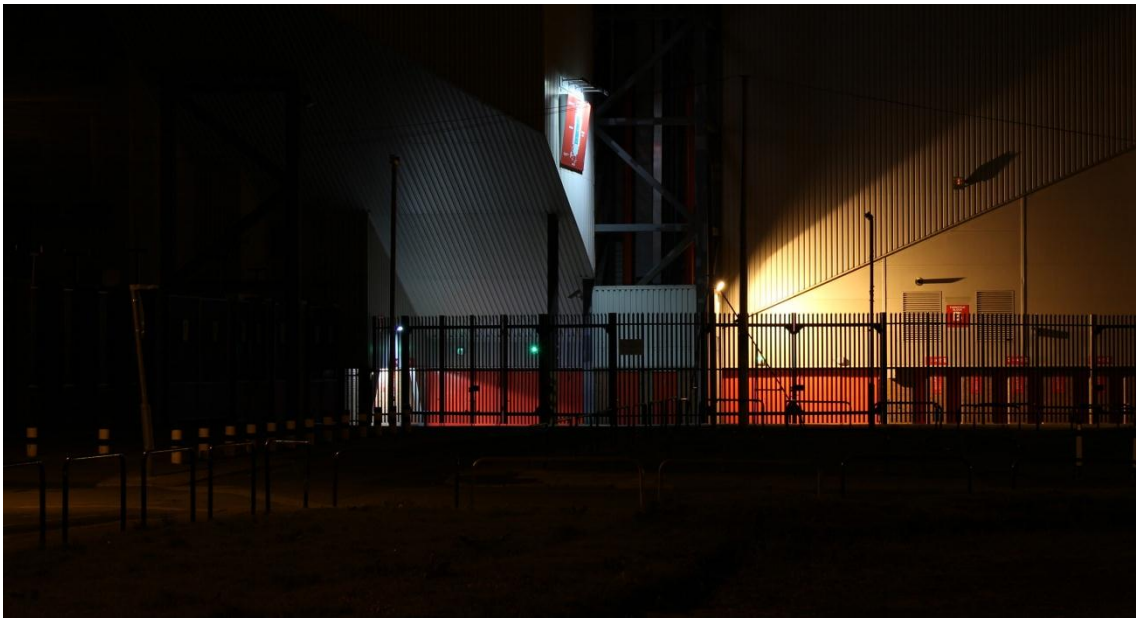
Figure 4.3: Gilman Street With Stadium Lights Off

Source: Mott MacDonald Ltd.

Figure 4.4: Gilman Street With Stadium Lights On

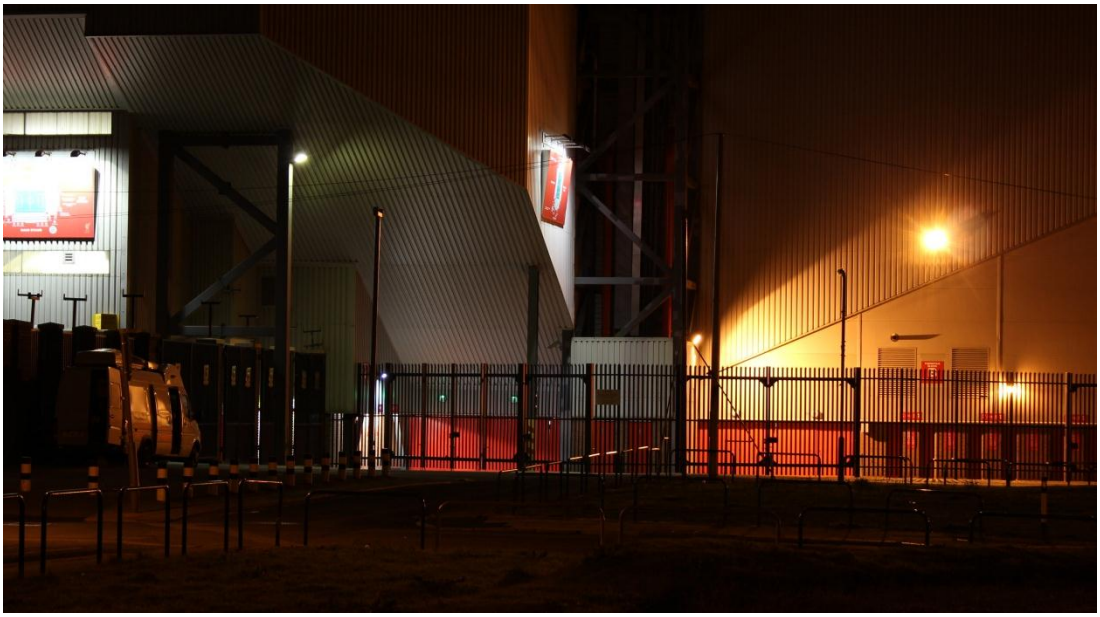
Source: Mott MacDonald Ltd.

Figure 4.5: Gilman Street Towards Stadium with Stadium Lights Off



Source: Mott MacDonald Ltd.

Figure 4.6: Gilman Street Towards Stadium with Stadium Lights On



Source: Mott MacDonald Ltd.

4.3 Baltic Street Survey Viewpoint Location No's: 17 - 19

Baltic Street is to the west of the stadium and joins Walton Breck Road at the south and Back Rockfield Road at the north. There are small 2-storey terraced houses on both sides of the street with no planting or trees on either side. There are double yellow lines for the length of the west side of Baltic Street and restricted parking on the east, 2-way traffic is allowed on Baltic Street. There is a speed hump at 2 locations on the highway in the area surveyed.

The majority of the properties on Baltic Street have no existing views of the stadium; however one property on the corner of Walton Breck Road appears to have a small direct view of the stadium from a second floor window.

There is existing highway lighting on Baltic Street in the form of lighting columns which are approximately 6 metres in height. Compared to Gilmore Street the luminaires have been upgraded and incorporate high pressure sodium lamps which have improved colour recognition properties when compared to low pressure sodium lamps however are considered poor when compared to 'white light' sources such as Cosmopolis and LED based lighting. The system of lighting appears to be operated by the local highway authority and as such will be to a standard of lighting appropriate for a residential road however the overall uniformity of the lighting appears to be poor.

The photos shown in Figures 4.7 and 4.8 were taken facing south on Baltic Street, looking towards Walton Breck Road.

From reviewing the Illuminance readings details in section 4.3.1 and 4.3.2, the difference in the non-match day and match day Illuminance readings are negligible. Based on these readings the stadium lighting has no impact in the areas of survey viewpoint location no's: 17 to 19. There is a slight increase in the non-match 1.5m reading for survey viewpoint location no: 19 however this is attributed to the readings being taken later in evening when the existing highway lighting, which is in close proximity, have been operational for longer and therefore at increased intensity.

Baltic Street is included in the area of housing intended for clearing as previously described.

4.3.1 Non-Match Day Illuminance Results

Table 4.7 is a summary of the measured levels of Illuminance for Baltic Street for the survey viewpoint location no's: 17 to 19 for a non-match day.

Table 4.7: Baltic Street Illuminance Results

Survey Viewpoint Location No	Measured at Ground Level (lux)	Measured at 1.5m Above Ground Level (lux)
17	8.7	6.6
18	1.7	1.2
19	31.4	47.9

4.3.2 Match Day Illuminance Results

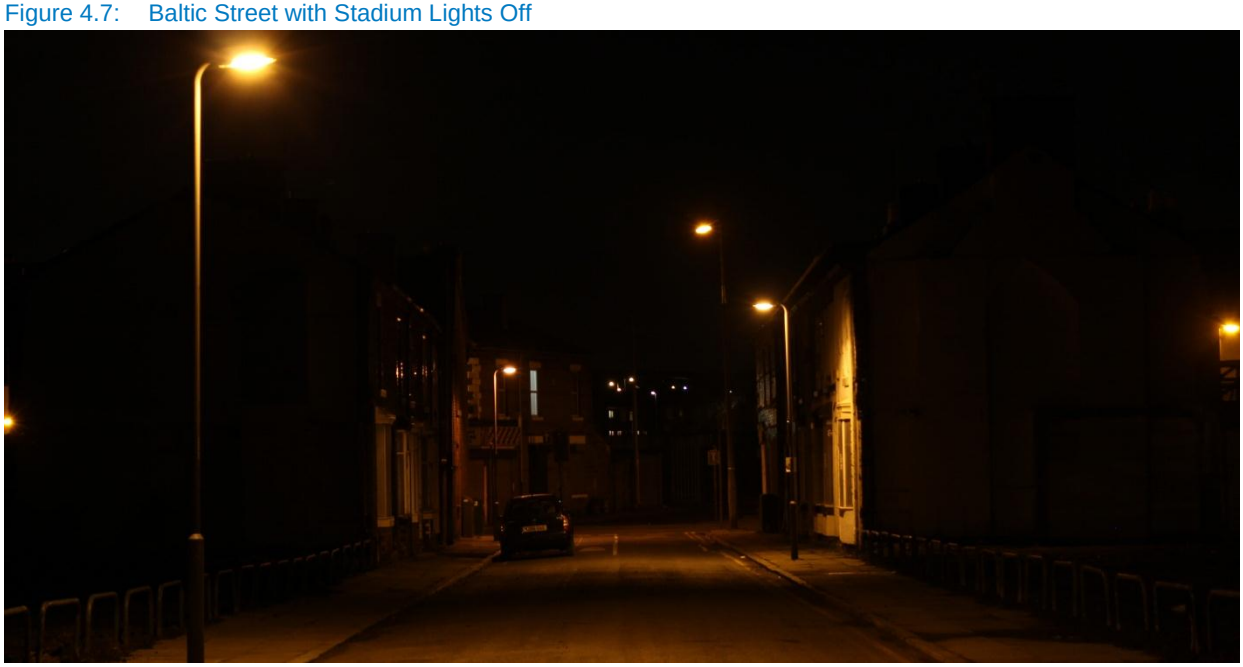
Table 4.8 is summary of the measured levels of Illuminance for Baltic Street for survey viewpoint location no's: 17 to 19 for a match day.

Table 4.8: Baltic Street Illuminance Results

Survey Viewpoint Location No	Measured at Ground Level (lux)	Measured at 1.5m Above Ground Level (lux)
17	7.1	4.5
18	1.4	1.0
19	29	42

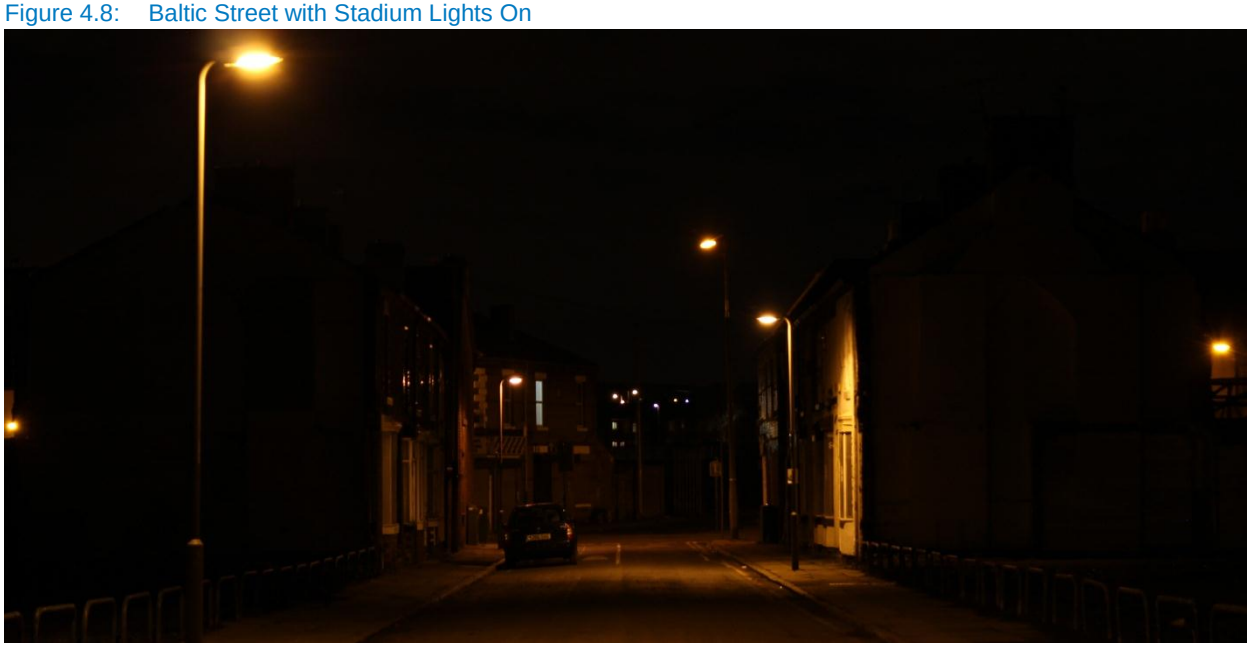
4.3.3 Site Survey Photo Comparison

Figure 4.7: Baltic Street with Stadium Lights Off



Source: Mott MacDonald Ltd.

Figure 4.8: Baltic Street with Stadium Lights On



Source: Mott MacDonald Ltd.

4.4 Alroy Road Survey Viewpoint Location No's: 21 - 23

Alroy Road is situated to the north west of the stadium and allows 1-way traffic heading south east. The road joins Anfield Road to the north east and Rockfield Road at the south west. There is restricted parking on both sides of Alroy Road and 2 speed humps towards either end. The houses on Alroy Road are generally 2-storey with the loft space utilised for an additional room with a front facing dormer window. There is a small area of private land outside each property adjoining the footway, some of which have planting however this is small and does not overhang into the footway and would not affect lighting.

There are no direct views of the stadium from Alroy Road. There are however views of the Anfield Road car park and its associated lighting as can been seen in the photos shown in Figures 4.9 and 4.10.

There is existing highway lighting on Alroy Road in the form of lighting columns which are approximately 6 metres in height with the majority of luminaires incorporating high pressure sodium lamps which have improved colour recognition properties when compared to low pressure sodium lamps however are considered poor when compared to 'white light' sources such as Cosmopolis and LED. There is one 4 metre lighting column at the junction of Rockfield road which incorporates a low pressure sodium light source. The system of lighting appears to be operated by the local highway authority and as such will be to a standard of lighting appropriate for a residential road.

