NORTH LINCOLNSHIRE GREEN ENERGY PARK

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Infrastructure Planning (Applications Prescribed Forms and Procedure) Regulations 2009

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North Lincolnshire Green Energy Park

Volume 6

Environmental Statement

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Glossary

Term	Definition
Ave	Average value
Colour Rendering (Ra)	An indicator of how accurately colours can be distinguished under different light sources. The colour rendering index (measured in Ra) compares the ability of different light sources to render colours accurately. This measures the ability of a light source to render colours naturally, without distorting the hues seen under a full spectrum radiator (like daylight). The colour rendering index (CRI) ranges from 0 to 100. Colour rendering index CRI
Colour Temperature	The colour temperature provides an indication of the light colour and is expressed in Kelvin (K). Lamps are generally rated between 2700K (warm), 4000K (neutral) and 6500K (cool). Unit: kelvin, K.
Control Gear	A 'package' of electrical or electronic components including ballast, power factor correction capacitor and starter. High frequency electronic control gear may include other components to allow dimming, etc.
Curfew	A time defined by the local authority when outdoor lighting is reduced or switched off.
Glare	The uncomfortable brightness of a light source against a darker background which results in dazzling the observer or may cause nuisance. Condition of vision in which there is discomfort or a reduction in the ability to see significant objects, or both, due to an unsuitable distribution or range of luminance.
Glare Rating (GR)	Glare Rating values may be calculated for sports and area lighting applications to indicate the amount of glare present for an observer within the lighted area. GR values range from 10 to 90 (regardless of US or Metric units), where a value of 10 indicates unnoticeable glare and a value of 90 indicates unbearable glare. For most applications, the CIE (International Commission on Illumination) recommends that the maximum amount of glare allowed should be less than 45 to 55, depending on the application.
Horizontal Illuminance (E, Eh)	Illuminance incident on the horizontal surface. Unit: lux (lx) = lm/m^2 Symbol: E, Eh
Illuminance	The amount of light falling on a surface of unit area. The unit of illuminance is the lux, equal to one lumen per square metre. Unit: lux (lx) = lm/m^2
LED	Light Emitting Diode used as a light source. Solid-state semiconductor device that converts electrical energy directly into light of a specific colour or even white light.
Light Output Ratio (LOR)	Ratio of the total light emitted by a luminaire to the total light output of the lamp(s) it contains measured at standard operating conditions.
Light Spill	The unwanted spillage of light onto adjacent areas which may affect sensitive receptors, particularly residential properties and ecological sites.
Light Trespass	The spilling of light beyond the boundary of a property which may cause nuisance to others, particularly when spilling into windows of neighbouring properties.
Lumen	Unit of luminous flux, used to describe the amount of light produced by a lamp or falling on a surface.
Lumen Depreciation	The decline in the light output of a light source during its lifetime.
Luminaire	The correct term for a light fitting. An apparatus which controls the light from a lamp and includes all components for fixing and protecting the lamps or light source, as well as connecting them to an electrical supply.
Maintained Illuminance (luminance)	Value below which the average illuminance on the specified surface is not allowed to fall. The maintained illuminance is specified at the end of the maintenance cycle, taking into consideration the maintenance factor. It is one of the main specification elements for the lighting designer. In the various slighting standards, the maintained illuminance is specified for various areas/activities. Unit: lux. Symbol: Em. (Eave)
Maintenance Factor	Correction factor used in lighting design to compensate for the rate of lumen depreciation, caused by lamp ageing (lumen depreciation and lamp failure) and dirt accumulation (luminaire and environment). It determines the maintenance cycle needed to ensure that illuminance does not fall below the maintained value.
Sky Glow	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.
Source Intensity	This is the brightness of the source of the luminaires and applies to each source in the potentially obtrusive direction, outside of the area being lit.
Ave	Average value
Uniformity Ratio	Ratio of the minimum over the average illuminance for a specified area (Emin/Eave). When defined as such, the uniformity ratio is also the ratio of the minimum over the maximum illuminance for a specified surface area (Emin/Emax).
Vertical Illuminance	Illuminance incident on the vertical surface. Unit: lux (lx) = lm/m^2 Symbol: Ev

1 Executive Summary

1.1.1 Buro Happold has been appointed to establish the baseline external lighting conditions and develop a lighting strategy for North Lincolnshire Green Energy Park Limited ('the Applicant) for the North Lincolnshire Green Energy Park (NLGEP) ('the Project'), located at Flixborough, North Lincolnshire.

