LIGHTING ASSESSMENT
### Redevelopment of Stamford Bridge
#### Grounds Lighting Assessment

**Issue and Revision Record**

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<tr>
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1 EXECUTIVE SUMMARY

The aim of the lighting environmental impact report is to focus on and identify the physical effects that lighting may have on the surrounding neighbourhood. The proposed lighting system shall be evaluated to ensure any spill light and glare impact to the surrounding area is reduced while fulfilling the functional needs of the project. The report will be based on visual observations of the existing light level conditions in the area surrounding the proposed stadium and calculations for spill and glare generated by the new sports lighting system.

The lighting guidelines being used for the proposed development require that in no event shall any light element associated with the stadium adversely impact the operation of motor vehicles on local roads. Additionally, spill light levels shall not significantly adversely impact the local residential community, nearby heritage and ecological sensitive receptors.

The design goal is to limit spill illumination to the surrounding neighbourhood. The design goals are to limit glare to all motorists around the stadium to a threshold value rating of 40 glare rating at motor intersections around the stadium.

A desktop study utilising professionally recognised computer generated lighting calculation, AGI (Advanced Graphics Interface) software, has assessed the proposed lighting systems conformity with recognised guideline requirements. The design of the Stadium Redevelopment involves a bowl that is completely enclosed and based upon the current conditions at the stadium and our calculated results of the proposed new sports lighting, ME Engineers has concluded that the environmental impact of the sports lighting will be an improvement relative to the existing situation.
2 INTRODUCTION

The following terms and definitions will be utilized throughout the report. The terminology is standard in the UK lighting design and the CIBSE/SLL (Chartered Institution of Building Services and Engineers/Society of Light and Lighting), which is the authority on lighting and its applications.

2.1 Units

Candela – Unit used to define the intensity of a light source.

Lumen – Unit used to define luminous flux. 1 lumen is defined as the luminous flux passing through a 1 foot opening in the surface of a sphere with a radius of 1 foot and a 1 candela light source at its center.

Lux – Unit used to define illumination. 1 lux is equal to 1 lumen falling on an area of 1 square meter.

Horizontal Light Level – The illumination on a horizontal plane. Readings are taken with the light meter in the horizontal position.

Vertical Light Level – The illumination on a vertical plane. Readings are taken with the light meter in the vertical position.

Maximum Vertical Light Level – The illumination measured on the vertical plane with the meter facing the brightest light source.

Line of Sight – Term used to express the condition in which a person’s view is directly in line with a light source.

Spill light – For the purpose of this report spill light can be defined as the illumination that is produced by a light source or light sources at a point or surface on which the light is not intended or desirable.

Glare – The discomfort or impairment of vision experienced when the image is excessively bright compared to the general surroundings.

Glare Rating – Calculation based on specific positions and viewing directions that are established to be of importance with regard to the potential reduction in visibility caused by lighting systems. These calculations are referred to as Threshold Increment Calculations. The glare rating is based on a scale of 10 to 100 with 100 being disabling glare and 10 being “no noticeable” glare.
2.2 General Lighting

The following table is intended to provide some points of reference for those unfamiliar with lux as a measurement of light levels. The data represents a conservative example of the lux measurements for the given conditions found worldwide:

<table>
<thead>
<tr>
<th>Light Source</th>
<th>Horizontal Lux</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Moon to Twilight</td>
<td>0.1 to 10</td>
</tr>
<tr>
<td>Typical City Centre Car Park</td>
<td>20 to 40</td>
</tr>
<tr>
<td>Street Lights – Housing Estate</td>
<td>2.5 to 10</td>
</tr>
<tr>
<td>Street Lights – Residential Estate</td>
<td>1 to 6</td>
</tr>
<tr>
<td>Office/Classroom</td>
<td>400 to 750</td>
</tr>
<tr>
<td>Professional Stadium</td>
<td>2,000 to 3,500</td>
</tr>
<tr>
<td>Sunny Day</td>
<td>30,000 to 50,000</td>
</tr>
</tbody>
</table>

Table 1: General Lux Levels

2.3 Policy, Legislation, Guidance & Industry Standards

This section sets out the relevant lighting policy, legislation and good practice guidance relevant to this lighting assessment.

International Legislation & Agreements

There is no relevant international legislation with regard to this lighting assessment.

National Legislation

The Clean Neighbourhoods and Environment Act 2005

Under Part 9, Section 102, subsection (1) of the Act, defines the light statutory nuisance from artificial lighting and includes guidance on suggested controls for local authorities for exterior lighting dependant on context.

National Policy

National Planning Policy Framework (NPPF)

Paragraph 125 of the NPPF (2) states: “By encouraging good design, planning policies and decisions should limit the impact of light pollution from artificial light on local amenity, intrinsically dark landscapes and nature conservation.”

Planning Practice Guidance

The online National Planning Practice Guidance (PPG), under ID31 Light Pollution advises on how to consider light within the planning system and has 6 sections.
• Section 1 relates to when is light pollution relevant to planning and how artificial light provides valuable benefits to society, and to not always being necessary. This also identifies that artificial light can cause “light pollution” and be a source of annoyance to people, harmful to wildlife. The maximum benefit, getting the best use of artificial light is about getting it right.