From reviewing the Illuminance readings details in section 4.4.1 and 4.4.2, the difference in the non-match day and match day Illuminance readings are negligible. Based on these readings the stadium lighting has

no impact in the areas of survey viewpoint location no's: 20 to 24. There is a slight increase in the non-match day 1.5m illuminance reading for survey viewpoint location no: 24. From our experience using light meters, we have attributed this to the slight variation in weather conditions between the non-match day and match day surveys. As the survey was conducted after rain/shower, cars, buildings and ground surfaces held higher reflectance values due to them being wet/damp which increases the amount of light being reflected from the existing street lighting onto the light meter.

4.4.1 Non-Match Day Illuminance Results

Table 4.9 is summary of the measured levels of Illuminance for Alroy Road for survey viewpoint location no's: 20 to 24 for a non-match day.

Table 4.9: Alroy Road Illuminance Results

Survey Viewpoint Location No	Measured at Ground Level (lux)	Measured at 1.5m Above Ground Level (lux)
20	27.5	42.1
21	6	6.3
22	6	6.3
23	4.6	5.3
24	10.8	16.0

4.4.2 Match Day Illuminance Results

Table 4.10 is summary of the measured levels of Illuminance for Alroy Road for survey viewpoint location no's: 20 to 24 for a match day.

Table 4.10: Alroy Road Illuminance Results

Survey Viewpoint Location No	Measured at Ground Level (lux)	Measured at 1.5m Above Ground Level (lux)
20	29.1	43.2
21	5.2	5
22	6.3	8.3
23	4.5	4.8
24	8.4	12.4

4.4.3 Site Survey Photo Comparison

Figure 4.9: Alroy Road with Stadium Lights Off

Source: Mott MacDonald Ltd.

Figure 4.10: Alroy Road with Stadium Lights On

Source: Mott MacDonald Ltd.

4.5 Rockfield Road - facing the stadium Locations No 20

Rockfield Road is situated to the north west of the stadium and Anfield Road on the north west. Rockfield Road allows 1-way traffic heading south east. Restricted parking is allowed on the south west side of the road and the north east side is restricted with double yellow lines. There are footways on either side of the road and speed humps at a number of locations along its length. The houses are 2-storey terraced, some of which have a dorma window in the loft space. There are no trees or planting on Rockfield Road however there is a small area of private land outside each house which may have some small planting which doesn't overhang into the footway and will not affect lighting.

There are existing minor views of the stadium roof and its lighting from Rockfield Road which can be seen in the photos provided in Figures 4.11 and 4.12. These photos were taken facing south east on Rockfield Road looking towards Lothair Road.

There is existing highway lighting on Rockfield Road in the form of lighting columns that are approximately 6 metres in height with the majority of luminaires incorporating a white light source such as a Cosmopolis lamp which have a considerably higher level of improved colour recognition properties when compared to high pressure sodium. The system of lighting appears to be operated by the local highway authority and as such will be to a standard of lighting appropriate for a residential road.

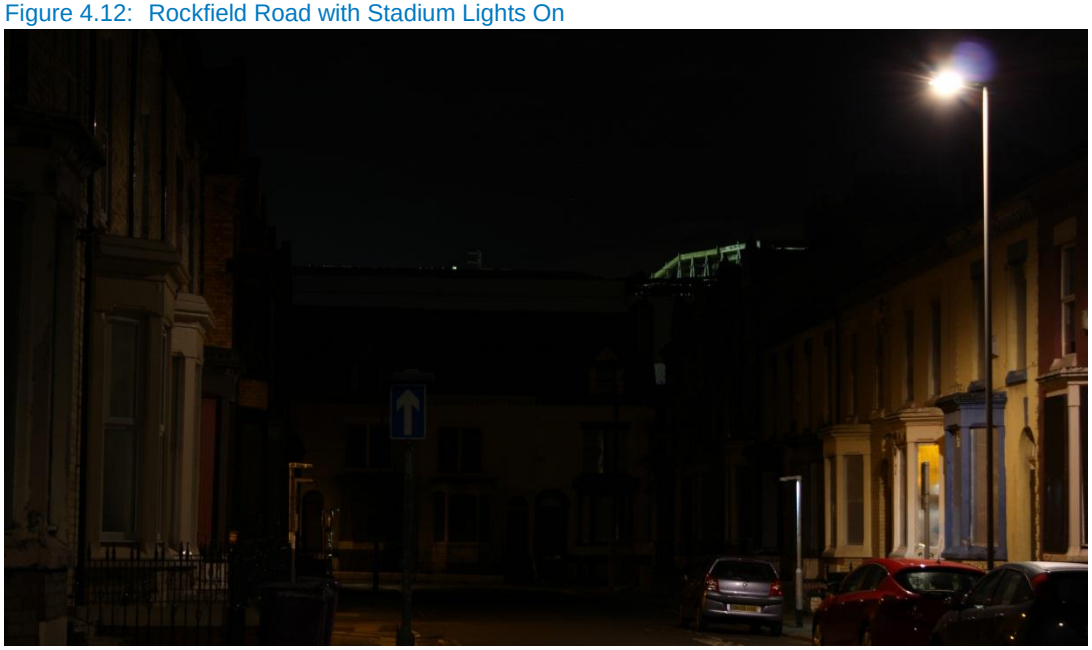
It was decided to take an additional photo at this location as the proposed development will remove the houses which currently block any lighting from the stadium and may potentially be an area of concern when the new development is modelled. The photos are shown in Figures 4.11 and 4.12 and as you can see the stadium floodlighting is visible in the match day picture.

4.5.1 Site Survey Photo Comparison

Figure 4.11: Rockfield Road with Stadium Lights Off

Source: Mott MacDonald Ltd.

Figure 4.12: Rockfield Road with Stadium Lights On



Source: Mott MacDonald Ltd.

4.6 Anfield Road/Mill Lane Survey Viewpoint Location No's: 24-27

Anfield Road runs to the north of the stadium and joins A580 Walkton Lane at the west end and Walton Breck Road at the east end.

There is a footway which runs down the side of the house shown in the photos located in Figures 4.13 and 4.14 leading to Stanley Park. Photos were taken at this location because it was obvious that there was a significant amount of spill light from the temporary car park north of the stadium.

There are footways on both sides of Anfield Road and double yellow lines along its length. Anfield Road allows 2-way traffic and speed humps are situated at several locations.

There are 3 large trees on the north side of the road close to the photograph location. Houses on the north side of the road close to the photograph location are large semi-detached 3-storey. Housing on the south side are a combination of small 2-storey terraced houses and large 2-storey terraced houses some of which have a room in the loft space with dormer type window/s.

The stadium is located on Anfield Road and as such is a significant feature. There is no floodlighting on the stadium in this location which is orientated towards the road. There is significant lighting of the temporary can park in the form floodlighting mounted at approximately 8 metres in height which is shown on the photo in Figure 4.15. As mentioned and shown in Figures 4.13 and 4.14 there is a significant amount of spill light from the car park affecting property number 45 on Anfield Road. Although there is hoarding around the car park this is not sufficient to shield the lighting from the car park.

There is existing highway lighting on Anfield Road in the form of lighting columns that are approximately 8 metres in height with the luminaires incorporating high pressure sodium lamps which have improved colour recognition properties when compared to low pressure sodium lamps however are considered poor when compared to 'white light' sources such as cosmopolis and LED. The system of lighting appears to be operated by the local highway authority and as such will be to a standard of lighting appropriate for a traffic route.

There is also lighting on the Footway to Stanley Park in the form of lighting columns approximately 4 metres in height however during the visit the lighting was not operational. The luminaires have been fitted with shields to limit light spill to the rear of the footpath.

From reviewing the Illuminance readings details in section 4.6.1 and 4.6.2, the difference in the non-match day and match day Illuminance readings are negligible. Based on these readings the stadium lighting has no impact in the areas of survey viewpoint location no's: 25 to 27, although it is apparent from Figure 4.14 that property number 45 on Anfield Road receives a significant amount of spill light from the temporary car park. The results from the survey do not also illustrate the temporary car park lighting as the hording provides a light shield of an estimated height of 2 metres, above the height of the light meter readings.

4.6.1 Non-Match Day Illuminance Results

Table 4.11 is summary of the measured levels of Illuminance for Anfield Road and Footway to Stanley Park survey viewpoint location no's: 25 – 27 for a non-match day.

Table 4.11: Anfield Road and Footway to Stanley Park Illuminance Results

Survey Viewpoint Location No	Measured at Ground Level (lux)	Measured at 1.5m Above Ground Level (lux)
25	11.6	9.6
26	20.6	30.6
27	19.0	22.1

4.6.2 Match Day Illuminance Results

Table 4.12 is summary of the measured levels of Illuminance for Anfield Road and Footway to Stanley Park survey viewpoint location no's: 25 – 27 for a match day.

Table 4.12: Anfield Road and Footway to Stanley Park Illuminance Results

Survey Viewpoint Location No	Measured at Ground Level (lux)	Measured at 1.5m Above Ground Level (lux)
25	11.00	9.4
26	21.0	32.1
27	18.3	21.0

4.6.3 Site Survey Photo Comparison

Figure 4.13: Anfield Road and Footway to Stanley Park with Stadium Lights Off

Source: Mott MacDonald Ltd.

Figure 4.14: Anfield Road and Footway to Stanley Park with Stadium Lights On

Source: Mott MacDonald Ltd.

Figure 4.15: Anfield Road Temporary Car Park Lighting

Source: Mott MacDonald Ltd.

4.7 Stanley Park Survey Viewpoint Location No's: 28 - 30

Stanley Park is located to the north of the stadium behind the temporary car park with night time photos shown in Figures 4.16 and Figures 4.17. At this photo location there is a run of trees and 6ft mesh fence before the temporary car park. Behind the temporary car park is Anfield Road, and behind Anfield Road is the stadium. The photos were taken along the footway which is approximately 2m above the ground level of the temporary car park.

At this photo location, lighting from the temporary car park can be seen on match day towards the bottom right of the image. Street lighting on Anfield Road can also be seen on the left side of the photo and stadium lighting and roof structure can be seen clearly at the top of the photo. There is no lighting in the vicinity of the footway in the park.

From reviewing the Illuminance readings details in section 4.7.1 and 4.7.2, there is a significant increase in match day lighting levels which has been attributed to the temporary car park lighting and the visible stadium pitch floodlighting having a detrimental effect on the general district brightness in the park area.

4.7.1 Non-Match Day Illuminance Results

Table 4.13 is summary of the measured levels of Illuminance on Stanley Park for survey viewpoint location no's: 28 to 30 for a non-match day.

Table 4.13: Stanley Park Illuminance Results

Survey Viewpoint Location No	Measured at Ground Level (lux)	Measured at 1.5m Above Ground Level (lux)
28	0.3	0.3
29	0.3	0.3
30	0.4	0.2

4.7.2 Match Day Illuminance Results

Table 4.14 is summary of the measured levels of Illuminance on Stanley Park for survey viewpoint location no's: 28 to 30 for a match day.

Table 4.14: Stanley Park Illuminance Results

Survey Viewpoint Location No	Measured at Ground Level (lux)	Measured at 1.5m Above Ground Level (lux)
28	1.4	4
29	2.1	7.1
30	1.3	1.4

4.7.3 Site Survey Photo Comparison

Figure 4.16: Stanley Park with Stadium Lights Off

Source: Mott MacDonald Ltd.

Figure 4.17: Stanley Park with Stadium Lights On

Source: Mott MacDonald Ltd.

4.8 Anfield Road Survey Viewpoint Location No's: 31 & 32

This location on Anfield Road faces north west looking towards the stadium. There is an entrance to a large detached house to the right of the image and beyond that, the temporary parking area. As mentioned previously, Anfield Road is 2-way, has double yellow lines and footways on both sides and traffic calming in several locations. There are no trees surrounding the photo location. There are significant views of the stadium and temporary car park in this location.

As discussed in section 4.6 there is existing highway lighting on Anfield Road as can be seen on the photos in Figure 4.18 and 4.19. There is also existing lighting for the temporary car park on the opposite side of the road from the stadium and existing lighting for the North West car park. There is however an increase in non-match day Illuminance at 1.5m reading height which has been attributed to lighting being emitted from the localised property. It is apparent that the lux level on the ground on match day is significantly greater due to the façade lighting at the stadium.

4.8.1 Non-Match Day Illuminance Results

Table 4.15 is summary of the measured levels of Illuminance for Anfield Road for survey viewpoint location no: 31 for a non-match day.

Table 4.15: Anfield Road Illuminance Results

Survey Viewpoint Location No	Lux Reading at Ground Level	Lux Reading 1.5m Above Ground Level
31	32	62.9

Source: Mott MacDonald Ltd.

4.8.2 Match Day Illuminance Results

Table 4.16 is summary of the measured levels of Illuminance for Anfield Road for survey viewpoint location no: 31 for a non-match day.

Table 4.16: Anfield Road Illuminance Results

Survey Viewpoint Location No	Lux Reading at Ground Level	Lux Reading 1.5m Above Ground Level
31	42.3	48.1

Source: Mott MacDonald Ltd.

4.8.3 Site Survey Photo Comparison

Figure 4.18: Anfield Road with Stadium Lights Off

Source: Mott MacDonald Ltd.

Figure 4.19: Anfield Road with Stadium Lights On

Source: Mott MacDonald Ltd.

4.9 Skerries Road Survey Viewpoint Location No's: 38 – 40

Skerries Road is located to the south east of the stadium and joins Anfield Road at the north end and Walton Breck Road at the south. Skerries road allows 1-way traffic heading south west, there is restricted parking on both sides with a narrow carriageway. There are footways on both sides of the road and traffic calming at 2 locations along its length. The houses are small 2-storey terraced on both sides. There is a small area of private property outside the front of each property, none of these have any significant planting and there are no trees on either side of the road. The photos shown in Figures 4.20 and 4.21 were taken facing north east on Skerries Road looking towards Anfield Road.

There is existing highway lighting on Skerries Road that are approximately 4 metres in height with the column closest to Walton Breck Road being approximately 6 metres in height. The luminaires incorporate low pressure sodium lamps which are classed as a monochromatic light source providing negligible colour recognition properties. The system of lighting appears to be operated by the local highway authority and as such will be to a standard of lighting appropriate for a residential road.

There are no existing significant views of the stadium from the front of the properties, there are however significant existing views from the rear of the properties of the stadium and the North West Car Park as per section 4.10. It is anticipated that this existing system of lighting will provide a level of spill light to the rear of these properties and gardens.