1.1.2 The Project is a Nationally Significant Infrastructure Project (NSIP) with an Energy Recovery Facility (ERF) capable of converting up to 760,000 tonnes of non-recyclable waste into 95 MW of electricity at its heart and a carbon capture, utilisation and storage (CCUS) facility which will treat the excess gasses released from the ERF to remove and store carbon dioxide (CO_2) prior to emission into the atmosphere.

1.1.3 The purpose of this report is to provide a lighting strategy that complies with the required British Standard, regulations and recommendations of best practice. The information and data within this report is produced for adoption by the appointed environmental consultant to provide a lighting environmental assessment for the Project.

1.1.4 The lighting strategy shall limit the impact of obtrusive light and undue light spill on to surrounding areas, protected natural environments and sensitive receptors, including the River Trent and proposed new areas of wetland habitats. The baseline conditions and lighting strategy shall provide suitable levels of information for the environmental consultant to carry out the required lighting environmental assessment for the Project.

1.1.5 The main risks relating to potential impact from the external artificial lighting from the Project are identified below:

- the impact of security and operational industrial-style lighting required for the Project on natural environments such as the River Trent, the River Trent shoreline, and the proposed wetland habitats in former farmland; and
- the impact of road lighting on the proposed New Access Road on the natural environments described above.

1.1.6 To assess the risks mentioned above and provide suitable mitigation measures to ensure minimal impact, the lighting strategy is co-ordinated with the requirements of landscape designers, ecology and rail consultants. The required illumination criteria of each function and appropriate lighting applications shall meet both functional and environmental requirements

1.1.7 This report provides a series of lighting calculation results in which the lighting strategy is tested. Sensitive receptors are identified and located in a digital lighting calculation model that includes the location of all potential lighting. The lighting calculations are provided to illustrate the potential impact of light on the areas of sensitive receptors and surrounding area and preliminarily confirm the proposed lighting strategy.

1.1.8 By allowing, implementing, and further developing the recommendations presented in this report, the project will move closer towards the submission of a full environmental impact assessment that will be required for further planning applications.

2 Project Review

2.1 The Project/Site Context

2.1.1 The Project is located within the Flixborough Industrial Estate, adjacent to the River Trent in North Lincolnshire. The industrial estate is located north of Scunthorpe.

2.1.2 The Project is in a rural area and the existing site is mostly comprised of the wharf operational area and storage. Former office buildings and workshop sheds are also included on the Application Land. The nature of the site is predominantly industrial manufacturing, storage, distribution, and logistics.

2.1.3 The natural environment is characterised for being flat and the surrounding areas are used for farming purposes. A series of drains carry water from the crops towards the river. Small batches of forests are located around the area.