• Section 2 relates to what factors should be considered and if a development might have implications for light pollution, by changing, materially changing light levels outside the development.

• Section 3 relates to relevant factors when considering where light shines “spills” beyond the boundary of the area being lit and may cause annoyance to people, impair sleeping, compromise, or effect natural systems (e.g., Plants, insects, etc) and how it can be avoided with careful design and positioning of lights.

• Section 4 relates to the use of lighting only when required in order to minimise light pollution and reduce harm to wildlife, improving people’s ability to enjoy the night sky. This considers the potential for part-night lighting (where schemes are turned off when not needed) or reduced between the hours of midnight and 6am. It also recommends turning off lighting or careful design to avoid adverse effects during sensitive periods, i.e., migration.

• Section 5 considers the character of the area and surrounding environment with reference to how these may affect what is considered to be an appropriate level of lighting for the type of development proposed. It cautions to avoid glare and an appropriate selection of lighting so that fulfils its purpose without over-lighting.

• Section 6 considers possible ecological impact as wildlife differ from humans in their sensitivity to light and how the positioning, type of light source, duration artificial light is on are factors on wildlife.

Regional Policy

The London Plan

The London Plan (4) encourages good practice design and careful consideration to ensure safe and holistic public realm lighting solutions. The following policies are considered to be of relevance:

• Policy 7.5 Public Realm, excerpt 7.19, states “the lighting of the public realm also needs careful consideration to ensure places and spaces are appropriately lit, and there is an appropriate balance between issues of safety and security, and reducing light pollution”;

• Policy 7.6 Architecture, excerpt 7.22, states “Lighting of, and on, buildings should be energy efficient and appropriate for the physical context”;

• Policy 7.18 Protecting Open Space and Addressing Deficiency, excerpt 7.61, considers that “Development proposals should begin by understanding their wider context and viewing promotion of nature conservation as integral to the scheme not as an ‘add-on’. The indirect impacts of development (e.g., noise, shading, lighting, etc) need to be considered alongside direction impacts (e.g., habitat loss)”. 

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Guidance & Industry Standards

British Standards (BS)

British Standards (BS) are intended to set a standard of quality for goods and services. BS documents applicable to both commercial and residential development include the following:

- BS 5489-1:2013 – Code of practice for the design of road lighting – Part 1 (7): Lighting of roads and public amenity areas. This document provides guidance on the design of lighting for roads and public amenity areas for identification of requirements and how they should be considered.
- BS EN 12193: 2007 - Light and Lighting – Sports Lighting. This document provides guidance on the design of lighting for indoor and outdoor sports events in the form of lux levels, uniformities, glare restriction and colour properties for players, athletes, referees, spectators and CTV transmission.
- BS EN 13201-2:2003 – Code of practice for the design of road lighting – Part 2 (8): Performance requirements. This document provides performance requirements for lighting installed for roads or public amenity areas in the form of lux levels and uniformities.
- BS EN 12464-2:2007 Lighting of work places - Part 2 (9): Outdoor work places. This document provides guidance for a variety of outdoor workplaces and the anticipated lighting requirements, in the form of lux levels and uniformities that are used as part of standard practice.

Guidance

The relevant guidance documents which assist with defining acceptable standards and thresholds for exterior lighting installations include the following:

- CIBSE/Society of Light and Lighting (SLL) – Lighting Guide 6 – The Outdoor Environment (2016) (10);
- CIBSE/Society of Light and Lighting (SLL) – Lighting Factfile 7 – Design and Assessment of Exterior Lighting Schemes (2011) (11);
- CIBSE/Society of Light and Lighting (SLL) – Lighting Handbook (2012) (12);
- FIFA ‘Football Stadiums Technical Recommendations and Requirements (2011);
- Institute of Lighting Professionals (ILP)– Guidance Notes for the Reduction of Obtrusive Light (2011) (13);
- Institute of Lighting Professionals and the Bat Conservation Trust – Bats and Lighting in the UK (2007) (14);
- Secured by Design – Lighting Against Crime (2011) (15); and
- CIE 150:2003 Guide on the Limitation of the Effects of Obtrusive Light from Outdoor Lighting Installations (16);
- CIE 112:1994 Glare Evaluation System for Use Within Outdoor and Area Lighting; and

The ILP’s ‘Guidance Notes for the Reduction of Obtrusive Light’ provides the basis for the comparative analysis when defining whether an installation will be obtrusive to the environment and neighbouring properties. It assists in quantifying and providing acceptable maximum threshold recommendations for light spill, sky glow and glare.

The lighting guidelines being used for the proposed development require that in no event shall any light element associated with the Stadium Redevelopment adversely impact the operation of motor vehicles on area roadways. Additionally, spill light levels shall not adversely impact the residential community or nearby heritage and ecological sensitive receptors. An example to consider would be the bats that have been recorded using the railway lines and nearby cementery to forage. Both spill and glare shall be less than the existing stadium’s impact to the environment.
2.4 Design Criteria

The proposed spill light and glare rating for the Stadium Redevelopment will be based upon the above documentation. The tables below provide the recommendations for good practice on spill light applicable to stadiums and glare within the outdoor environment.