From reviewing the Illuminance readings details in section 4.9.1 and 4.9.2, the difference in the non-match day and match day Illuminance readings are negligible. Based on these readings the stadium lighting has no impact in the areas of survey viewpoint location no's: 32 and 38 to 41. There is a slight increase in the non-match day 1.5m illuminance reading for survey viewpoint location no's: 39. From our experience using light meters, we have attributed this to the slight variation in weather conditions between the non-match day and match day surveys. As the survey was conducted after rain/shower, cars, buildings and ground surfaces held higher reflectance values due to them being wet/damp which increases the amount of light being reflected from the existing street lighting onto the light meter.

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4.9.1 Non-Match Day Illuminance Results

Table 4.17 is summary of the measured levels of Illuminance for Skerries Road for survey viewpoint location no's: 32 and 38 to 41 for a non-match day.

Table 4.17: Skerries Road Illuminance Results

Survey Viewpoint Location No	Measured at Ground Level (lux)	Measured at 1.5m Above Ground Level (lux)
32	19.8	46.9
38	1.5	1.4
39	14.8	32.2
40	3.1	2.4
41	3.6	3.6

4.9.2 Match Day Illuminance Results

Table 4.18 is summary of the measured levels of Illuminance for Skerries Road for survey viewpoint location no's: 32 and 38 to 41 for a match day.

Table 4.18: Skerries Road Illuminance Results

Survey Viewpoint Location No	Measured at Ground Level (lux)	Measured at 1.5m Above Ground Level (lux)
32	22	43
38	1.3	1
39	6.2	6.8
40	2.4	2
41	3.5	3.6

4.9.3 Site Survey Photo Comparison

Figure 4.20: Skerries Road with Stadium Lights Off

Source: Mott MacDonald Ltd.

Figure 4.21: Skerries Road with Stadium Lights On

Source: Mott MacDonald Ltd.

4.10 North West Car Park Survey Viewpoint Location No's: 33 - 37

North West Car Park runs parallel to Skerries Road and perpendicular to Anfield Road. The gardens to the rear of the properties on Skerries Road back on to the car park. There is lighting provided to the car park area in the form of floodlighting attached to the stadium orientated towards the rear of the properties on Skerries Road and tilted at approximately 70˚ from the horizontal. The existing building mounted floodlighting is shown on the photo in Figure 4.22.

The photo shown in Figure 4.23 shows the spill light from the North West Car Park lighting falling on the rear of the properties on Skerries Road.

From reviewing the Illuminance readings details in section 4.10.1 and 4.10.2, there is a significant increase of Illuminance during match day. The difference has been attributed to the North West Car Park lighting which is only operational during match days.

4.10.1 Non-Match Day Illuminance Results

We were unable to access the North West car park on the non-match day. The results shown in Table 4.19 have been assumed based on our on-site observations.

Table 4.19: North West Car Park Illuminance Results

Survey Viewpoint Location No	Measured at Ground Level (lux)	Measured at 1.5m Above Ground Level (lux)
33	<1	<1
34	<1	<1
35	<1	<1
36	<1	<1
37	<1	<1

4.10.2 Match Day Illuminance Results

Table 4.20 is summary of the measured levels of Illuminance for the North West Car Park for survey viewpoint location no's: 33 to 37 for a match day.

Table 4.20: North West Car Park Illuminance Results

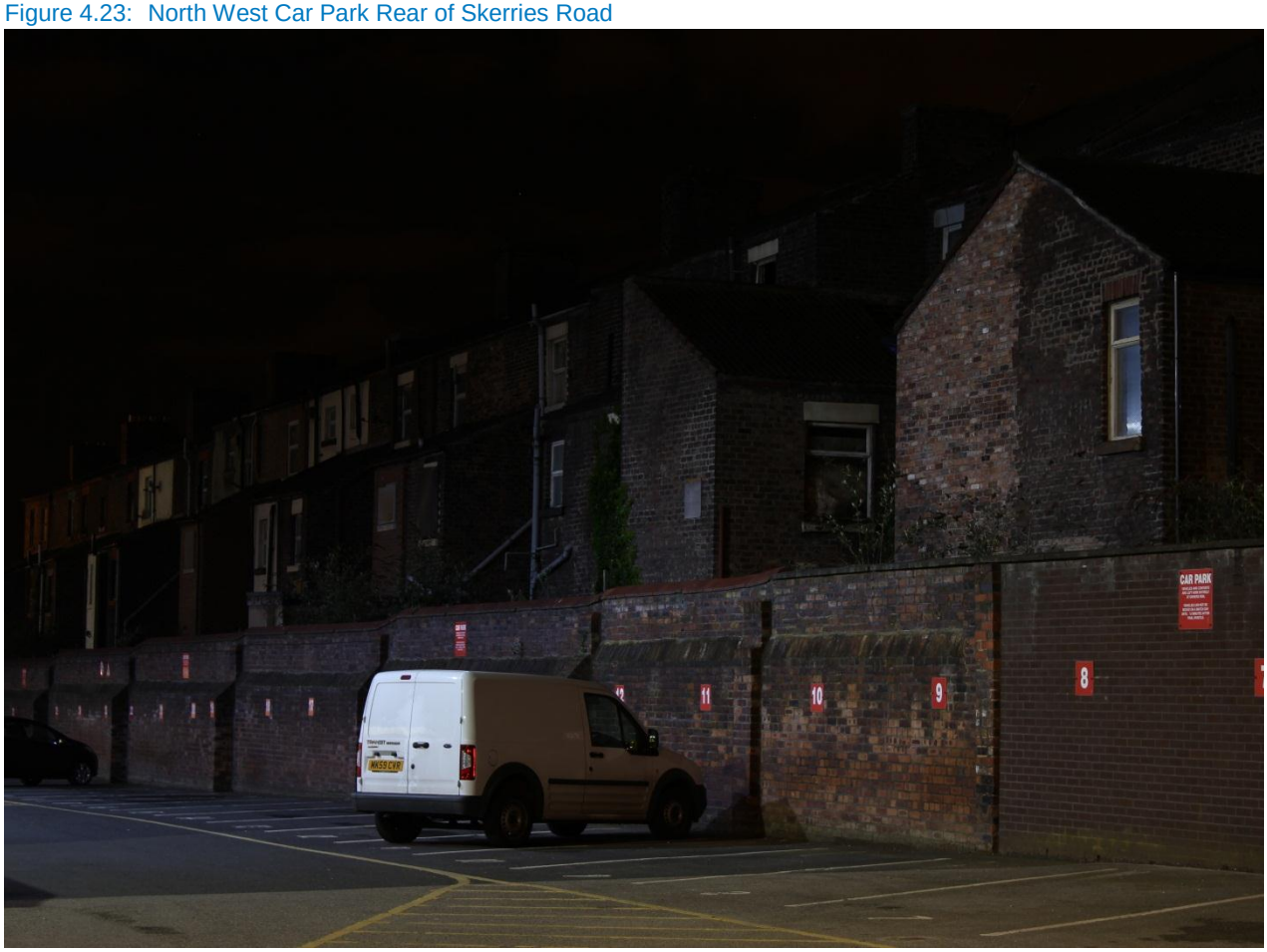
Survey Viewpoint Location No	Measured at Ground Level (lux)	Measured at 1.5m Above Ground Level (lux)
33	7.5	9.51
34	13.6	14.5
35	9.2	10.12
36	6.5	6.2
37	4.5	4.1

4.10.3 Site Survey Photo

Figure 4.22: North West Car Park with Stadium Lights On

Source: Mott MacDonald Ltd.

Figure 4.23: North West Car Park Rear of Skerries Road



Source: Mott MacDonald Ltd.

5 Proposed Development

5.1 Proposed Lighting Design

The following sub-section is a description of the proposals for external lighting around the stadium the architectural feature lighting and the (Phase1) proposals for new floodlighting the pitch. In this instance the exterior lighting for the car parks and the architectural feature lighting has been provided by iGuzzini and the stadium pitch lighting has been provided by Mott MacDonald.

5.1.1 Stadium Pitch Lighting

The Stadium pitch lighting has been designed to the Premier League Handbook 2014/15, summarised below:

- Maintained vertical illuminance of:

  An average of 1650 Lux and a minimum of 1000 lux when measured towards the principal camera on the Television Gantry

- An average of 1000 Lux and a minimum of 650 Lux at any one location on the pitch when measured towards the pitch level cameras on the 4 sides of the stadium.

- Uniformity of:

  U1 [min/max] > 0.50
  U2 [min/ave] > 0.6

- Calculation grid:
  Calculation of the illuminance values shall be undertaken on the pitch using a minimum of 96 measurement points in a grid format at 5m x 5m.

- Vertical illuminance calculation grids have been assumed to be at 1.5m above pitch level

Refer to the design memo issued by Richard Clibborn of Mott MacDonald within Appendix D.1.A for detailed information on the pitch flood lighting design.

For details of the luminaires, lamp, optical setting, arrangement, lamp output and overall maintenance factor utilised for the Stadium Pitch Lighting design refer to Appendix D.1.D, for summary information please refer to Table 5.1.

Table 5.1: Luminaire Schedule Stadium Pitch Floodlighting

Manufacturer & Model	Lamp/Optic	Quantity	Maintenance Factor
Philips Arena Vision	B2, B4, B6 & B8	180	1

Source: Mott MacDonald Ltd.

5.1.2 External Stadium Public Realm Lighting

The external stadium lighting has been designed in accordance with BS5489-1, BS EN12464-2 & CIBSE Guide LG6 to appropriate lighting levels for their intended use. See table 5.2 for details, as provided by iGuzzini on 09-05-2014.:

Table 5.2: iGuzzini External Stadium Lighting

Lit Area Descriptor	Lighting Standard/s	Average illuminance (Lux)	Uniformity (Uo)
Alroy Road & Gilman Street* (Roadway Surface)	BS5489-1, Table 5, Class S2	10	0.47
Front of Stadium Forecourt	CIBSE LG6 (1992), Section 4.1, Open Pavement	**19	**0.48
Side of Stadium Forecourt	CIBSE LG6 (1992), Section 4.1, Open Pavement	**25	**0.29
Entire Stadium Forecourt	CIBSE LG6 (1992), Section 4.1, Open Pavement	**22	**0.30
Car Park	BS EN12464-2, clause 5.9.3, Heavy Traffic	21	0.25
TV Parking Zone	BS EN12464-2, clause 5.9.3, Heavy Traffic	25	0.44

Source: iGuzzini

* S class lighting should be provided from highway boundary to highway boundary rather than for the roadway surface, this issue will be resolved at the next stage of the deign process.

** The calculations supplied are not sufficient to provide confirmation that the requirements of CIBSE LG6, Section 4.1 have been achieved in terms of horizontal and vertical illuminance at a height of 1.5m. Furthermore the uniformity requirement of greater than 0.3 has not been achieved. It is our recommendation that a standard in line with modern lighting practices should be used such as BS 5489-1:2013.

For details of the luminaires, lamp, optical setting, arrangement, lamp output and overall maintenance factor utilised for the External Stadium Public Realm Lighting design refer to Appendix D.3.B, for summary information please refer to table 5.3.

Table 5.3: Luminaire Schedule iGuzzini Exterior Lighting

Manufacturer & Model	Lamp/Optic	Quantity	Maintenance Factor
iGuzzini Frame Woody	39w LED BV13	108	1
iGuzzini Maxi Woody	39w LED BV13	56	1
iGuzzini WoW	89w LED BH38	7	1
iGuzzini WoW	128w LED BH39	19	1

Source: Mott MacDonald Ltd.

5.1.3 External Architectural Feature Lighting

The architectural feature lighting is not designed to meet any specific standards, rather to provide a night time feature with illumination levels that are proportionate to the site surroundings.

Refer to Appendix D.2.F for a schedule of architectural feature lighting utilised on this project.

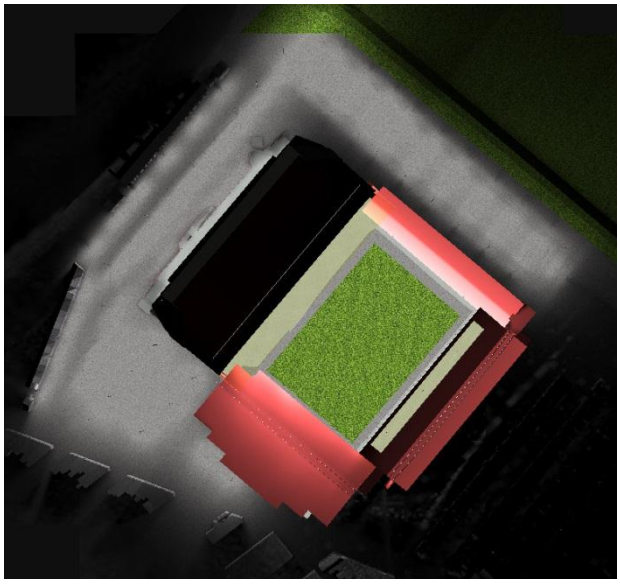
Table 5.1: architectural feature lighting summary table

Manufacturer & Model	Lamp/Optic	Quantity	Maintenance Factor
iGuzzini (A1) Linealuce	LED (Warm White)	28	1
iGuzzini (A2) Linealuce	LED (Neutral White)	59	1
iGuzzini (B1) Iroll	LED (Neutral White)	14	1
iGuzzini (C1) Strip Tube	LED (Warm White)	37	1
iGuzzini (D1) Maxi Woody	LED (Warm White)	22	1
iGuzzini (D2) Maxi Woody	LED (Warm White)	14	1
iGuzzini (E1) Maxi Woody	LED (Neutral White)	19	1
iGuzzini (E2) Maxi Woody	LED (Neutral White)	6	1

Source: Mott MacDonald Ltd.

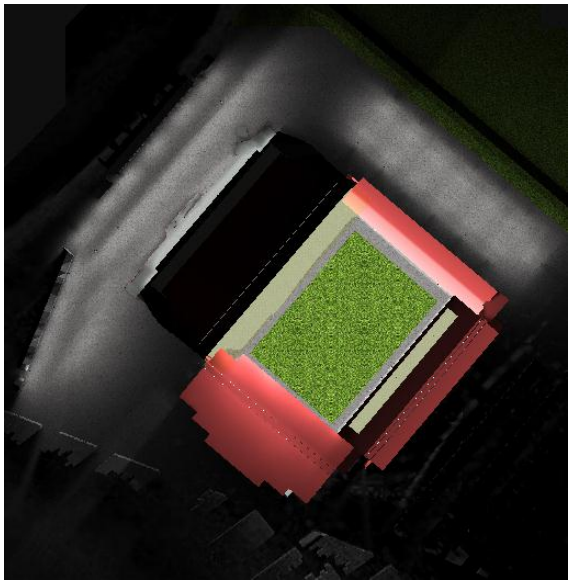
From the above information and the aide of the deign team and the architects model we were able to plot the proposed luminaires into AGi 32 lighting software package to create the model shown below for both scenarios pre and post curfew.