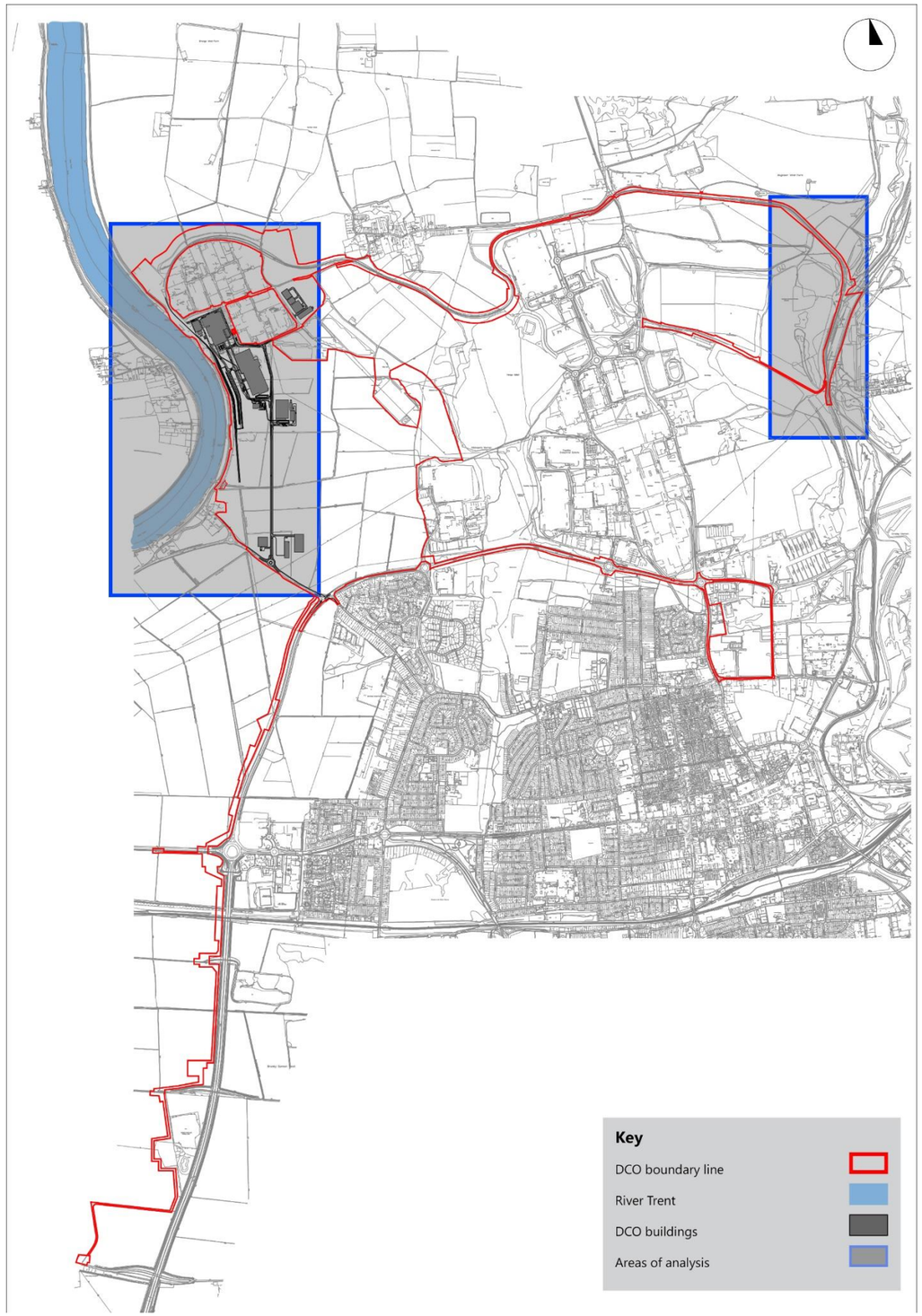


Figure 2-1 The Order Limits

2.2 Project Description

2.2.1 The North Lincolnshire Green Energy Park (NLGEP) ('the Project'), located at Flixborough, North Lincolnshire, is a Nationally Significant Infrastructure Project (NSIP) with an Energy Recovery Facility (ERF) capable of converting up to 760,000 tonnes of non-recyclable waste into 95 MW of electricity at its heart and a carbon capture, utilisation and storage (CCUS) facility which will treat the excess gasses released from the ERF to remove and store carbon dioxide (CO2) prior to emission into the atmosphere.

2.2.2 The NSIP incorporates a switchyard, to ensure that the power created can be exported to the National Grid or to local businesses, and a water treatment facility, to take water from the mains supply or recycled process water to remove impurities and make it suitable for use in the boilers, the CCUS facility, concrete block manufacture, hydrogen production and the maintenance of the water levels in the wetland area.

2.2.3 The Project will include the following Associated Development to support the operation of the NSIP:

- a bottom ash and flue gas residue handling and treatment facility (RHTF)
- a concrete block manufacturing facility (CBMF)
- a plastic recycling facility (PRF)
- a hydrogen production and storage facility
- an electric vehicle (EV) and hydrogen (H2) refuelling station
- battery storage
- a hydrogen and natural gas above ground installations (AGI)
- a new access road and parking
- a gatehouse and visitor centre with elevated walkway
- railway reinstatement works including, sidings at Dragonby, reinstatement and safety improvements to the 6km private railway spur, and the construction of a new railhead with sidings south of Flixborough Wharf
- a northern and southern district heating and private wire network (DHPWN)
- habitat creation, landscaping and ecological mitigation, including green infrastructure and 65 acre wetland area
- new public rights of way and cycle ways including footbridges
- Sustainable Drainage Systems (SuDS) and flood defence; and
- utility constructions and diversions.