<table>
<thead>
<tr>
<th>Measure of Illumination</th>
<th>Distance from stadium perimeter</th>
<th>Illumination level (lux)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal spill</td>
<td>from perimeter to 50m radius</td>
<td>25</td>
</tr>
<tr>
<td>Horizontal spill</td>
<td>From 50m radius to 250m radius</td>
<td>10</td>
</tr>
<tr>
<td>Maximum vertical</td>
<td>from perimeter to 50m radius</td>
<td>40</td>
</tr>
<tr>
<td>Maximum vertical</td>
<td>From 50m radius to 250m radius</td>
<td>20</td>
</tr>
</tbody>
</table>

Table 2: Guidance on Light Spill

Glare Rating (GR) shall not exceed 40 at motor intersections around the stadium, which are depicted on the Field Measurements plan under Section 4. Generally, for sports competition on the field of play it is generally accepted that the GR value remain below 50.

<table>
<thead>
<tr>
<th>CIE Observation Notes</th>
<th>Glare Rating (GR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unbearable</td>
<td>90</td>
</tr>
<tr>
<td>-</td>
<td>80</td>
</tr>
<tr>
<td>Disturbing</td>
<td>70</td>
</tr>
<tr>
<td>-</td>
<td>60</td>
</tr>
<tr>
<td>Just Admissible</td>
<td>50</td>
</tr>
<tr>
<td>-</td>
<td>40</td>
</tr>
<tr>
<td>Noticeable</td>
<td>30</td>
</tr>
<tr>
<td>-</td>
<td>20</td>
</tr>
<tr>
<td>Unnoticeable</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 3: Guidance on Glare Rating

Impacts from spill light are normally related to interruption of sleep but may also interfere with other light-sensitive areas.
Glare results from a direct line of sight to a light source and the reflection from a light source.

The effect of light is often determined by the contrast posed with the immediate background. In general terms, spill light can be a nuisance primarily to sleep interruption and glare can be disabling primarily to motorists and pedestrians. In defining the intensity of light, the terms maximum vertical and horizontal are used. These terms relate to the orientation of the light meter measuring the light level. In the horizontal conditions, the meter is oriented horizontally aiming straight up. In the maximum vertical condition, the meter is pointed directly at the light source. The maximum vertical condition is considered the worst-case measure of light intensity.

Light spill from the building will aim to not exceed the 10cd/m² threshold, with minimal direct views of the functional lights from outside the building. There will be a lighting control system so that the interior levels can be adjusted to suit the various requirements of building usage.

### 2.5 Site Location

**Stadium & Neighbouring Areas**

The Stadium Redevelopment will be replacing the existing stadium, which is surrounded by local businesses, private residences and public areas.

![Figure 1: Stadium Location Map](image-url)
2.6 Lighting Design

2.6.1 Sports Lighting:
The sports lighting design for the Stadium Redevelopment will be similar to other professional facilities. The illumination on the playing field shall be approximately 1,650 lux with state-of-the-art light LED technology fittings that focus the lighting onto the pitch with beam efficiency of 50% or greater; compared to the existing facilities, which have a beam efficiency of less than 30%. The Stadium Redevelopment will produce less spill light outside the stadium and less glare away from the stadium than the existing sports lighting system, as is indicated in the table under Section 3.

The architecture and geometry of the existing stadium is such that gaps in the structure allow for light to leak from the openings. In addition, the low mounting height of the existing sports lights requires the lights to be tilted up higher than normal which can contribute to unintended light escaping the grounds.

The architectural design of the new stadium is more enclosed than the existing stadium. Based on the geometry of the roof of the Stadium Redevelopment, it can be seen from the calculations carried out that it will not cause as much illumination spill and glare as the existing stadium. The location of the new sports fittings will be arrayed under the roof overhang canopy and mostly regressed into the structure. The arrayed light pattern will provide control of the light with less light spillage and glare. Refer to Section 3 for the Results Summary Table comparing the existing and the redeveloped stadium.

A number of lighting sources would be associated with the Stadium Redevelopment. The most prominent source would be the field lights but other sources would include exterior building façade, signage, and pedestrian area lighting that would be used to activate the area on game days. The stadium lighting sources would only occur during a night event, dependant on the time of year 2 to 3 hours prior to the event and 1 to 2 hours after completion. Lighting necessary for cleaning up after an event would only utilize 50% percent of the sports lighting after the event.

There will be a dedicated architectural lighting control system that can adjust the sports lighting levels to suit the various requirements of building usage.

2.6.2 Interior Lighting:
The interior lighting of the stadium will be designed to meet guide practice lighting design techniques and levels. The positioning and selection of interior luminaires will ensure interior glare and glow is minimised. The lighting design considers a ‘layering of light’ approach which carefully considers the contributions of interior light from all artificial sources and elements such as kiosk designs, signage, and all lighting techniques to be implemented to ensure each space is not over-lit.

In general, the current proposal for the concourses includes for circular large diameter light box luminaires utilising multi-layered micro-pyramidal optic diffusing lenses to provide direct illumination to the concourse walkways and minimise glare. The proposals provide one luminaire per structural bay and proportion the scale and the size of the luminaire appropriately, i.e. the circular luminaires will be smaller towards the perimeter of the building to reflect the tightening of the structural grid spacing and to reduce the visual impact of interior lighting along the perimeter of the building.