Figure 5.1: LFC Pre Curfew Ariel



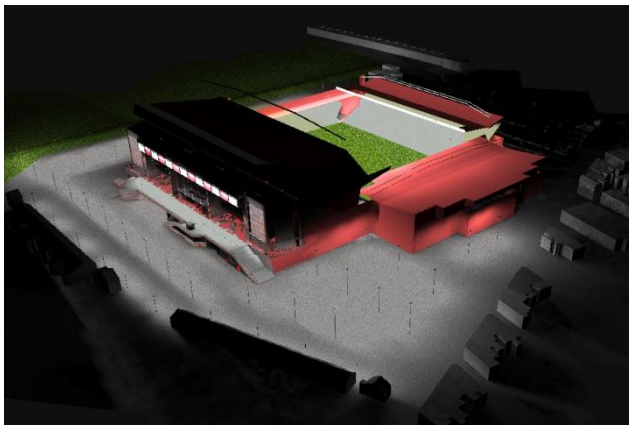
Source: Mott MacDonald

Figure 5.2: LFC Post Curfew Ariel



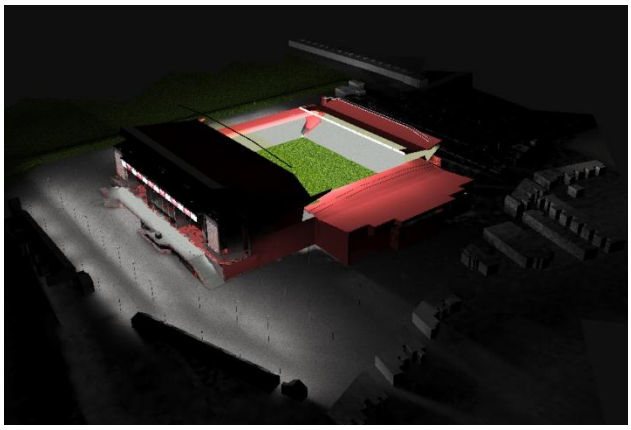
Source: Mott MacDonald

Figure 5.3: LFC Pre Curfew East



Source: Mott MacDonald

Figure 5.4: LFC Post Curfew East



Source: Mott MacDonald

Figure 5.5: LFC Pre Curfew North

Source: Mott MacDonald

Figure 5.6: LFC Post Curfew North

Source: Mott MacDonald

Figure 5.7: LFC Pre Curfew South

Source: Mott MacDonald

Figure 5.8: LFC Post Curfew South

Source: Mott MacDonald

Figure 5.9: LFC Pre Curfew West

Source: Mott MacDonald

Figure 5.10: LFC Post Curfew West

Source: Mott MacDonald

This then allows us to manipulate the the model to take readings at the same locations as the baseline case study (on site assessment) and compare the existing match day impact against the proposed impact created by the development.

6 Predicted Impacts - Obtrusive Light Assessment

This section of the report highlights four specific forms of obtrusive light that are to be assessed in detail.

The four forms of light pollution that are within the scope of this assessment are as follow:

- Sky Glow – (in terms of the Upward Light Ratio) the upward spill of light into the sky which can cause a glowing effect and is often seen above cities when viewed from a dark area;
- Light Intrusion – the spilling of light beyond the boundary of the area being lit. the unwanted spillage of light onto adjacent areas that may affect sensitive receptors, particularly residential properties;
- Luminaire Intensity – a measure of the amount of light that a source radiates in a given direction; and.
- Building Luminance – an indicator of how bright a surface will appear from a given observer position.

The obtrusive light limitations for an exterior lighting installation are dependent on the location of the site in terms of its environmental zone; the definitions of these zones are given within Appendix A – Guidance notes for the reduction of obtrusive light GN01:2011. For the purposes of this report the environmental zone has been assessed and assigned as E3, for further details of the environmental zone and the restriction that apply to that zone please refer to Section 2.

6.1 Maintenance Factor for Obtrusive Light calculations

To ensure that Obtrusive Light calculations cover the worst case scenario the maintenance factor has been set at 1.0, as required by ILP guidance notes.

6.2 Construction Phase Lighting Impact Assessment

During the construction phase the townscape character will be affected through the possible installation of temporary site lighting. Site lighting will either be provided for the purposes of health and safety or site security. The main causes for concern for the lighting used during construction will be spill light and glare (luminaire intensity).

Lighting for health and safety will be needed where work is required to take place during the hours of diminishing ambient lighting levels which is likely to occur if the construction works are carried out during the winter months or if night working is carried out. This form of lighting should become non-operational outside of the operational working hours of the construction site. The effects caused by this type of lighting are thought to be **minor adverse effects** due to the unlikelihood that this lighting will be operation for any lengthy period during the hours of darkness. The majority of residential properties within the area are located in areas of existing highway lighting.

Security lighting will be operational during the night with the location, levels of light and hours of operation being dependent on the individual security concerns of the construction site. Security lighting is normally concentrated towards the perimeter and entrances to the construction site. It is considered that due to the nature of construction that significant lighting for security will be required which is thought to have **moderate adverse effects**.

This element of the works will have a **moderate adverse effect** on the townscape character of this area, for the duration of the construction phase.

6.3 Obtrusive Light Assessment for Phase 1 Design (Full Planning Application)

6.3.1 Sky Glow - Upward Light Ratio (ULR)

Upward Light Ratio or ULR is the maximum permitted percentage of the luminaires flux that goes directly into the sky, the general term for ULR over a large area such as a city or town is referred to as Sky Glow. Please note that Upward Light Ratio is not subject to differing limits dependant on time and hence there are no pre and post curfew readings, as they are not required.

Table 6.1: ULR – ILP Guidance

Source of requirement	Maximum permissible ULR
ILP Guidance – Sky Glow (ULR) E3 Zone	ULR <= 5%

6.3.1.1 Sky Glow – Stadium Pitch Flood Lighting

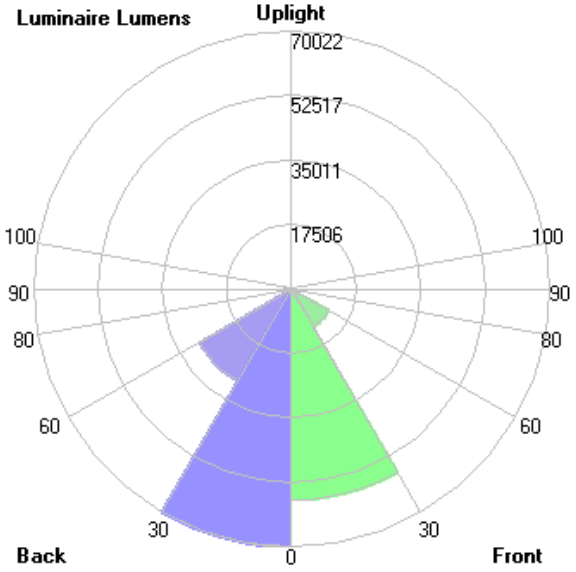
The luminaire utilised for the pitch flood lighting design has an upward light ratio of 0% when mounted at 0° tilt, as can be seen on the photometric distribution Table 6.2 and Luminaire classification system diagram figure 6.1.

Table 6.2: Photometric Distribution Table

LCS Zone	Lumens	%Lamp	%Lumens
FL (Forward Low) 0° to 30°	71920.6	32.7	40.1
FM (Forward Medium) 30° to 60°	7332.1	3.3	4.1
FH (Forward High) 60° to 80°	966.1	0.4	0.5
FVH (Forward Very High) 80° to 90°	164.3	0.1	0.1
BL (Back Low) 0° to 30°	76083.0	34.6	42.5
BM (Back Medium) 30° to 60°	21248.8	9.7	11.9
BH (Back High) 60° to 80°	1335.4	0.6	0.7
BVH (Back Very High) 80° to 90°	135.1	0.1	0.1
UL (Up Low) 90° to 100°	13.8	0.0	0.0
UH (Up High) 100° to 180°	11.0	0.0	0.0
Total	**179210.2**	**81.5**	**100**

Source: AGi 32 Lighting Software - Manufactures Data

Figure 6.1: Luminaire Classification System (LCS) for Philips Arena vision MVF404



Source: AGi 32 Lighting Software - Manufactures Data

For this analysis as the luminaires are mounted between a 0° tilt and a maximum tilt of 73.271° the ULR has been determined by comparing the upward light spill onto a horizontal plane just above the proposed stadium, with a calculated average pitch illuminance of 2376 lux:-

$$ULR = \frac{Ev_{(MaximumUpwardSpill)}}{Ev_{(AveragePitchIlluminance)}}$$

Table 6.3: calculation summary

Label	CalcType	Units	Results
Maximum Limit	Ratio	%	5%
Pitch_Horiz_0m	Illuminance	Lux	2376 Eav
Flood Light ULR	Illuminance	Lux	0
ULR Achieved	Ratio	%	0%

Source: Mott MacDonald Ltd.

Photometric data and lighting model analysis show a total ULR of 0% therefore the level of effect has been classified as **None / Negligible**.

6.3.1.2 Sky Glow – External Public Realm Lighting

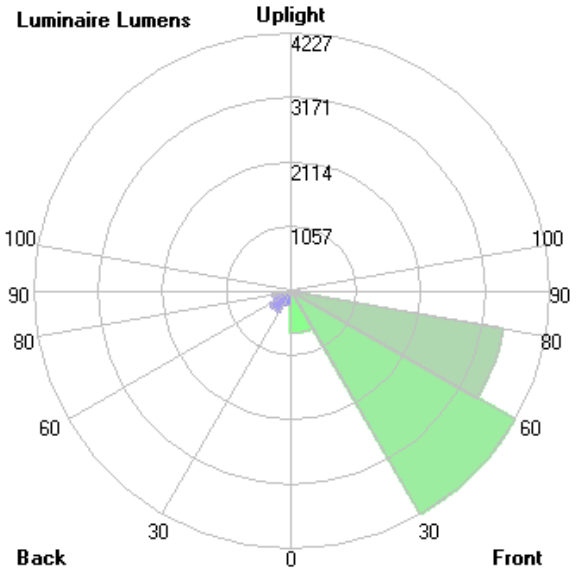
The luminaires utilised for the External Public Realm lighting design have an upward light ratio of 0% when mounted at 0° tilt, as can be seen on the photometric distribution Table 6.4 and luminaire classification system diagrams, this specifically applies to the iGuzzini Wow C1 & E1 type luminaires. (Refer to Appendix D.3.A for further design detail and luminaire information)

Table 6.4: Photometric Distribution Table

LCS Zone	Lumens	%Lamp	%Lumens
FL (Forward Low) 0° to 30°	697.9	N/A	7.3
FM (Forward Medium) 30° to 60°	4227.4	N/A	44.3
FH (Forward High) 60° to 80°	3525.6	N/A	36.9
FVH (Forward Very High) 80° to 90°	132.8	N/A	1.4
BL (Back Low) 0° to 30°	237.8	N/A	2.5
BM (Back Medium) 30° to 60°	403.7	N/A	4.2
BH (Back High) 60° to 80°	298.3	N/A	3.1
BVH (Back Very High) 80° to 90°	26.6	N/A	0.3
UL (Up Low) 90° to 100°	0.0	N/A	0.0
UH (Up High) 100° to 180°	0.0	N/A	0.0
Total	**9550.1**	**N/A**	**100**

Source: AGi 32 Lighting Software - Manufactures Data

Figure 6.2: Luminaire Classification System (LCS) for iGuzzini WOW



Source: AGi 32 Lighting Software - Manufactures Data

Luminaire reference A1, the iGuzzini Frame Woody was not available within the AGi32 lighting software therefore confirmation was requested from the manufacturer of the ULR at a 20^0 tilt, see following confirmation details:

BV13 (TYPE A1) angled by 20 degrees = **ULR 5.46%***

Luminaire reference D1, the iGuzzini Wow was not available within the AGi32 lighting software therefore confirmation was requested from the manufacturer of the ULR at a 10^0 tilt, see following confirmation details:

BH38 (TYPE D1) angled by 10 degrees = **ULR 0.3%***

* Refer to Appendix H.1 for a copy of iGuzzini ULR confirmation e-mail.

Photometric data and lighting model analysis shows that one luminaire arrangement within the external public realm lighting has a total ULR of 5.46%, therefore the level of effect has been classified as **Minor Adverse effect**.

6.3.1.3 Sky Glow – External Architectural Feature Lighting

This element of the external lighting installation will require the deliberate and careful use of upward light, for example ground recessed luminaires, wall wash type luminaires and ground mounted floodlights. In these cases the limits for upward light do not apply, however care should be taken to minimise any wasted

upward light by proper use of suitably directional luminaires, correct beam angles and lighting controlling attachments such as louvers, barn doors etc. refer to Appendix A for suitable examples.

6.3.2 Light Intrusion (onto windows)

This section of the report checks the Light Intrusion onto windows of properties in the affected areas. The spilling of light beyond the boundary of the area being lit onto adjacent areas may affect sensitive receptors, particularly residential properties. The 3D model has been constructed with ALL proposed luminaires in the design positions provided to ensure that the results provided are realistic and accurate. All maintenance factors have been set a 1.0 to allow for the worst case scenario of initial first day installation.

Table 6.5: Summary of Light Intrusion (onto windows)

Source of requirement	Pre Curfew Maximum Permissible Lux	Post Curfew Maximum Permissible Lux
ILP Guidance – Light Intrusion E3 Zone and LCC requirements	6	2

Source: ILP / LCC

Although the ILP recommends a maximum pre curfew limit of 10 Lux onto windows, it has been requested by LCC that this figure should be reduced to a maximum of 6 lux. The maximum post curfew limit set by the ILP of 2 Lux will apply.

It has been confirmed by LCC that 23:00hrs is the curfew time, after which the more stringent requirements for control of obtrusive light, highlighted in table 6.5, will apply.

Please refer to the Spill Light Contour Plans, drawing numbers 317415-EIA-003 & 317415-EIA-004 within Appendix I.1 & I.2, these plans provide a general overview of the spill light contours associated with this proposed development.

6.3.2.1 Pre Curfew Light Intrusion – Survey Viewpoint Locations

Please refer to table 6.6 for a full list of the modelled light intrusion readings at all 41 survey viewpoint locations, for further information relating to the location of the survey viewpoint locations please refer to drawing numbers 317415-EIA-001 & 317415-EIA-002 within Appendix B.1 & B.2.