2.2.4 2.2.4 The Project will also include development in connection with the above works such as security gates, fencing, boundary treatment, lighting, hard and soft landscaping, surface and foul water treatment and drainage systems and CCTV.

2.3 Existing Baseline Lighting Conditions

2.3.1 This section provides information on the existing artificial lighting conditions present within the areas of the Application Land, upon which the existing baseline conditions are established. The existing artificial lighting conditions are established via site surveys to determine the day and night-time characteristics for the area of the Application Land and immediate surrounding areas.

2.3.2 The basis of the external lighting strategy within this document takes into consideration the existing lighting conditions and context of the broader environmental and social impacts.

2.3.3 The information for the Project, is broadly divided into three sections to include the existing Flixborough Industrial Estate, the area of brownfield land south of the Estate, the area forming the existing transport corridor connecting the development towards the northeast and south.

2.3.4 Details of the existing baseline lighting conditions are provided within the site survey section 2.4.

2.3.5 The Environmental Site Assessment published 5th January 2021 by ERM Consultants should be referenced for further details of the existing environment and the Landscape Character and Design Appraisal report published October 2020 by LDA Design Consultants for the historic and cultural associations of the landscape and character.

2.4 Site Survey

2.4.1 The site visit was carried out between the hours of 1300hrs and 1900hrs on 25th January 2021.

- sky conditions: clear sky with partial cloud; and
- sunset 14.39hrs.

2.4.2 Moon conditions

- Phase: Waxing Gibbous; Illumination: 89%
- Moon Age: 11.54 days; Moon Angle: 0.50; Moon Distance: 398,414.33 km

- Sun Angle: 0.54; Sun Distance: 147,292,876.25 km

2.4.3 Camera settings:

- Nikon D90 Digital SLR
- Lens: Nikon AF-S 18-105mm f/3.5-5.6, f/22-36.
- Aperture F5.6.

2.4.4 Light meter:

- Konica Minolta Luminance Meter LS-100.
- Type T-10.
- Last calibrated: 9th December 2020.

2.5 Existing Lighting Conditions.

2.5.1 The following provides details of lighting measurements and visual observations of the existing external lighting conditions and lighting applications obtained from the site survey for the relevant areas of proposed development.

Flixborough Industrial Estate

Figure 2-2 Area of survey for the existing Flixborough Industrial Estate.