There will be a dedicated architectural lighting control system that can adjust the interior lighting levels to suit the various requirements of building usage.
2.6.3 Façade Illumination:
The intended night time illuminated presentation of the building is to place the architecture in silhouette, therefore, lighting techniques enhancing the exterior presentation of the building will be contained within the building envelop. There is no proposed dedicated lighting treatments to the perimeter external faces of the structure. The design will limit any intrusion of light into neighbouring windows to 10 cd/m² (pre-curfew) / 2 cd/m² (post-curfew) and limit building luminance to 10 cd/m² average. Pre-curfew refers to the time during an event, and post-curfew refers to the time after an event.

2.6.4 Public Realm / Landscape Illumination:
The external lighting to the public realm and access routes will be designed to accommodate the safe movement and egress of large crowds on event days, yet also accommodate the more casual use of these spaces during non-event days. Generally, the lighting design will facilitate multi-functional columns that will be located along the perimeter of the property boundary. The lighting optics utilised within these lighting columns will ensure the lighting effects face inwards towards the stadium and will limit backward light spill to neighbouring properties. The lighting will be controlled via a dedicated architectural dimming control system to provide a number of lighting scenes to respond to the varying operational requirements.

The external lighting around the ground will consist of either 6 or 8 metre high lighting columns apart from the ‘shed end’, the narrow passage between property retaining wall and building on the south side, where the proposal is to upgrade the existing design. The new 6 or 8 metre high lighting columns will facilitate combinations of lighting, CCTV, and PAVA. These columns will utilise asymmetric optics and full-cut downward distribution optics. All lighting distributions will be pointed away from neighbouring properties and luminaire photometrics will be selected to minimise any backward light spill into neighbouring properties with respect to the ILP Guidance Notes for the Reduction of Obtrusive Light.

Along the southern ‘shed end’, the external lighting design will consist of a direct like for like replacement of the existing traditional wall mounted lanterns and directional security floodlights. The existing luminaries will be replaced with LED variations with controlled asymmetric light distributions.

In addition to the functional lighting, there is a small amount of landscape lighting highlights to trees, benches, and other street furniture. All landscape lighting elements will utilised low powered LEDs for minimal upward and reflected light.

All external lighting will dimmable LEDs and shall be controlled by astronomic timeclock input and photoelectric cell. This will ensure programmable set-dimmed settings can be fine tuned for event days, non-event days, and also associate the external lighting levels in respect to time of seasonal variations of daylight.

All external lighting shall be 4000K colour temperature apart from within the entrance foyers contained within the building structure which will be illuminated at 3000K for a warmer appearance.
A summary of the designed operational lighting level targets is contained within the table below.

<table>
<thead>
<tr>
<th>Area / Uses</th>
<th>E (average, maintained, horizontal lux)</th>
<th>Uniformity</th>
</tr>
</thead>
<tbody>
<tr>
<td>External Concourse (Non-event)</td>
<td>10</td>
<td>0.25</td>
</tr>
<tr>
<td>External Concourse (Event day)</td>
<td>20</td>
<td>0.40</td>
</tr>
<tr>
<td>Building Entrances</td>
<td>75</td>
<td>0.40</td>
</tr>
</tbody>
</table>

Table 4: Lighting Level Design Targets

2.7 Lighting Impact Process / Methodology

In order to assess the level of change with a new lighting installation in place, the existing lighting condition (baseline) is compared with the new lighting condition. Whilst defining the baseline conditions, potential receptors likely to be affected by changed lighting in the local area are identified. The assessment focuses on:

- The magnitude of the change in lighting levels; and
- How sensitive the receptor is to that change/how likely the change is to be noticeable.

The general process of carrying out an environmental impact report is as follows:

- Code research of lighting regulations/ordinance.
- Develop design criteria.
- Study of area surrounding the stadium (residences, offices, building heights, road intersections).
- Definition of typical light levels to give some reference points for typical night time conditions.
- Evaluation of current architectural model to minimize sports lighting impact on spill light and glare.
- Field observation and measurement of current lighting conditions around the stadium.
- Computer calculation of sports lighting based on architectural and sports lighting design.
- Interpretation of calculation results and implement light mitigation if necessary.
- Conclude whether any resilient impacts remain.

2.8 Explanation of Field Observations and Measurements

There are several factors that will impact spill light and glare. The first three items indicated below will directly impact both spill light and glare. Items 4 and 5 will impact glare only.

1. The general nature of the surrounding area. Lighting will have a greater impact in residential occupancies due to the relatively low light levels used within most residences.
2. The topography of the surrounding areas and potential direct views of the field lights from homes, apartments and private dwelling units.

3. The presence or absence of structures to effectively block any potential spill light.

4. The amount of city lighting in the area surrounding the stadium. Generally, the glare impact is reduced when the contrast between the field lights and the surrounding ambient light produced by the city lights is lessened, i.e., as the background light levels are increased, the glare impact due to the stadium field lighting is decreased.

5. The amount of light falling on the surrounding streets. Similar to item 4 above, as the light levels on a given street increases, the glare impact due to field lights decreases.