Table 6.6: Pre Curfew Light Intrusion

Illuminance Grid Location	Calculation Type	Units	Pre Curfew Max
Survey Viewpoint Location_01	Illuminance	Lux	0
Survey Viewpoint	Illuminance	Lux	0

Illuminance Grid Location	Calculation Type	Units	Pre Curfew Max
Location_02			
Survey Viewpoint Location_03	Illuminance	Lux	0.1
Survey Viewpoint Location_04	Illuminance	Lux	0.4
Survey Viewpoint Location_05	Illuminance	Lux	4.5
Survey Viewpoint Location_06	Illuminance	Lux	3.8
Survey Viewpoint Location_07	Illuminance	Lux	3.5
Survey Viewpoint Location_08	Illuminance	Lux	4.6
Survey Viewpoint Location_09	Illuminance	Lux	4.2
Survey Viewpoint Location_10	Illuminance	Lux	4.6
Survey Viewpoint Location_11	Illuminance	Lux	3.4
Survey Viewpoint Location_12	Illuminance	Lux	0.5
Survey Viewpoint Location_13	Illuminance	Lux	0.2
Survey Viewpoint Location_14	Illuminance	Lux	25.4
Survey Viewpoint Location_15	Illuminance	Lux	18.1
Survey Viewpoint Location_16	Illuminance	Lux	23.8
Survey Viewpoint Location_17	Illuminance	Lux	0.1
Survey Viewpoint Location_18	Illuminance	Lux	0
Survey Viewpoint Location_19	Illuminance	Lux	0
Survey Viewpoint Location_20	Illuminance	Lux	0
Survey Viewpoint Location_21	Illuminance	Lux	0
Survey Viewpoint Location_22	Illuminance	Lux	0
Survey Viewpoint Location_23	Illuminance	Lux	0
Survey Viewpoint Location_24	Illuminance	Lux	12.5
Survey Viewpoint Location_25	Illuminance	Lux	0.2

Illuminance Grid Location	Calculation Type	Units	Pre Curfew Max
Survey Viewpoint Location_26	Illuminance	Lux	0.3
Survey Viewpoint Location_27	Illuminance	Lux	0.4
Survey Viewpoint Location_28	Illuminance	Lux	3.3
Survey Viewpoint Location_29	Illuminance	Lux	0.9
Survey Viewpoint Location_30	Illuminance	Lux	1.6
Survey Viewpoint Location_31	Illuminance	Lux	0.1
Survey Viewpoint Location_32	Illuminance	Lux	0
Survey Viewpoint Location_33	Illuminance	Lux	0
Survey Viewpoint Location_34	Illuminance	Lux	0
Survey Viewpoint Location_35	Illuminance	Lux	0
Survey Viewpoint Location_36	Illuminance	Lux	0
Survey Viewpoint Location_37	Illuminance	Lux	0
Survey Viewpoint Location_38	Illuminance	Lux	0
Survey Viewpoint Location_39	Illuminance	Lux	0
Survey Viewpoint Location_40	Illuminance	Lux	0
Survey Viewpoint Location_41	Illuminance	Lux	0

Source: Mott MacDonald Ltd.

3D Lighting model analysis shows that all three locations on Gilman Street are over the ILP limits for a pre curfew light intrusion, by a significant margin therefore the level of effect has been classified as **Major Adverse.**

Note: Properties in Gilman Street are now vacant and are intended for clearance in the 3rd quarter of 2014 to make way for proposed development in line with the Anfield SRF.

3D Lighting model analysis shows that one location on Alroy Road is over the ILP limits for a pre curfew light intrusion, by a significant margin therefore the level of effect has been classified as **Moderate Adverse.**

6.3.2.2 Pre Curfew Light Intrusion – Light Intrusion onto Windows

Table 6.7: Pre-Curfew Light Intrusion onto windows

Illuminance Grid Location	Calculation Type	Units	Pre Curfew Max
House number 150 to 160 Walton Breck Road	Obtrusive Light	Lux	10.7
House number 162 - 170 Walton Breck Road	Obtrusive Light	Lux	13.3
House number 172 - 182 Walton Breck Road	Obtrusive Light	Lux	12.7
House number 194 Walton Breck Road	Obtrusive Light	Lux	12.1
House number 208 - 220 Walton Breck Road	Obtrusive Light	Lux	0.2
House number 45 Anfield Road South East 01	Obtrusive Light	Lux	1.6
House number 45 Anfield Road South West 02	Obtrusive Light	Lux	2.4
House number 45 Anfield Road South West 01	Obtrusive Light	Lux	0.1
House number 53 Rockfield Road	Obtrusive Light	Lux	5
No. 2 to No. 24 Alroy Road	Obtrusive Light	Lux	1.9
Christ Church Walton Breck Road	Obtrusive Light	Lux	0
No. 1 to No. 39 Gilman Street Calculation Grid 1	Obtrusive Light	Lux	35.2
North West Car Park – Rear of Residential Properties	Obtrusive Light	Lux	0.0
Skerries Road - Residential Front face of Residential Properties	Obtrusive Light	Lux	0.0

Source: Mott MacDonald Ltd

3D Lighting model analysis shows that the following properties on Walton Breck Road suffer from light intrusion onto windows that exceed LCC pre curfew requirements of 6 lux; these are house numbers 159, 160, 162, 164, 166, 168, 170, 172, 174, 176 & 178. The properties are a mix of residential and commercial with the majority of residential sections on the top floor, to ensure that we cover the worst case all of these properties have been classified as residential, the level of effect has been classified as **Major Adverse.**

Whilst 194 Walton Breck Road has a maximum light intrusion level of 12.1 lux this light spill level does not encroach on any windows and as such has been classified as **None/Negligible.**

3D Lighting model analysis shows that the following properties on Gilman Street suffer from light intrusion onto windows that exceed LCC pre curfew requirements of 6 lux; these are house numbers 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 29, 31, 33, 35, & 37. The properties are residential in nature and the level of effect has been classified as **Major Adverse.**

Note: Properties in Gilman Street are now vacant and are intended for clearance in the 3rd quarter of 2014 to make way for proposed development in line with the Anfield SRF.

6.3.2.3 Post Curfew Light Intrusion – Survey Viewport Locations

Please refer to table 6.8 for a full list of the modelled light intrusion readings at all 41 survey viewpoint locations, for further information relating to the location of the survey viewpoint locations please refer to drawing numbers 317415-EIA-001 & 317415-EIA-002 within Appendix B1 & B2.

Table 6.8: Post Curfew Light Intrusion

Illuminance Grid Location	Calculation Type	Units	Post Curfew Max
Survey Viewpoint Location_01	Illuminance	Lux	0
Survey Viewpoint Location_02	Illuminance	Lux	0
Survey Viewpoint Location_03	Illuminance	Lux	0
Survey Viewpoint Location_04	Illuminance	Lux	0
Survey Viewpoint Location_05	Illuminance	Lux	0
Survey Viewpoint Location_06	Illuminance	Lux	0.1
Survey Viewpoint Location_07	Illuminance	Lux	0.2
Survey Viewpoint Location_08	Illuminance	Lux	0.8
Survey Viewpoint Location_09	Illuminance	Lux	0.7
Survey Viewpoint Location_10	Illuminance	Lux	1.3
Survey Viewpoint Location_11	Illuminance	Lux	1.9
Survey Viewpoint Location_12	Illuminance	Lux	0
Survey Viewpoint Location_13	Illuminance	Lux	0
Survey Viewpoint Location_14	Illuminance	Lux	24
Survey Viewpoint Location_15	Illuminance	Lux	17.1
Survey Viewpoint Location_16	Illuminance	Lux	23.5
Survey Viewpoint Location_17	Illuminance	Lux	0
Survey Viewpoint Location_18	Illuminance	Lux	0
Survey Viewpoint Location_19	Illuminance	Lux	0
Survey Viewpoint Location_20	Illuminance	Lux	0
Survey Viewpoint Location_21	Illuminance	Lux	0
Survey Viewpoint Location_22	Illuminance	Lux	0
Survey Viewpoint Location_23	Illuminance	Lux	0
Survey Viewpoint Location_24	Illuminance	Lux	11.7
Survey Viewpoint Location_25	Illuminance	Lux	0
Survey Viewpoint Location_26	Illuminance	Lux	0
Survey Viewpoint Location_27	Illuminance	Lux	0
Survey Viewpoint Location_28	Illuminance	Lux	0.1
Survey Viewpoint Location_29	Illuminance	Lux	0.9
Survey Viewpoint Location_30	Illuminance	Lux	1.6
Survey Viewpoint Location_31	Illuminance	Lux	0.1
Survey Viewpoint Location_32	Illuminance	Lux	0
Survey Viewpoint Location_33	Illuminance	Lux	0

Illuminance Grid Location	Calculation Type	Units	Post Curfew Max
Survey Viewpoint Location_34	Illuminance	Lux	0
Survey Viewpoint Location_35	Illuminance	Lux	0
Survey Viewpoint Location_36	Illuminance	Lux	0
Survey Viewpoint Location_37	Illuminance	Lux	0
Survey Viewpoint Location_38	Illuminance	Lux	0
Survey Viewpoint Location_39	Illuminance	Lux	0
Survey Viewpoint Location_40	Illuminance	Lux	0
Survey Viewpoint Location_41	Illuminance	Lux	0

Source: Mott MacDonald Ltd.

3D Lighting model analysis shows that all three locations on Gilman Street are over the ILP limits for a post curfew light intrusion, by a significant margin therefore the level of effect has been classified as **Major Adverse.**

Note: Properties in Gilman Street are now vacant and are intended for clearance in the 3rd quarter of 2014 to make way for proposed development in line with the Anfield SRF.

3D Lighting model analysis shows that one location on Alroy Road is over the ILP limits for a post curfew light intrusion, by a significant margin therefore the level of effect has been classified as **Moderate Adverse.**

6.3.2.4 Post Curfew Light Intrusion – Light Intrusion onto Windows

Table 6.9: Post Curfew Light Intrusion onto windows

Illuminance Grid Location	Calculation Type	Units	Post Curfew Max
House number 150 to 160 Walton Breck Road	Obtrusive Light	Lux	7.4
162 - 170 Walton Breck Road	Obtrusive Light	Lux	6.2
172 - 182 Walton Breck Road	Obtrusive Light	Lux	4.3
194 Walton Breck Road	Obtrusive Light	Lux	0.4
208 - 220 Walton Breck Road	Obtrusive Light	Lux	0.0
45 Anfield Road South East 01	Obtrusive Light	Lux	1.0
45 Anfield Road South East 02	Obtrusive Light	Lux	1.8
45 Anfield Road South West 01	Obtrusive Light	Lux	0.0
53 Rockfield Road	Obtrusive Light	Lux	4.8
Alroy Road	Obtrusive Light	Lux	1.8
Christ Church Walton Breck Road	Obtrusive Light	Lux	0.0
Gilman Street Calculation Grid 1	Obtrusive Light	Lux	33.5
North West Car Park – Rear of Residential Properties	Obtrusive Light	Lux	0.1
Skerries Road - Front face of Residential Properties	Obtrusive Light	Lux	0.1

Source: Mott MacDonald Ltd

3D Lighting model analysis shows that the following properties on Walton Breck Road suffer from light intrusion onto windows, the level of lighting intrusion exceeds the 2 Lux post curfew limit agreed by LCC; the house numbers are 154, 156, 158, 159, 160, 162, 164, 166, 168, 170, 172 & 174. The property has been classified as residential and the level of effect has been classified as **Moderate Adverse.**

3D Lighting model analysis shows that the following property on Rockfield Road suffer from light intrusion onto windows, house number 53 is residential and the effect has been classified as **Moderate Adverse.**

3D Lighting model analysis shows that the following properties on Gilman Street suffer from light intrusion onto windows that exceed LCC agreed post curfew requirement of 2 lux; these are house numbers 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31, 33, 35 & 37 . The properties are residential in nature with the level of effect classified as **Moderate Adverse.**

Note: Properties in Gilman Street are now vacant and are intended for clearance in the 3rd quarter of 2014 to make way for proposed development in line with the Anfield SRF.

6.3.3 Luminous Intensity

Luminous intensity is a direct calculation, measured in Candelas, from an observer location at a given height looking at the luminaire. It is standard practice for an observer height to be 1.5m above ground level and we have followed this practice.

It has been confirmed by LCC that 23:00hrs is the curfew time, after which the more stringent requirements for control of luminous intensity apply.

Table 6.10: Luminous Intensity Requirements – ILP Guidance

Source of requirement	Maximum permissible Pre Curfew	Maximum permissible Post Curfew
ILP Guidance – Luminous Intensity E3 Zone	10,000 cd	1,000 cd

Source: ILP / LCC

Luminous Intensity has been calculated for both Pre-Curfew hours (before 23:00) and Post curfew hours (after 23:00) for the entire site.

The following table shows the Proposed Luminaire Intensity Results calculated using manufacturer's data and AGI32 lighting software; Please refer to table 6.6 for a full list of the modelled light intrusion readings at all 41 survey viewpoint locations, for further information relating to the location of the survey viewpoint locations please refer to drawing numbers 317415-EIA-001 & 002 within Appendix B1 & B2.