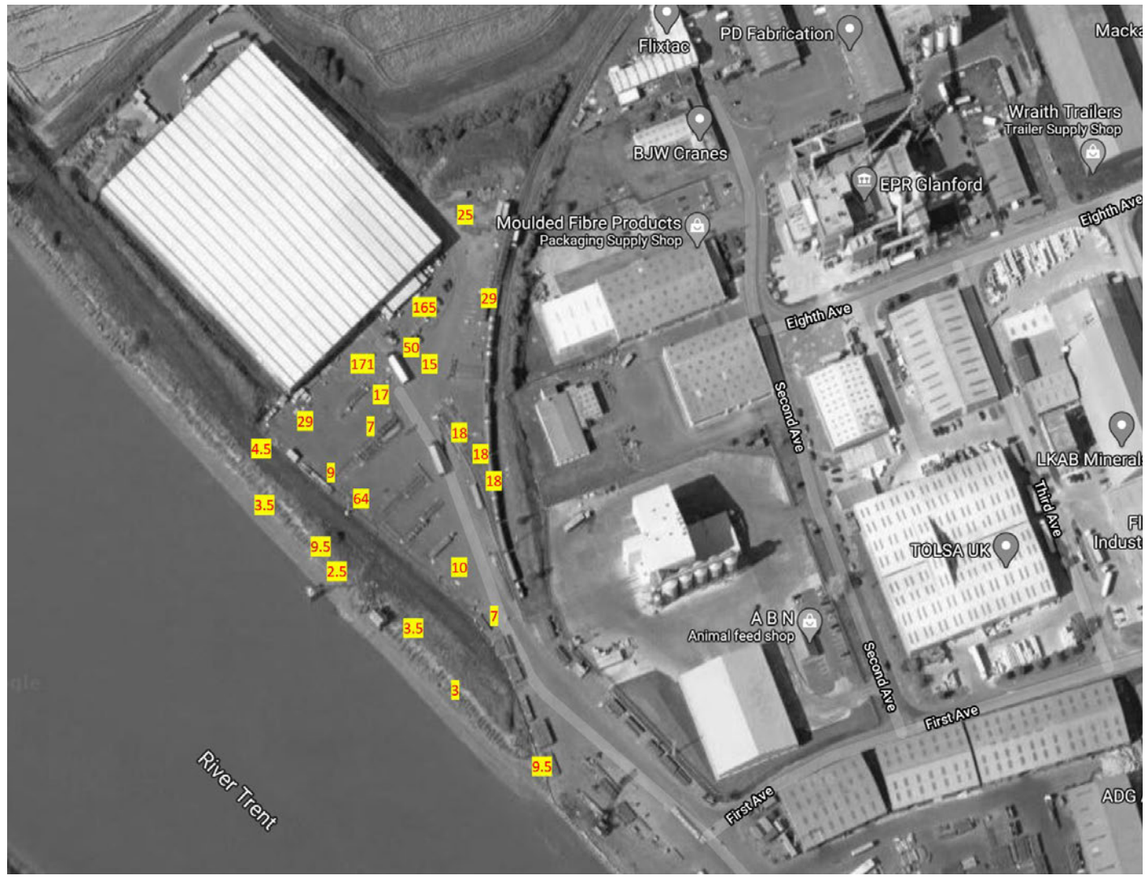


Figure 2-3 Existing illumination levels noted in units of Lux for Area 1 of the existing Flixborough Industrial Estate.

Figure 2-4 Existing illumination levels noted in units of Lux for Area 2 of the existing Flixborough Industrial Estate.

Figure 2-5 Location plan for site photograph reference.

Figure 2-6 View 1.1, North - Entrance to Flixborough Industrial Estate

2.5.2 The external entrance to the Flixborough Industrial Estate is not illuminated at night-time. Stather Road providing access to the estate from the south and northeast is not illuminated.

Figure 2-7 View 1.2, South - Entrance to Flixborough Industrial Estate.

2.5.3 Wall mounted luminaires adjacent the entrance provide illumination upon entering the estate.

Figure 2-8 View 1.2, East - Flixborough Industrial Estate parking area.

Figure 2-9 View 1.3, North - Flixborough Industrial Estate parking area.

2.5.4 Illumination of the car park is provided from wall mounted floodlights located on at high level on building exterior, together with mast mounted flood lights. Illumination levels vary from 58lux to 4lux with low uniformity. The flood lighting generally does not contain light limiting shielding elements and have minimal control for the distribution of light with the majority appearing to utilise wide flood beam distribution characteristics. Whilst the lighting applications for the car park illumination do not appear to emit light spill beyond acceptable levels boundary of the estate, a level of high glare is visually present from the light sources.

Figure 2-10 View 1.3, East - Flixborough Industrial Estate Storage area.

2.5.5 Building façade mounted luminaires provide illumination of the perimeter areas around the buildings and adjacent circulations routes. Light sources are a mixture of metal halide and LED floodlights.

Figure 2-11 View 1.4, East - Flixborough Industrial Estate Storage area.

2.5.6 The area of storage located east of viewpoint 1.3 is illuminated via a combination building-mounted flood lights and high-level lighting masts.

Figure 2-12 View 1.3, North - Flixborough Industrial Estate, port gantry crane.

2.5.7 The lighting fixtures located at high-level on the port side crane are unshielded from light projected towards the River Trent and are a contributing factor of light spill onto the River Trent.