Field Observations were made at various positions around the existing stadium and in the local streets as indicated under Section 4, indicated by the red arrows on the map and circled in blue for the relevant picture and measurements. At these positions ambient light levels were taken of existing conditions. The average calculated lux presented is an average night time measurement of a single point reading of lux at the locations that are indicated on the Position Lighting Spill Map in Figure 2.

Readings are intended to establish existing conditions for future comparison and are not intended to be a random sampling that would be required in order to determine a statistical average for any given street.

Calculations for illumination and glare calculations are based upon a computer model of the stadium, new lighting locations, assumptions of aiming, distributions and the surrounding topography. The calculations are from the stadium only and do not account for any street lighting that is present. These measurements are in lux and are indicated in Results Summary Table in Section 3.

The values shown in the Results Summary Table, which correspond to the points indicated on the Field Measurements photograph in Section 4, represent the horizontal light and the vertical light level approximately 1 metre above the ground level aimed toward the stadium site. All light readings included always refer to the night time photographs.

Glare ratings are calculated by comparing the brightness of two objects. In our calculations the objects being compared are the pitch and the sports lighting. This method is a standard way of calculating glare and is based upon the CIE (Commission Internationale de L’eclairage) document 112-1994. Due to the mathematical calculation used, the minimum glare result can be no less than 10. Where a result of 10 is calculated for average, maximum, and minimum values there would be no anticipated glare as a result of either the viewing angle, distance or obstructions.

Photometric Calculations have been included on the Position Lighting Spill Map in Figure 2 with the following layout:

- Calculation title
- Grid orientation grid tilt and meter type all refer to the orientation of the grid in the computer model
- Observer location is the position of the observer in the computer model
It should be noted that there was minimal light spill in some of the areas in which the measurements were taken. Additionally, several instances were observed in which the existing street lighting was either partially on or completely off. Finally, it is possible the existing light level conditions may change due to the addition of new street or building lights in a specific location between the time of this report and the opening of the stadium. It is recommended that new measurements be taken at any potential mitigated location upon completion of the project, to verify the installed values meet the calculated values within this report.

2.9 Spill Light

As indicated by the design criteria explained in Section 2.4, light levels in excess of 40 lux generally interfere with light-sensitive activities such as sleep, as indicated under the PPG Section 3, which rely on dark conditions. The ambient light levels in the stadium area and the immediate surrounding area measured give an average horizontal light reading of 3 lux. Consequently, any light generated by the proposed field lighting, which would be greater than 10 lux could impact surrounding light-sensitive users.

These impacts would be greatest when spill light occurs after 10pm. Bedrooms that face away from the stadium or are otherwise shielded would not be affected.

The spill light calculations, shown in Section 4, provide values calculated along loci of circles centered at the centre of the pitch. The horizontal values are calculated with the metre pointed at zenith, vertical values assume the meter is pointed directly at the stadium.

Calculations performed by ME Engineers based upon the proposed building configuration and proposed design locations of sports lighting racks indicated that a maximum vertical illumination contribution of 33 lux can be anticipated at a limited vantage point on a 150m ring around the stadium. If this were to occur at a position where it could affect a user, the impact would be limited. The average vertical illumination around the 150m ring circle is calculated at 9.24 lux. This contribution drops to an average of 8.05 lux on a 250m ring indicating that the sports lighting will not be a major source of spill light into the surrounding neighbourhoods. Refer to Table 2 for guidance on light spill levels.

![Figure 2: Position Lighting Spill Map](image)
2.10 Glare

Based on ME Engineers experience with other sports facilities utilizing standard glare rating calculations, significant increases in the glare rating would be expected to be limited to a radius of 320 metres. When nearby streets are at ground level, as is the case at the Stadium Redevelopment, the potential for glare is generally less than a 30GR.

Glare Rating calculations in Section 4 assume an observer located at a position indicated on the Field Measurements plan is viewing lighting contributions from sports lighting only. The maximum glare rating calculated from our computer model is 33.64GR. This represents the worst case scenario for an observer in View Position 12 on the Field Measurements plan under Section 4 of this report.

Overall the 22 Field Observation Positions where existing light level readings were taken and have been used for the new calculated levels provide a general sampling of the viewing angles to the stadium. The anticipated glare rating would be less than 30GR, which would not be considered a nuisance glare.
3 INTERPRETATION OF OBSERVATIONS AND CONCLUSIONS

Spill Light and Glare Impact – Some patrons, motorists, and pedestrians within 320 metres of the stadium will experience some degree of spill light and glare due to the field lighting. It is expected that the vertical spill light levels will range from 10 to 21 lux for buildings immediately adjacent to stadium, with direct line-of-sight to the headframes to less than 5 lux for buildings at the boundary of the 320 metre radius. As expected, buildings furthest from the stadium will experience the lowest amounts of spill light and glare.

For the purpose of this report, “light sensitive” buildings are limited to homes. For any specific light sensitive building, if the street in front of the building has street lighting poles then there is a high probability that the lower level of the building will not be impacted by stadium spill light and glare.

3.1 Light Control Measures

Specific measures to control spill light and glare are incorporated into the project design. All lighting sources shall be directed downwards or otherwise shielded so as to keep all light and glare confined to the project boundary. The sport lighting fixture will be equipped with glare shields and cut off louvers for glare and spill light control.