6.3.3.1 Pre Curfew Results

Table 6.11: Proposed Luminous Intensity Results Pre-Curfew

Illuminance Grid Location	Calculation Type	Units	Pre Curfew Max
Survey Viewpoint Location_01	Luminance	cd/m²	1101
Survey Viewpoint Location_02	Luminance	cd/m²	1138
Survey Viewpoint Location_03	Luminance	cd/m²	1183
Survey Viewpoint Location_04	Luminance	cd/m²	1640
Survey Viewpoint Location_05	Luminance	cd/m²	1859
Survey Viewpoint Location_06	Luminance	cd/m²	2024
Survey Viewpoint Location_07	Luminance	cd/m²	2020
Survey Viewpoint Location_08	Luminance	cd/m²	15221
Survey Viewpoint Location_09	Luminance	cd/m²	2097
Survey Viewpoint Location_10	Luminance	cd/m²	2094
Survey Viewpoint Location_11	Luminance	cd/m²	2610
Survey Viewpoint Location_12	Luminance	cd/m²	2000
Survey Viewpoint Location_13	Luminance	cd/m²	1890
Survey Viewpoint Location_14	Luminance	cd/m²	2260
Survey Viewpoint Location_15	Luminance	cd/m²	2239
Survey Viewpoint Location_16	Luminance	cd/m²	1579
Survey Viewpoint Location_17	Luminance	cd/m²	1179
Survey Viewpoint Location_18	Luminance	cd/m²	112
Survey Viewpoint Location_19	Luminance	cd/m²	41
Survey Viewpoint Location_20	Luminance	cd/m²	1511
Survey Viewpoint Location_21	Luminance	cd/m²	1022
Survey Viewpoint Location_22	Luminance	cd/m²	943
Survey Viewpoint Location_23	Luminance	cd/m²	945
Survey Viewpoint Location_24	Luminance	cd/m²	1464
Survey Viewpoint Location_25	Luminance	cd/m²	8
Survey Viewpoint Location_26	Luminance	cd/m²	592
Survey Viewpoint Location_27	Luminance	cd/m²	832
Survey Viewpoint Location_28	Luminance	cd/m²	21686
Survey Viewpoint Location_29	Luminance	cd/m²	21094
Survey Viewpoint Location_30	Luminance	cd/m²	18076
Survey Viewpoint Location_31	Luminance	cd/m²	26204
Survey Viewpoint Location_32	Luminance	cd/m²	1165
Survey Viewpoint Location_33	Luminance	cd/m²	370
Survey Viewpoint Location_34	Luminance	cd/m²	327
Survey Viewpoint Location_35	Luminance	cd/m²	98
Survey Viewpoint Location_36	Luminance	cd/m²	63

Illuminance Grid Location	Calculation Type	Units	Pre Curfew Max
Survey Viewpoint Location_37	Luminance	cd/m²	34
Survey Viewpoint Location_38	Luminance	cd/m²	19
Survey Viewpoint Location_39	Luminance	cd/m²	0
Survey Viewpoint Location_40	Luminance	cd/m²	0
Survey Viewpoint Location_41	Luminance	cd/m²	0

Source: Mott MacDonald Ltd.

3D Lighting model analysis shows that one location on Walton Breck Road is over the ILP limit for a pre curfew luminous intensity, by a significant margin therefore the level of effect has been classified as **Minor Adverse.**

There are 3 locations within Stanley Park which is over the ILP limit for a pre curfew luminous intensity, by a significant margin therefore the level of effect has been classified as **Moderate Adverse.**

There is 1 location on Anfield road over the ILP limit for a pre curfew luminous intensity, by a significant margin therefore the level of effect has been classified as **Moderate Adverse.**

6.3.3.2 Post Curfew Results

Table 6.12: Proposed Luminous Intensity Results Post-Curfew

Illuminance Grid Location	Calculation Type	Units	Post Curfew Max
Survey Viewpoint Location_01	Luminance	cd/m²	262
Survey Viewpoint Location_02	Luminance	cd/m²	270
Survey Viewpoint Location_03	Luminance	cd/m²	292
Survey Viewpoint Location_04	Luminance	cd/m²	337
Survey Viewpoint Location_05	Luminance	cd/m²	418
Survey Viewpoint Location_06	Luminance	cd/m²	1032
Survey Viewpoint Location_07	Luminance	cd/m²	1147
Survey Viewpoint Location_08	Luminance	cd/m²	15211
Survey Viewpoint Location_09	Luminance	cd/m²	1553
Survey Viewpoint Location_10	Luminance	cd/m²	2050
Survey Viewpoint Location_11	Luminance	cd/m²	2607
Survey Viewpoint Location_12	Luminance	cd/m²	499
Survey Viewpoint Location_13	Luminance	cd/m²	217
Survey Viewpoint Location_14	Luminance	cd/m²	2255
Survey Viewpoint Location_15	Luminance	cd/m²	2236
Survey Viewpoint Location_16	Luminance	cd/m²	1578
Survey Viewpoint Location_17	Luminance	cd/m²	220
Survey Viewpoint Location_18	Luminance	cd/m²	112
Survey Viewpoint Location_19	Luminance	cd/m²	41

Illuminance Grid Location	Calculation Type	Units	Post Curfew Max
Survey Viewpoint Location_20	Luminance	cd/m²	1511
Survey Viewpoint Location_21	Luminance	cd/m²	553
Survey Viewpoint Location_22	Luminance	cd/m²	568
Survey Viewpoint Location_23	Luminance	cd/m²	773
Survey Viewpoint Location_24	Luminance	cd/m²	525
Survey Viewpoint Location_25	Luminance	cd/m²	8
Survey Viewpoint Location_26	Luminance	cd/m²	40
Survey Viewpoint Location_27	Luminance	cd/m²	77
Survey Viewpoint Location_28	Luminance	cd/m²	21685
Survey Viewpoint Location_29	Luminance	cd/m²	21086
Survey Viewpoint Location_30	Luminance	cd/m²	18076
Survey Viewpoint Location_31	Luminance	cd/m²	26204
Survey Viewpoint Location_32	Luminance	cd/m²	1165
Survey Viewpoint Location_33	Luminance	cd/m²	370
Survey Viewpoint Location_34	Luminance	cd/m²	327
Survey Viewpoint Location_35	Luminance	cd/m²	98
Survey Viewpoint Location_36	Luminance	cd/m²	63
Survey Viewpoint Location_37	Luminance	cd/m²	34
Survey Viewpoint Location_38	Luminance	cd/m²	19
Survey Viewpoint Location_39	Luminance	cd/m²	0
Survey Viewpoint Location_40	Luminance	cd/m²	0
Survey Viewpoint Location_41	Luminance	cd/m²	0

Source: Mott MacDonald Ltd.

As you can see from table 6.12, survey viewpoint location no's: 6 to 11, 14 to 16, 20 and 28 to 32 all show calculations results above the required maximum advised by the ILP.

3D Lighting model analysis shows that there are six locations on Walton Breck Road is over the ILP limits for a post curfew luminous intensity, by a significant margin therefore the level of effect has been classified as **Moderate/Major Adverse.**

There are three locations on Gilman Street over the ILP limits for a post curfew luminous intensity, by a significant margin therefore the level of effect has been classified as **Minor Adverse.**

Note: Properties in Gilman Street are now vacant and are intended for clearance in the 3rd quarter of 2014 to make way for proposed development in line with the Anfield SRF.

There is one location on Alroy Road that is over the ILP limit for a post curfew luminous intensity, by a significant margin therefore the level of effect has been classified as **Minor Adverse.**

There are three locations in Stanley Park that are over the ILP limit for a post curfew luminous intensity, by a significant margin therefore the level of effect has been classified as **Moderate Adverse.**

There is 1 location on Anfield Road over the ILP limit for a post curfew luminous intensity, by a significant margin therefore the level of effect has been classified as **Minor Adverse.**

There is 1 location on Skerries Road over the ILP limit for a post curfew luminous intensity, by a significant margin therefore the level of effect has been classified as **Minor Adverse.**

6.3.4 Building Luminance

Table 6.13: Building Luminance – ILP Guidance

Source of requirement	Maximum Permissible Average Building Luminance
ILP Guidance – Building Luminance - E3 Zone	Average Luminance (cd/m2) = 10

Building luminance should be limited to avoid over lighting, it should also be related to the general districts brightness. The limit suggested by the ILP and provided within table 6.13 is applicable to LFC main stand as the stand is lit as a night time feature.

The luminance results, as provided by SKM within Appendix D.2.D, confirm that the Main Stand frontage luminance is well under the 10 cd/m^2 average luminance limit set by the ILP.

Lighting model analysis therefore shows the Main Stand frontage luminance is well under the 10 cd/m^2 average luminance limit set by the ILP therefore the level of effect has been classified as **None / Negligible**.

6.4 Obtrusive Light Recommendations for Phase 2 (Outline Planning Application)

The following section will establish the conditions and limitation of lighting required for Phase 2 which will be used for the outline planning application. Our guidance recommends that this section lays out the requirements for the lighting of the Phase 2 design and will establish;

- Relevant Documents / Standards;
- General levels of light;
- Lighting limitations.

As described in section 3.2.2 and confirmed by LCC it is accepted that the environmental zone of E3 is continued to be used for the phase 2 of the development and therefore recommended that the proposed lighting designs for Phase 2 are within the following parameters based on this zone:

6.4.1 Relevant Documents / Standards

The following documents and standards should be considered in the design and specification of Phase 2:

- BS 5489-1:2013 Code of practice for the design of road lighting. Part 1: Lighting of roads and public amenity areas.
- BS EN 13201-1:2004 Road Lighting Part 1 Selection of Lighting Classes
- BS EN 13201-2:2003 Road Lighting Part 2 Performance Requirements.
- BS EN 13201-3:2003 Road Lighting Part 3 Calculation of Performance.
- BS EN 12464-2:2007 Lighting of Work Places Part 2 (Outdoor Work Places).
- Institution of Lighting Professionals (ILP) Guidance Notes for the Reduction of Obtrusive Light GN01:2011.
- BS 12193:2007 Light and Lighting – Sports Lighting.
- The Society of Light and Lighting Code for Lighting.
- Premier League Handbook 2014/15.

6.4.2 General Levels of Light

The design of the stadium pitch lighting should be carried out in accordance with the Premier League Handbook 2014/15 and has been summarised in section 5.1.1. Lighting level requirements for the public realm lighting are shown in Table 6.14 which are based on our current understanding of the proposals.

Liaison with LCC should be carried out to negotiate the possibility of LCC adopting the lighting on Alroy Road and Gilman Street and as such an agreed lighting class will need to be established. The lighting levels shown in Table 6.14 are estimated based on our lighting experience.

Table 6.14: Required Lighting Levels

Lit Area Descriptor	Lighting Standard/s	Required	Required	Required
		Average illuminance (Lux)	Minimum illuminance (Lux)	Uniformity (Uo)
Alroy Road & Gilman Street*	BS5489-1:2013, Table A.5, Class S2	7.5**	1.5**	See ***
Front of Stadium Forecourt	BS5489-1:2013, Table A.8, Class CE2	20	N/A	0.40
Side of Stadium Forecourt	C BS5489-1:2013, Table A.8, Class CE2	20	N/A	0.40
Entire Stadium Forecourt	BS5489-1:2013, Table A.8, Class CE2	20	N/A	0.40
Car Park	BS EN12464-2:2007, clause 5.9.3, Heavy Traffic	20	N/A	0.25
TV Parking Zone	BS EN12464-2:2007, clause 5.9.3, Heavy	20	N/A	0.25

Lit Area Descriptor	Lighting Standard/s	Required	Required	Required
	Traffic			

Source: Mott MacDonald Ltd.

* S class lighting should be provided from highway boundary to highway boundary rather than for the roadway surface.

** Required lighting levels should be adjusted to account for S/P ratio of light source.

*** Uniformity should be as high as reasonably practicable and as such the average illuminance value should not be exceed by any more than 1.5 times the specified value.

6.4.3 Lighting Pollution Limitations

The following limitations have been determined from the Institution of Lighting Professionals (ILP) Guidance Notes for the Reduction of Obtrusive Light GN01:2011 based on an agreed Environmental Zone of E3.

6.4.3.1 Sky Glow - Upward Light Ratio (ULR)

We recommend that the maximum permissible ULR should be less than 5%.

Table 6.15: Summary of ULR Requirements

Source of requirement	Maximum permissible ULR
ILP Guidance - Sky Glow (ULR) E3 Zone	ULR <=5%

Source: ILP

6.4.3.2 Light Intrusion (onto windows)

Although the ILP recommends a maximum pre curfew limit of 10 Lux onto windows, it has been requested by LCC that this figure should be reduced to a maximum of 6 lux. The maximum post curfew limit set by the ILP of 2 Lux will apply.

It has been confirmed by LCC that 23:00hrs is the curfew time, after which the more stringent requirements for control of obtrusive light, highlighted in table 6.16, will apply.

Table 6.16: Summary of Light Intrusion (onto windows)

Source of requirement	Pre Curfew Maximum Permissible Lux	Post Curfew Maximum Permissible Lux
ILP Guidance – Light Intrusion E3 Zone and LCC requirements	6	2

Source: ILP / LCC

6.4.3.3 Luminaire Intensity

We recommend that the requirements for luminaire intensity are 10,000 Candelas pre curfew and 1,000 Candelas post curfew.

It has been confirmed by LCC that 23:00hrs is the curfew time, after which the more stringent requirements for control of obtrusive light, highlighted in table 6.17, will apply.

Table 6.17: Summary of Luminaire Intensity

Source of requirement	Pre Curfew Maximum Candelas	Post Curfew Maximum Candelas
ILP Guidance – Luminaire Intensity E3 Zone	10,000	1,000

Source: ILP

6.4.3.4 Building Luminance

We recommend that building lighting that is specifically provided to light the building as a feature is designed to mitigate the following:

- Over Lighting in relation to the general district brightness,
- Down-lighters are utilised where possible and where uplighter's are utilised the light does not spill over the top of the building face,
- Shields and baffles are used to reduce any glare from the luminaire, and
- Luminaires are hidden behind facades where practicable.

The average building luminance should be limited to 10 cd/m².