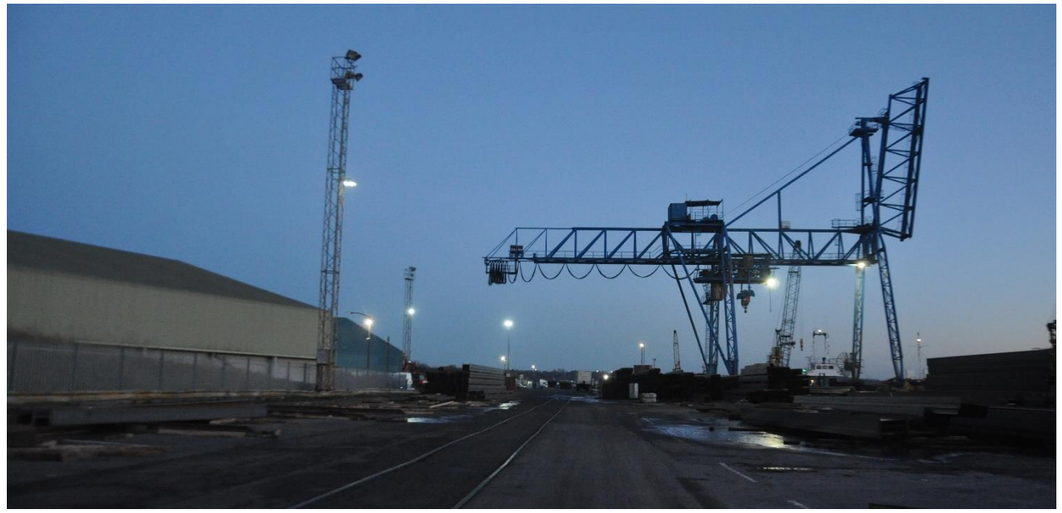


Figure 2-13 View 1.4, South - Flixborough Industrial Estate, port loading bay.

2.5.8 The lighting for the area of port and loading bay are addressed via a combination of lighting masts with multiple floodlights, lighting columns and localised lighting on the crane structure. The light sources are a mixture of LED and metal halide.

Figure 2-14 View 1.4, South - Flixborough Industrial Estate.

Figure 2-15 View 1.4, South-West - Flixborough Industrial Estate, port loading bay.

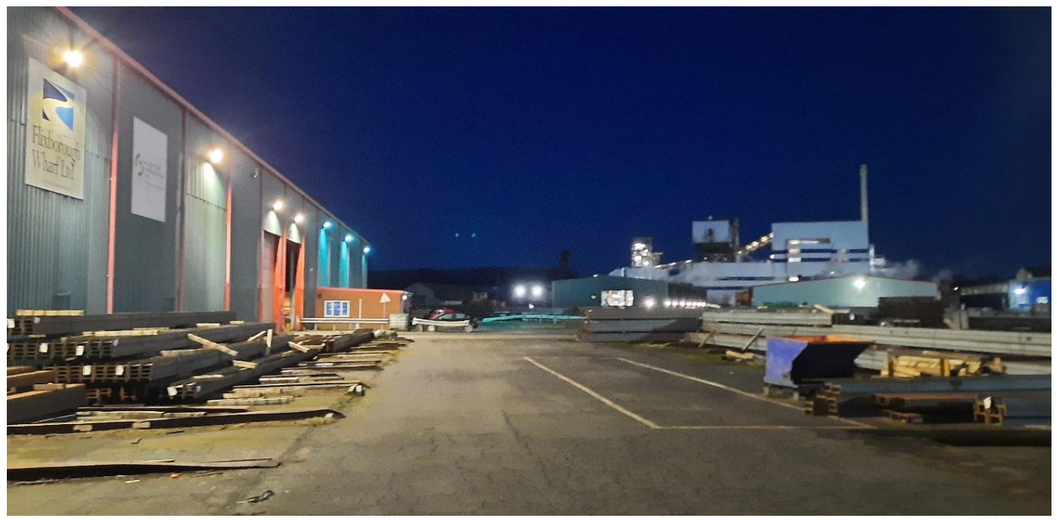


Figure 2-17 View 1.4, East - Flixborough Industrial Estate.

Figure 2-16 View 1.3, North - Flixborough Industrial Estate.

2.6 Existing Areas of Proposed Development and Surrounding Roadways Infrastructure

Figure 2-18 View 2.1 – Photograph viewpoint location plan.

Figure 2-19 View 2.1, North – Stather Road.

2.6.1 Stather Road runs parallel to the River Trent from the B1216, Ferry Road West, providing the current access to Flixborough Industrial Estate from the road network south connecting with the M181. Stather Road is unilluminated during hours of darkness.

2.6.2 The area of land adjacent Stather Road running parallel to the River Trent is of an elevated section, forming means of flood defence.

Figure 2-20 View 2.1, Northeast – Stather Road.

2.6.3 The area east of Stather Road, consist predominantly of agricultural and brownfield land.

2.6.4 The area is unilluminated during hours of darkness. Light measurement reading between 0.13 and 0.17lux, generally consisting of light contributions from the moon and skyglow.