At the completion of the project, the lighting system will be aimed and commissioned to optimize the video illumination quality on the playing field and minimize the glare and spill to the area outside the stadium. Additional re-aiming can be made at this stage of the project to further reduce the amount of glare and spill to the environment.

3.2 Summary

Based upon current conditions at the existing stadium and calculated results of the new sports lighting, ME Engineers has concluded that the environmental impact of the sports lighting will be an improvement for the Stadium Redevelopment over the existing situation. Because of the existing sports lighting at the current site, the environmental impact will be lessened resulting from the incorporation of new lens technology into the sports lighting fixtures, which reduce glare. Additionally the seating bowl being totally enclosed on all sides by the building skin and sunscreen will aid in shielding those houses nearest to the stadium (those most prone to spill light and glare) from direct views of the sports lighting. The Results Summary Table can be found in Section 3.3.

3.3 Results Summary Table

<table>
<thead>
<tr>
<th>Light Receptor Points on Field Measurement Plan</th>
<th>Location</th>
<th>Existing Stadium</th>
<th>New Stadium</th>
<th>Maximum Glare Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Horizontal Lux</td>
<td>Vertical Lux</td>
<td>Horizontal Lux</td>
</tr>
<tr>
<td>1</td>
<td>Outside London Oratory School Entrance</td>
<td>2.16</td>
<td>3.04</td>
<td>0.17</td>
</tr>
<tr>
<td>2</td>
<td>Billing Street</td>
<td>5.29</td>
<td>5.20</td>
<td>1.89</td>
</tr>
<tr>
<td>3</td>
<td>Billing place</td>
<td>35.4</td>
<td>78.5</td>
<td>15.5</td>
</tr>
<tr>
<td>Light Receptor Points on Field Measurement Plan</td>
<td>Location</td>
<td>Existing Stadium</td>
<td>New Stadium</td>
<td>Maximum Glare Rating</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Horizontal Lux</td>
<td>Vertical Lux</td>
<td>Horizontal Lux</td>
</tr>
<tr>
<td>4</td>
<td>Billing road</td>
<td>3.22</td>
<td>3.50</td>
<td>0.08</td>
</tr>
<tr>
<td>5</td>
<td>Fulham road – View from the bridge</td>
<td>12.25</td>
<td>5.20</td>
<td>0.45</td>
</tr>
<tr>
<td>6</td>
<td>Fulham road</td>
<td>16.20</td>
<td>7.40</td>
<td>0.7</td>
</tr>
<tr>
<td>7</td>
<td>Fulham road – Entrance Gate</td>
<td>12.69</td>
<td>3.57</td>
<td>0.99</td>
</tr>
<tr>
<td>8</td>
<td>Hillary Close – Fulham road</td>
<td>16.54</td>
<td>2.09</td>
<td>2.24</td>
</tr>
<tr>
<td>9</td>
<td>Fulham road – entrance</td>
<td>18.24</td>
<td>10.86</td>
<td>3.34</td>
</tr>
<tr>
<td>10</td>
<td>Stadium Grounds – Fitness Centre</td>
<td>9.33</td>
<td>8.76</td>
<td>No picture included in Field Measurement pictures as new Stadium footprint covers area picture taken from for the existing results, therefore this has not been included, as this would be under the stadium footprint.</td>
</tr>
<tr>
<td>11</td>
<td>Stadium Grounds – West Stand</td>
<td>14.25</td>
<td>8.01</td>
<td>12.98</td>
</tr>
<tr>
<td>12</td>
<td>Stadium Grounds</td>
<td>12.08</td>
<td>8.44</td>
<td>5.58</td>
</tr>
<tr>
<td>13</td>
<td>Hillary Close – off Fulham road</td>
<td>0.86</td>
<td>0.34</td>
<td>0.41</td>
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<tr>
<td>14</td>
<td>Stadium Grounds - South Stand</td>
<td>11.05</td>
<td>13.3</td>
<td>5.75</td>
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<tr>
<td>15</td>
<td>Stadium Grounds – facing Hotel</td>
<td>21.8</td>
<td>14.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Light Receptor Points on Field Measurement Plan</td>
<td>Location</td>
<td>Existing Stadium</td>
<td>New Stadium</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Horizontal Lux</td>
<td>Vertical Lux</td>
<td>Horizontal Lux</td>
</tr>
<tr>
<td>16</td>
<td>Stadium Grounds – Shed End</td>
<td>46.05</td>
<td>23.3</td>
<td>43.55</td>
</tr>
<tr>
<td>17</td>
<td>Kings road/ Holmead road</td>
<td>9.56</td>
<td>4.98</td>
<td>4.16</td>
</tr>
<tr>
<td>18</td>
<td>Kings road/ Rumbold road</td>
<td>3.06</td>
<td>2.34</td>
<td>1.74</td>
</tr>
<tr>
<td>19</td>
<td>Kings road/ Maxwell road</td>
<td>23.63</td>
<td>1.63</td>
<td>14.43</td>
</tr>
<tr>
<td>20</td>
<td>Britannia road</td>
<td>6.5</td>
<td>12.8</td>
<td>1.86</td>
</tr>
<tr>
<td>21</td>
<td>Britannia road/ Moore Park road</td>
<td>15.45</td>
<td>11.18</td>
<td>0.75</td>
</tr>
<tr>
<td>22</td>
<td>Moore Park/ Maxwell road</td>
<td>3.17</td>
<td>1.84</td>
<td>0.51</td>
</tr>
<tr>
<td>23</td>
<td>Back of Fulham Broadway shopping centre</td>
<td>8.04</td>
<td>4.15</td>
<td>0.9</td>
</tr>
</tbody>
</table>
4 FIELD MEASUREMENTS