Table 6.18: Summary of Building Luminance

Source of requirement	Average Building Luminance in cd/m²
ILP Guidance – Luminaire Intensity E3	10

Source: ILP

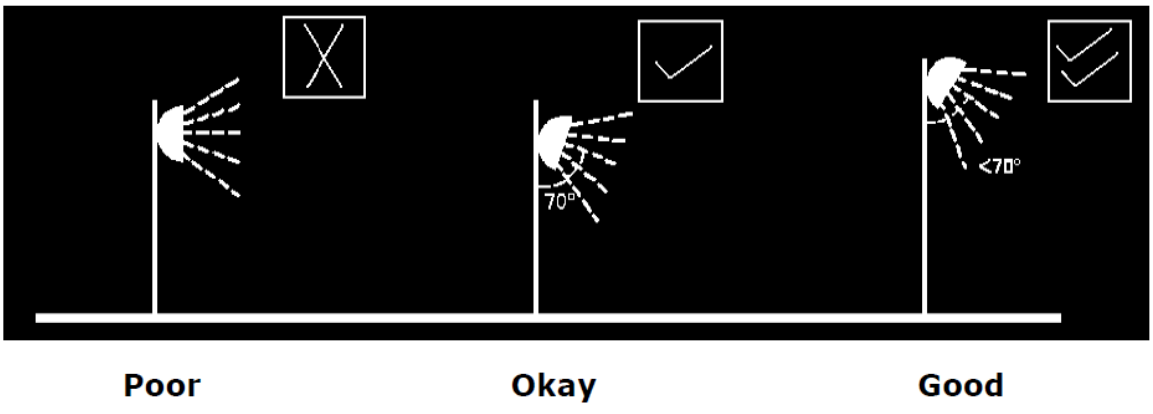
7 Potential Mitigation

7.1 Construction Phase Mitigation

To minimise the effects of lighting provided for construction phase, the following mitigation methods should be applied:

- Ensure that the correct level of light is provided and that areas of lighting are carefully selected. Lighting levels should be selected from relevant British / European standards to ensure lighting is appropriate to the task in hand and that areas are not over lit (refer to BS EN 12464-2-2007 Lighting for work places (outdoor));
- Hours of operation should be limited during periods of diminishing ambient lighting levels. There should be an agreement in place that work tasks requiring lighting for health and safety purposes should not be carried out during periods that could be considered a nuisance;
- The limitations for obtrusive light obtained from the ILP Guidance Notes for the Reduction of Obtrusive Light GN01:2011 as provided in Table 3.2 should be adhered to. Further guidance on the applicable environmental zones and limitations can be found in Section 3;
- Floodlighting provided should ideally be mounted at a tilt of 0° and utilise a double asymmetrical photometric configuration. The ILP advises in GN01:2011 that a maximum main beam angle of 70° should be utilise to minimise the effects of glare, an example of main beam angles for floodlighting is shown in Figure 7.1; and
- Luminaires should be located and directed away from residential properties.
- Possible use of infrared spectrum security lighting, as infrared light is outside of our visible spectrum.
- Where security lighting is being considered as a form of deterrent for vandalism and theft, alternative forms of security should also be considered to limit the burden to the lighting.
- The use of solid site hoarding to contain and limit light spill and also improve security.

Figure 7.1: ILP Recommended main beam angles for floodlights



Source: ILP – Guidance Notes for the Reduction of Obtrusive Light GN01:2011

7.2 Operational Phase Mitigation

To minimise the effects of the lighting provided for the operation phase 1 of the development, the following mitigation methods have either been applied or will need to be applied:

- Lighting levels have been designed to relevant British / European standards.
- The lighting provided for the sports pitch has been based on the correct competition level of usage with the levels of lighting deemed appropriate and proportionate to the relevant standard.
- Restrictions on the operational times for the sports pitch and the surrounding development including public realm lighting and façade lighting will need to be agreed and applied. These restrictions will need to be implemented though the correct specification of the control equipment in the form of timers and photocells.
- Illuminance levels can be mitigated trees, vegetation, and street furniture and so careful consideration of the public realm design will assist in reducing potential significant adverse impacts and effects.

7.2.1 Upward Light Ratio Mitigation

The upward light ratio of all proposed luminaires has been assessed with one luminaire identified as having an upward light ratio in excess of the 5% limit as detailed in the ILP guidance document provided in Appendix A. The identified luminaire is the iGuzzini BV13 Type A1 which is being proposed for the public realm lighting. From reviewing the design the luminaire has been mounted at a tilt of 20º from the horizontal of the luminaire. The manufacture's data sheet suggests that the luminaire mounted at this 20º tilt will have an upward light ratio of 5.46% which is in excess of the 5% limit. It is therefore recommended that consultation with the manufacturer, iGuzzini, is carried out to ascertain an appropriate tilt for the luminaire so that the 5% upward light ratio limit is not exceeded and the required design levels are achieved.

7.2.2 Façade Lighting Mitigation

The proposed lighting design for the façade lighting can be mitigated using the following methods:

- Keep lighting understated and aim to enhance rather than swamp architectural character.
- Ensure light is directed only at the structure which may require relocating luminaires and using baffles and shielding where possible.
- Minimise upward lighting where it distorts the architectural detailing.
- The operational periods of the lighting should be considered to maximise the visual beauty of the building during periods of darkness however floodlighting the building at dusk or dawn should be discouraged.
- Consider the choice of surface materials being illuminated, the reflectance characteristics of the material may be high causing reflected light to generate excessive sky glow.

7.2.3 Luminous Intensity Mitigation

From our analysis of the designs, it is apparent that there are many locations where the luminous intensity experienced by the surrounding buildings and emanating from the proposed luminaires, is in excess of the limits for pre and post curfew times, as detailed in the ILP guidance document provided in Appendix A for pre curfew.

It is recommended that to mitigate the luminous intensity of the luminaires the following methods are utilised:

- Baffles and shields should be applied to luminaires facing the houses where possible to reduce the visibility of the luminaire.
- Luminaires should be orientated away from adjacent buildings where possible.
- Where luminaires are located in close proximity to adjacent buildings, the luminaire mounting heights and tilts should be reduced where possible.
- Further design development will be required and negotiations with local council to reduce the overall standard of lighting along Gillman Street and Alroy Road from S2 lighting class to S3 lighting class.

7.2.4 Light Intrusion into Windows

From our analysis of the designs, it is apparent that there are many locations where the light intrusion into the windows of the surrounding buildings is in excess of the limits for pre and post curfew times as detailed in the ILP guidance document provided in Appendix A.

It is recommended that to mitigate the light spill into windows the following methods are utilised:

- Baffles and shields should be applied to luminaires facing adjacent houses where possible to reduce the visibility of the luminaire.
- Luminaires should be orientated away from adjacent buildings where possible.
- Where luminaires are located in close proximity to adjacent buildings, the luminaire mounting heights and tilts should be reduced where possible.
- Further design development will be required and negotiations with local council to reduce the overall standard of lighting along Gillman Street and Alroy Road from S2 lighting class to S3 lighting class.

8 Calculation and Methodology

8.1 Calculation Notes and Methodology

Numerical modelling and calculations have been carried out using the lighting analysis software AGi32, version 14.6 and have been checked by Alex Moore & Toby Sargant of Mott MacDonald Ltd.

3-dimensional geometric models of the football pitches and the adjacent buildings have been developed based on Ordnance Survey map data, site photographs and Mott MacDonald's site surveys.

For the purpose of this assessment, a Radiosity Stopping Criterion of 99% has been used; this is to ensure that results are as accurate as possible.

8.2 Assumptions

The following assumptions have been made:

1. Obtrusive light is considered for the properties surrounding football ground and the survey viewpoint locations indicated on drawing numbers 317415-EIA-001 & 002.
2. All topographical levels for any existing buildings considered in the calculations are from a combination of Ordinance Survey data and the site survey. An assumption based on this information has been taken for the position and height of windows.
3. Existing lighting information has not been included in the proposed lighting calculations.
4. Trees and all other vegetation have been ignored for the purpose of this analysis to provide a 'worst case' assessment, i.e. in winter when vegetation is minimal, or to allow for vegetation to be removed in the future.
5. Luminaire photometry from the relevant lighting manufacturers was utilised.
6. Upward Light Ratio, Light Spill, Luminance Intensity and Building Luminance calculations utilise an overall maintenance factor of 1.0, as this is the worst case scenario. This maintenance factor would be equivalent to the initial installation rather than the deteriorated light output from the luminaires which would occur over months and years of use.
7. Luminance Intensity is via direct calculation only and takes no account of the reflective properties of the various surfaces.
8. Spill Light calculations performed are direct calculations only; no account of the reflective properties of the various surfaces has been incorporated into the model.

9 Conclusions

9.1 Phase 1 – detailed assessment for full planning application

Comparing the results from the lighting model calculations with the requirements of the ILP guidance notes for the reduction of obtrusive light, 2011 it can be seen that the results for upward light ratio, light intrusion and luminaire intensity are in excess of the pre and post curfew limits assessed. The applicable limits and results are summarised in Tables 9.1 and 9.2.

As the majority of the applicable ILP limits are exceeded we can conclude that from an obtrusive light perspective the lighting designs as a whole are not satisfactory.

The area of the lighting model which causes the most concern and the area we feel has the main contribution to the results being in excess of the limitations is the public realm lighting. Further design development and a review of the lighting standards used should be carried out.

Table 9.1: Pre- Curfew ULR, Luminaire Intensity, Light Intrusion & Building Luminance Summary

Source of requirement	**Maximum permissible ULR**
ILP Guidance – Sky Glow (ULR) E3 Zone	ULR <=5%
Result Criteria	**Results**
ULR(max)	5.46%
Source of requirement	**Maximum permissible level (lux)**
ILP Guidance – Light intrusion onto windows (Eav) E3 Zone	6
Result Criteria	**Result (lux)**
light intrusion (max)	35.2
Source of requirement	**Maximum permissible Luminaire Intensity I (cd)**
ILP Guidance –Luminous intensity (candelas) E3 Zone	I <= 10,000 Candela
Calculation Area	**Calculated maximum Luminaire Intensity I (cd)**
Survey Viewpoint Location No: 31	I(max) = 26,204 Candela
Source of requirement	**Average permissible Luminance (cd/m^2)**
ILP Guidance – Building Luminance	10 cd/m^2
Result Criteria	**Results (cd/m^2)**
	<10 cd/m²

Source: Mott MacDonald Ltd

Table 9.2: Post Curfew ULR, Luminaire Intensity & Light Intrusion summary

Source of requirement	Maximum permissible ULR
ILP Guidance – Sky Glow (ULR) E3 Zone	LR <=5%
Result Criteria	**Results**
ULR(max)	5.46%
Source of requirement	**Maximum permissible level (lux)**
ILP Guidance – Light intrusion onto windows (Eav) E3 Zone	2
Result Criteria	**Result (lux)**
light intrusion (max)	33.5
Source of requirement	**Maximum permissible Luminaire Intensity I (cd)**
ILP Guidance – Light intrusion onto windows (Eav) E3 Zone	I <= 10,000 Candela
Calculation Area	**Calculated maximum Luminaire Intensity I (cd)**
Survey Viewpoint Location No: 31	I(max) = 26,204 Candela

Source: Mott MacDonald Ltd

9.2 Phase 2 – Outline assessment for outline planning application

At this stage there are no results to review for the Phase 2 element. Established conditions and limitations of the lighting required for Phase 2 have been included in section 6.4 which will be used for the outline planning application.

10 Glossary of Terms

10.1 Glossary of terms

Artificial Light Source – Man made lighting such as floodlights and illuminated bollards.

Candela – International System of Units (SI) for Luminous Intensity, a common candle emits light with a luminous intensity of approximately one candela.

Eav – The illuminance on a vertical plane at any specific point, measured in Lux.

I – Light intensity in Candela's.

Illuminance – Measurement of Luminous Flux at a point on a surface.

Luminance – Luminance is an indicator of how bright surface will appear

Light Distribution – See Luminaire Photometry.

Light Intensity – See Luminous Intensity.

Light Intrusion – Light that falls beyond the boundary of the area being lit.

Light Pollution – See Obtrusive Light.

Light Spill – See Light Intrusion.

Light Trespass – See Light Intrusion.

Louver – Device fitted either externally or internally to a luminaire to reduce obtrusive light being emitted from the luminaire.

Lumens – SI unit for Luminous Flux, a measure of the total amount of visible light emitted by a given source.

Luminaire – Complete light fitting housing the lamp, control gear and optical distribution controls.

Luminaire Intensity – See luminous intensity.

Luminaire Photometry – See Photometric.

Luminous Intensity – Measurement in Candelas of the light emanating from the light source viewed from a specific location beyond the boundary of the installation.

Luminous Flux or Luminous Power – Measurement (in Lumens) of visible light produced by a light source.

Lux – SI unit for Illuminance, one lumen per square metre.

Maintenance Factor – Ratio applied to the average Illuminance levels in the calculation model which accounts for the depreciation of lumens emitted from the lamp over time and dirt accumulated on the luminaire.

Obtrusive Light – Light which falls or can be viewed beyond the boundary of the area being lit which causes annoyance, discomfort or distraction.

Photocell – Device that switches a luminaire dependent on the level of light experienced, for external lighting the photocell would typically switch the luminaire on at dusk and off at dawn.

Photometric – The distribution of luminous intensity, in candelas for the transvers and axial planes, in layman's terms this is the "footprint" of the light distribution for a given luminaire.

Radiosity Stopping Criterion – AGi32 uses a radiosity calculation engine to predict lighting distribution in a 3 dimensional environment. The stopping criterion indicates the amount of light that can remain in the environment before calculations are concluded. When the stopping criterion is high calculation times are also high however the accuracy of results is improved.

Sky Glow – The illumination of the sky at night by artificial light sources including light emitted directly upward from the light source and also reflected from the ground surface.

Upward Light Ratio (ULR) – Percentage of Flux emitted from a luminaire and / or whole installation at and above the horizontal position of the luminaire.

Appendices

Appendix A. Guidance Notes for the Reduction of Obtrusive Light

A.1 Guidance Notes for the Reduction of Obtrusive Light GN01:2011

The Institution of Lighting Engineers

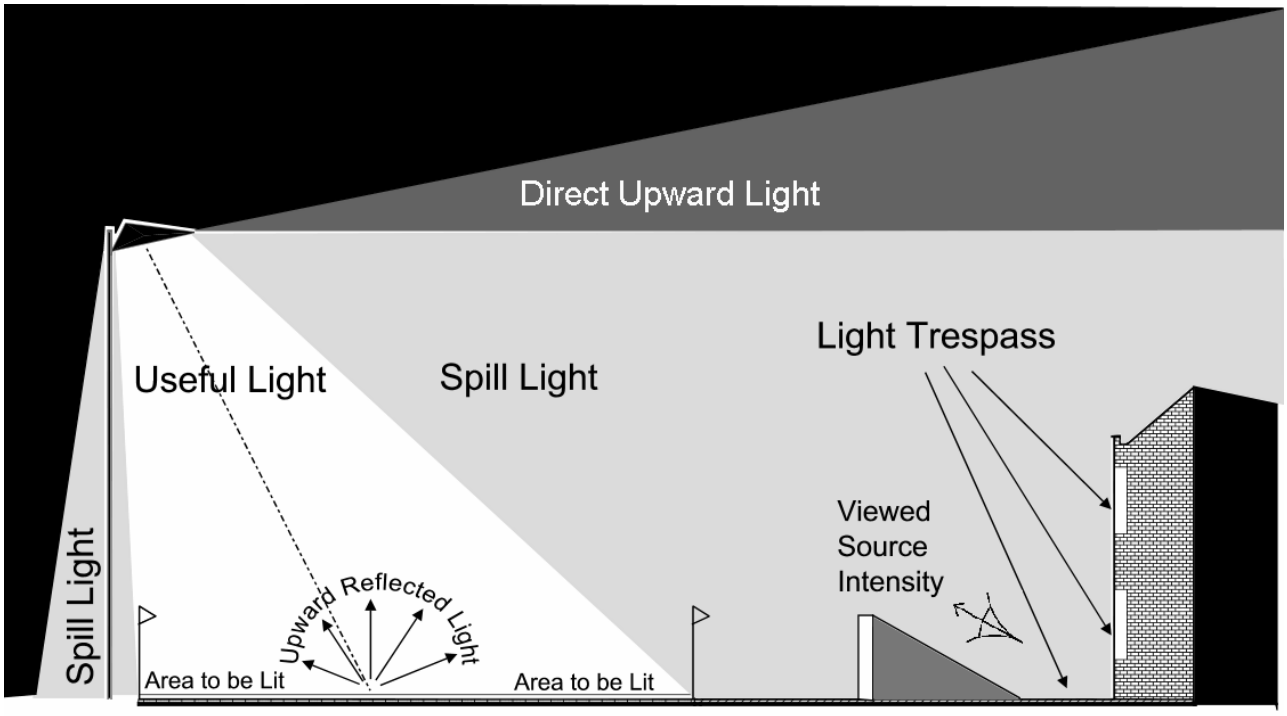
E-mail ile@ile.org.uk Website www.ile.org.uk

GUIDANCE NOTES FOR THE REDUCTION OF OBTRUSIVE LIGHT

ALL LIVING THINGS adjust their behaviour according to natural light. Man's invention of artificial light has done much to enhance our night-time environment but, if not properly controlled, **obtrusive light** (commonly referred to as light pollution) can present serious physiological and ecological problems.

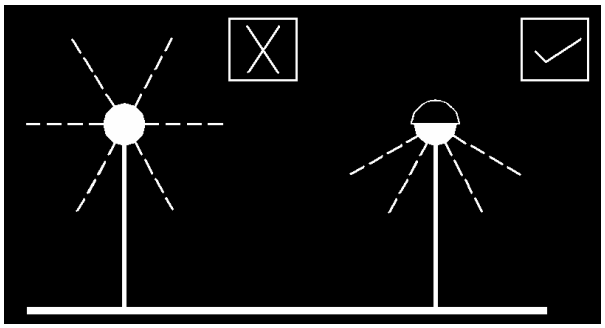
Obtrusive Light, whether it keeps you awake through a bedroom window or impedes your view of the night sky, is a form of pollution and can be substantially reduced without detriment to the lighting task.

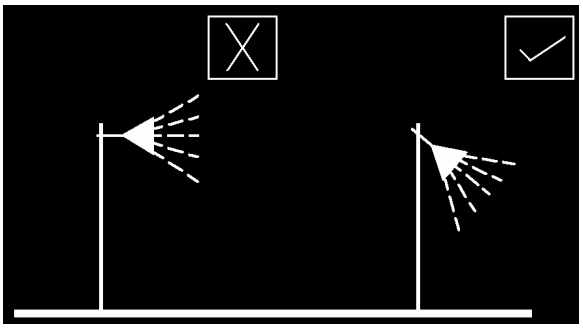
Sky glow, the brightening of the night sky above our towns, cities and countryside, **Glare** the uncomfortable brightness of a light source when viewed against a dark background, and **Light Trespass**, the spilling of light beyond the boundary of the property or area being lit, are all forms of obtrusive light which may cause nuisance to others, waste money and electricity and result in the unnecessary emissions of greenhouse gases. Think before you light. Is it necessary? What effect will it have on others? Will it cause a nuisance? How can I minimise the problem?



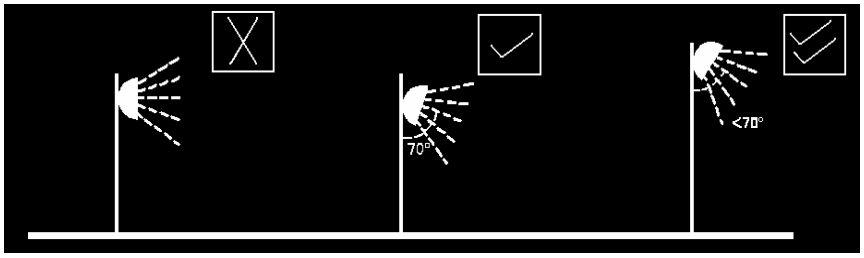
Do not "over" light. This is a major cause of obtrusive light and is a waste of energy. There are published standards for most lighting tasks, adherence to which will help minimise upward reflected light. Organisations from which full details of these standards can be obtained are given on the last page of this leaflet.

Dim or switch off lights when the task is finished. Generally a lower level of lighting will suffice to enhance the night time scene than that required for safety and security.



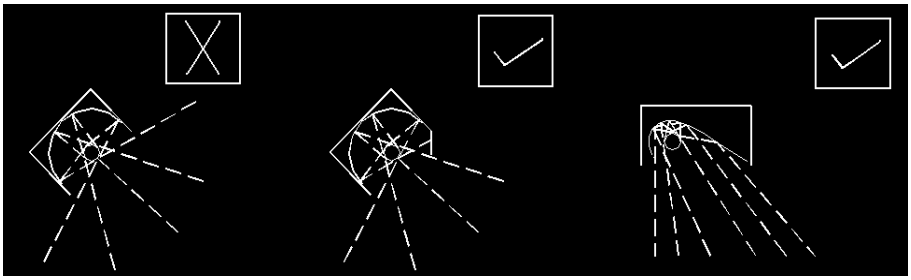


Use specifically designed lighting equipment that minimises the upward spread of light near to and above the horizontal. Care should be taken when selecting luminaires to ensure that appropriate units are chosen and that their location will reduce spill light and glare to a minimum. Remember that lamp light output in LUMENS is not the same as lamp wattage and that it is the former that is important in combating the problems of obtrusive light

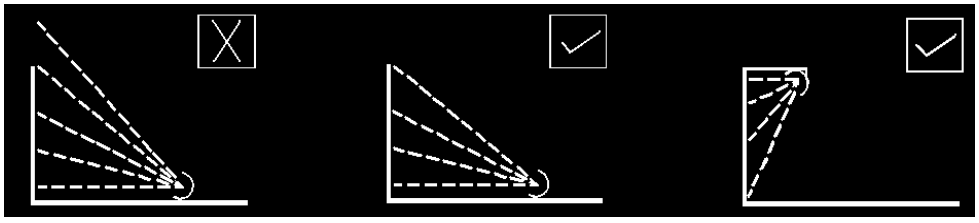


Keep glare to a minimum by ensuring that the main beam angle of all lights directed towards any potential observer is not more than 70°. Higher mounting heights allow lower main beam angles, which can assist in reducing glare. In areas with low ambient lighting levels, glare can be very obtrusive and extra care should be taken when positioning and aiming lighting equipment. With regard to domestic security lighting the ILE produces an information leaflet GN02 that is freely available from its web site.

The UK Government will be providing an annex to PPS23 Planning and Pollution Control, specifically on obtrusive light. However many Local Planning Authorities (LPA's) have already produced, or are producing, policies that within the new planning system will become part of the local development framework. For new developments there is an opportunity for LPA's to impose planning conditions related to external lighting, including curfew hours.



For sports lighting installations (see also design standards listed on Page 4) the use of luminaires with double-asymmetric beams designed so that the front glazing is kept at or near parallel to the surface being lit should, if correctly aimed, ensure minimum obtrusive light. In most cases it will also be beneficial to use as high a mounting height as possible, giving due regard to the daytime appearance of the installation. The requirements to control glare for the safety of road users are given in Table 2.



When lighting vertical structures such as advertising signs direct light downwards, wherever possible. If there is no alternative to up-lighting, as with much decorative lighting of buildings, then the use of shields, baffles and louvres will help reduce spill light around and over the structure to a minimum.

For road and amenity lighting installations, (see also design standards listed on Page 4) light near to and above the horizontal should normally be minimised to reduce glare and sky glow (Note ULRs in Table 1). In sensitive rural areas the use of full horizontal cut off luminaires installed at 0° uplift will, in addition to reducing sky glow, also help to minimise visual intrusion within the open landscape. However in many urban locations, luminaires fitted with a more decorative bowl and good optical control of light should be acceptable and may be more appropriate.

ENVIRONMENTAL ZONES:

It is recommended that Local Planning Authorities specify the following environmental zones for exterior lighting control within their Development Plans.

Category	Examples	
E1:	**Intrinsically dark landscapes**	National Parks, Areas of Outstanding Natural Beauty, etc
E2:	**Low district brightness areas**	Rural, small village, or relatively dark urban locations
E3:	**Medium district brightness areas**	Small town centres or urban locations
E4:	**High district brightness areas**	Town/city centres with high levels of night-time activity

Where an area to be lit lies on the boundary of two zones the obtrusive light limitation values used should be those applicable to the most rigorous zone.

DESIGN GUIDANCE

The following limitations may be supplemented or replaced by a LPA's own planning guidance for exterior lighting installations. As lighting design is not as simple as it may seem, you are advised to consult and/or work with a professional lighting designer before installing any exterior lighting.

Table 1 – Obtrusive Light Limitations for Exterior Lighting Installations

Environmental Zone	Sky Glow ULR [Max %] (1)	Light Trespass (into Windows) Ev [Lux] (2)		Source Intensity I [kcd] (3)		Building Luminance Pre-curfew (4)
		Pre- curfew	Post- curfew	Pre- curfew	Post- curfew	Average, L [cd/m2]
E1	0	2	1*	2.5	0	0
E2	2.5	5	1	7.5	0.5	5
E3	5.0	10	2	10	1.0	10
E4	15.0	25	5	25	2.5	25

ULR = **Upward Light Ratio of the Installation** is the maximum permitted percentage of luminaire flux for the total installation that goes directly into the sky.

Ev = **Vertical Illuminance in Lux** and is measured flat on the glazing at the centre of the window

I = **Light Intensity in Cd**

L = **Luminance in Cd/m2**

Curfew = **The time after which stricter requirements (for the control of obtrusive light) will apply**; often a condition of use of lighting applied by the local planning authority. If not otherwise stated - 23.00hrs is suggested.

***** = From Public road lighting installations only

(1) **Upward Light Ratio** – Some lighting schemes will require the deliberate and careful use of upward light – e.g. ground recessed luminaires, ground mounted floodlights, festive lighting – to which these limits cannot apply. However, care should always be taken to minimise any upward waste light by the proper application of suitably directional luminaires and light controlling attachments.

(2) **Light Trespass (into Windows)** – These values are suggested maxima and need to take account of existing light trespass at the point of measurement. In the case of road lighting on public highways where building facades are adjacent to the lit highway, these levels may not be obtainable. In such cases where a specific complaint has been received, the Highway Authority should endeavour to reduce the light trespass into the window down to the after curfew value by fitting a shield, replacing the luminaire, or by varying the lighting level.

(3) **Source Intensity** – This applies to each source in the potentially obtrusive direction, outside of the area being lit. The figures given are for general guidance only and for some sports lighting applications with limited mounting heights, may be difficult to achieve.

(4) **Building Luminance** – This should be limited to avoid over lighting, and related to the general district brightness. In this reference building luminance is applicable to buildings directly illuminated as a night-time feature as against the illumination of a building caused by spill light from adjacent luminaires or luminaires fixed to the building but used to light an adjacent area.

Table 2 – Maximum Values of Threshold Increment from Non-Road Lighting Installations				
Light Technical Parameter TI	**Road Classification** [5]			
	No road lighting	ME5	ME4/ ME3	ME2 / ME1
	15% based on adaptation luminance of 0.1cd/m^2	15% based on adaptation luminance of 1cd/m^2	15% based on adaptation luminance of 2 cd/m^2	15% based on adaptation luminance of 5 cd/m^2

TI = **Threshold Increment** is a measure of the loss of visibility caused by the disability glare from the obtrusive light installation

(5) **Road Classifications** as given in BS EN 13201 - 2: 2003 Road lighting Performance requirements
Limits apply where users of transport systems are subject to a reduction in the ability to see essential information. Values given are for relevant positions and for viewing directions in path of travel. See CIE Publication 150:2003, Section 5.4 for methods of determination. For a more detailed description and methods for calculating and measuring the above parameters see CIE Publication 150:2003.

RELEVANT PUBLICATIONS AND STANDARDS:

British Standards: www.bsi.org.uk	BS 5489-1: 2003 Code of practice for the design of road lighting – Part 1: Lighting of roads and public amenity areas BS EN 13201-2:2003 Road lighting – Part 2: Performance requirements BS EN 13201-3:2003 Road lighting – Part 3: Calculation of performance BS EN 13201-4:2003 Road lighting – Part 4: Methods of measuring lighting performance. BS EN 12193: 2003 Light and lighting – Sports lighting	
Countryside Commission/DOE www.odpm.gov.uk	Lighting in the Countryside: Towards good practice (1997) *(Out of Print)*	
CIBSE/SLL Publications: www.cibse.org	CoL LG1 LG4 LG6 FF7	Code for Lighting (2002) The Industrial Environment (1989) Sports (1990+Addendum 2000) The Exterior Environment (1992) Environmental Considerations for Exterior Lighting (2003)
CIE Publications: www.cie.co.at	01 83 92 115 126 129 136 150 154	Guide lines for minimizing Urban Sky Glow near Astronomical Observatories (1980) Guide for the lighting of sports events for colour television and film systems (1989) Guide for floodlighting (1992) Recommendations for the lighting of roads for motor and pedestrian traffic (1995) Guidelines for minimizing Sky glow (1997) Guide for lighting exterior work areas (1998) Guide to the lighting of urban areas (2000) Guide on the limitations of the effect of obtrusive light from outdoor lighting installations (2003) The Maintenance of outdoor lighting systems (2003)
Department of Transport www.defra.gov.uk		Road Lighting and the Environment (1993) (Out of Print)
ILE Publications: www.ile.org	TR 5 TR24 GN02	Brightness of Illuminated Advertisements (2001) A Practical Guide to the Development of a Public Lighting Policy for Local Authorities (1999) Domestic Security Lighting, Friend or Foe
ILE/CIBSE Joint Publications ILE/CSS Joint Publications		Lighting the Environment - A guide to good urban lighting (1995) Seasonal Decorations – Code of Practice (2005)
Campaign for Dark Skies (CfDS) www.dark-skies.org		

NB: These notes are intended as guidance only and the application of the values given in Tables 1 & 2 should be given due consideration along with all other factors in the lighting design. Lighting is a complex subject with both objective and subjective criteria to be considered. The notes are therefore no substitute for professionally assessed and designed lighting, where the various and maybe conflicting visual requirements need to be balanced.