4.1 Light Receptor Point No.1

Existing Lighting Conditions –

Measured Existing Stadium Lighting Conditions:
- Vertical Illuminance = 3.04 lux
- Horizontal Illuminance = 2.16 lux

Calculated Stadium Redevelopment Lighting Contribution:
- Vertical Illuminance = 0.86 lux
- Horizontal Illuminance = 0.17 lux

New Stadium Glare Rating: 18.45

Match Day View to Existing Stadium
4.2 Light Receptor Point No.2

Existing Lighting Conditions –

Measured Existing Stadium Lighting Conditions:
- Vertical Illuminance = 5.2 lux
- Horizontal Illuminance = 5.29 lux

Calculated Stadium Redevelopment Lighting Contribution:
- Vertical Illuminance = 1.41 lux
- Horizontal Illuminance = 1.89 lux

New Stadium Glare Rating: 23.81

Match Day View to Existing Stadium
4.3 Light Receptor Point No.3

Existing Lighting Conditions –
Measured Existing Stadium Lighting Conditions:
- Vertical Illuminance = 78.5 lux
- Horizontal Illuminance = 35.4 lux

Calculated Stadium Redevelopment Lighting Contribution:
- Vertical Illuminance = 45.5 lux
- Horizontal Illuminance = 15.5 lux

New Stadium Glare Rating: 28.73

Match Day View to Existing Stadium
4.4 Light Receptor Point No.4

Existing Lighting Conditions –

Measured Existing Stadium Lighting Conditions:

- Vertical Illuminance = 3.5 lux
- Horizontal Illuminance = 3.22 lux

Calculated Stadium Redevelopment Lighting Contribution:

- Vertical Illuminance = 1.4 lux
- Horizontal Illuminance = 0.08 lux

New Stadium Glare Rating: 27.12

Match Day View to Existing Stadium
4.5 Light Receptor Point No.5

Existing Lighting Conditions –

Measured Existing Stadium Lighting Conditions:
  - Vertical Illuminance = 5.2 lux
  - Horizontal Illuminance = 12.25 lux

Calculated Stadium Redevelopment Lighting Contribution:
  - Vertical Illuminance = 2.6 lux
  - Horizontal Illuminance = 0.45 lux

New Stadium Glare Rating: 20.63

Match Day View to Existing Stadium
4.6 Light Receptor Point No.6

Existing Lighting Conditions –

Measured Existing Stadium Lighting Conditions:
- Vertical Illuminance = 7.4 lux
- Horizontal Illuminance = 16.2 lux

Calculated Stadium Redevelopment Lighting Contribution:
- Vertical Illuminance = 0.5 lux
- Horizontal Illuminance = 0.7 lux

New Stadium Glare Rating: 18.81

Match Day View To Existing Stadium
4.7 Light Receptor Point No.7

Existing Lighting Conditions –

Measured Existing Stadium Lighting Conditions:

- Vertical Illuminance = 3.57 lux
- Horizontal Illuminance = 12.69 lux

Calculated Stadium Redevelopment Lighting Contribution:

- Vertical Illuminance = 1.22 lux
- Horizontal Illuminance = 0.99 lux

New Stadium Glare Rating: 20.21

Match Day View To Existing Stadium
4.8 Light Receptor Point No.8

Existing Lighting Conditions –

Measured Existing Stadium Lighting Conditions:
- Vertical Illuminance = 2.09 lux
- Horizontal Illuminance = 16.54 lux

Calculated Stadium Redevelopment Lighting Contribution:
- Vertical Illuminance = 0.51 lux
- Horizontal Illuminance = 2.24 lux

New Stadium Glare Rating: 25.63

Match Day View To Existing Stadium
4.9 Light Receptor Point No.9

Existing Lighting Conditions –

Measured Existing Stadium Lighting Conditions:

- Vertical Illuminance = 10.86 lux
- Horizontal Illuminance = 18.24 lux

Calculated Stadium Redevelopment Lighting Contribution:

- Vertical Illuminance = 4.06 lux
- Horizontal Illuminance = 3.34 lux

New Stadium Glare Rating: 29.78

Match Day View To Existing Stadium
4.10 Light Receptor Point No.11

Existing Lighting Conditions –

Measured Existing Stadium Lighting Conditions:

- Vertical Illuminance = 8.01 lux
- Horizontal Illuminance = 14.25 lux

Calculated Stadium Redevelopment Lighting Contribution:

- Vertical Illuminance = 6.49 lux
- Horizontal Illuminance = 12.98 lux

New Stadium Glare Rating: 30.26

Match Day View To Existing Stadium
4.12 Light Receptor Point No.12

Existing Lighting Conditions –

Measured Existing Stadium Lighting Conditions:

- Vertical Illuminance = 8.44 lux
- Horizontal Illuminance = 12.08 lux

Calculated Stadium Redevelopment Lighting Contribution:

- Vertical Illuminance = 3.35 lux
- Horizontal Illuminance = 5.58 lux

New Stadium Glare Rating: 33.64

Match Day View To Existing Stadium
4.13 Light Receptor Point No.13

Existing Lighting Conditions –

Measured Existing Stadium Lighting Conditions:
- Vertical Illuminance = 0.34 lux
- Horizontal Illuminance = 0.86 lux

Calculated Stadium Redevelopment Lighting Contribution:
- Vertical Illuminance = 0.08 lux
- Horizontal Illuminance = 0.41 lux

New Stadium Glare Rating: 29.33

Match Day View To Existing Stadium
4.14 Light Receptor Point No.14

Existing Lighting Conditions –

Measured Existing Stadium Lighting Conditions:
- Vertical Illuminance = 13.3 lux
- Horizontal Illuminance = 11.05 lux

Calculated Stadium Redevelopment Lighting Contribution:
- Vertical Illuminance = 3.6 lux
- Horizontal Illuminance = 5.75 lux

New Stadium Glare Rating: 22.70

Match Day View To Existing Stadium
4.15 Light Receptor Point No.15

Existing Lighting Conditions –

Measured Existing Stadium Lighting Conditions:
- Vertical Illuminance = 14.5 lux
- Horizontal Illuminance = 21.8 lux

Calculated Stadium Redevelopment Lighting Contribution:
- Vertical Illuminance = 2.6 lux
- Horizontal Illuminance = 1.0 lux

New Stadium Glare Rating: 20.94

Match Day View To Existing Stadium
4.16  

Light Receptor Point No.16

Existing Lighting Conditions –

Measured Existing Stadium Lighting Conditions:

- Vertical Illuminance = 23.3 lux
- Horizontal Illuminance = 46.05 lux

Calculated Stadium Redevelopment Lighting Contribution:

- Vertical Illuminance = 18.0 lux
- Horizontal Illuminance = 43.55 lux

New Stadium Glare Rating: 28.41

Match Day View To Existing Stadium
4.17 Light Receptor Point No.17

Existing Lighting Conditions –

Measured Existing Stadium Lighting Conditions:
- Vertical Illuminance = 4.98 lux
- Horizontal Illuminance = 9.56 lux

Calculated Stadium Redevelopment Lighting Contribution:
- Vertical Illuminance = 2.25 lux
- Horizontal Illuminance = 4.16 lux

New Stadium Glare Rating: 15.72

Match Day View To Existing Stadium
4.18 Light Receptor Point No.18

Existing Lighting Conditions –

Measured Existing Stadium Lighting Conditions:

- Vertical Illuminance = 2.34 lux
- Horizontal Illuminance = 3.06 lux

Calculated Stadium Redevelopment Lighting Contribution:

- Vertical Illuminance = 1.02 lux
- Horizontal Illuminance = 1.74 lux

New Stadium Glare Rating: 15.88

Match Day View To Existing Stadium
4.19 Light Receptor Point No.19

Existing Lighting Conditions –

Measured Existing Stadium Lighting Conditions:
- Vertical Illuminance = 1.63 lux
- Horizontal Illuminance = 23.63 lux

Calculated Stadium Redevelopment Lighting Contribution:
- Vertical Illuminance = 2.91 lux
- Horizontal Illuminance = 14.43 lux

New Stadium Glare Rating: 16.84

Match Day View To Existing Stadium
4.20 Light Receptor Point No.20

Existing Lighting Conditions –

Measured Existing Stadium Lighting Conditions:

- Vertical Illuminance = 12.8 lux
- Horizontal Illuminance = 6.5 lux

Calculated Stadium Redevelopment Lighting Contribution:

- Vertical Illuminance = 9.26 lux
- Horizontal Illuminance = 1.86 lux

New Stadium Glare Rating: 19.88

Match Day View To Existing Stadium
4.21 Light Receptor Point No.21

Existing Lighting Conditions –

Measured Existing Stadium Lighting Conditions:

- Vertical Illuminance = 11.18 lux
- Horizontal Illuminance = 15.45 lux

Calculated Stadium Redevelopment Lighting Contribution:

- Vertical Illuminance = 0.19 lux
- Horizontal Illuminance = 0.75 lux

New Stadium Glare Rating: 22.21

Match Day View To Existing Stadium
4.22  Light Receptor Point No.22

Existing Lighting Conditions –

Measured Existing Stadium Lighting Conditions:

- Vertical Illuminance = 1.84 lux
- Horizontal Illuminance = 3.17 lux

Calculated Stadium Redevelopment Lighting Contribution:

- Vertical Illuminance = 0.12 lux
- Horizontal Illuminance = 0.51 lux

New Stadium Glare Rating: 20.16

Match Day View To Existing Stadium
4.23 Light Receptor Point No.23

Existing Lighting Conditions –

Measured Existing Stadium Lighting Conditions:
- Vertical Illuminance = 4.15 lux
- Horizontal Illuminance = 8.04 lux

Calculated Stadium Redevelopment Lighting Contribution:
- Vertical Illuminance = 1.23 lux
- Horizontal Illuminance = 0.9 lux

New Stadium glare Rating: 28.46

Match Day View To Existing Stadium