2.6.5 The area of Application Land is within a lower section of land surrounded by higher elevated sections north, and east, together with trees lining the perimeter. The perimeter area south is demarcated by the B1216, Ferry Road and A1077, Phoenix Parkway, which are both slightly elevated with partial hedge row and small trees lining the roads either side.

Figure 2-21 View 2.1, East – Stather Road.

Figure 2-22 View 2.2, North – Stather Road

2.6.6 Wild grass and small trees line the elevated areas between Stater Road and the River Trent.

Figure 2-23 View 2.3, South – Entrance to Rainham Steel from Stather Road.

2.6.7 The entrance to the Rainham Steel works, includes for lighting columns located at the entrance a perimeter area within the steel works. The lighting is only made operational as required for illumination during hours of darkness.

Figure 2-24 View 2.3, South – Stather Road. Entrance to steel works.

Figure 2-25 View 2.3, East – Stather Road.

Figure 2-26 View 2.4, East – Stather Road.

2.6.8 Lighting visual on the right are those providing local illumination within the industrial estate.

Figure 2-27 View 2.4, East - Stather Road.

2.6.9 The section of Stather Road leading east towards Flixborough Town is unilluminated during the hours of darkness.

Figure 2-28 View 2.5, South – First Avenue.

2.6.10 The network of roads servicing both vehicular and pedestrian access within the Flixborough Industrial Estate are illuminated with lighting columns to an expected road lighting classification of C2 (20lux minimum maintained - BS 5489-1:2020).

Figure 2-29 View 2.5, Northwest – Access road leading to private property. Unilluminated.

Figure 2-30 View 2.5, North.

Figure 2-31 View 2.6, West – First Avenue.

Figure 2-32 View 2.6, East – Stather Road

2.6.11 The view east towards Flixbotrough Town is obstructed by the inclination of landscape and tree lined horizon.

Figure 2-33 – View 2.6, West – Stather Road.

Figure 2-34 View 2.7, Southeast - Stather Road junction towards B1216

2.6.12 Ferry Road West (B1216) connecting Sather Road with main road network is illuminaited from the junction eastwards utilising lighting columns. The area of the Application Land north is unilluminated with partial foliage cover from the roadside.

Figure 2-35 View 2.8, East – Ferry Road Junction with Phoenix Parkway (A1077).

Figure 2-36 View 2.9, East – Ferry Road Junction with Phoenix Parkway (A1077).

2.6.13 Phoenix Parkway to the southeast of the Application Land is on a elevated section with partial screening from small trees and shrubs. The area of residential housing south of Phoenix Parkway is more densely populated with a tree lined perimeter to the roadyway, providing shielding and direct view of the road and adjacent areas north.

Figure 2-37 View 2.10, East – Ferry Road Junction with Phoenix Parkway (A1077).

Figure 2-38 View 2.11, North –Holyrood Drive.

2.6.14 Southeast of the Application Land located on Holyrood Drive the Skippingdale Retail Park and various retail and industrial units.

Figure 2-39 View 2.11, North –Holyrood Drive

Figure 2-40 View 2.12, North – Holyrood Drive

2.7 Roadways within the Order Limits

2.7.1 The lighting provisions of the existing network of roadways within the Order Limits, are intended to remain as per their current provisions, with modifications to lighting arrangements to cater for the new junctions proposed on Ferry Road West (B1216), and Sather Road.

Figure 2-41 Viewpoint Location Map

Figure 2-42 View 3.1 North – Stather Road

2.7.2 Sather Road is intended to be remain is to remain unilluminated as per existing conditions.

Figure 2-43 View 3.2 South – Phoenix Parkway (A1077).

2.7.3 The section of A1077 south from the B1216 junction to the M181/A18 junction is to remain unilluminated as per existing conditions.

Figure 2-44 View 3.3 South – M181

2.7.4 The M181 south from the A18 junction is a illuminated section of roadway with lighting columns located on each side of the roadside verge. Considered to be illuminated within a Category M3 lighting classification (BS5489). No alternations to the existing lighting are envisaged.

Figure 2-45 View 3.4 East – South – Phoenix Parkway (A1077).

2.7.5 The section of A1077 east from the Holyrood Drive junction is a illuminated section of carriageway with lighting columns located on the south side of the roadside verge. Considered to be illuminated within a Category M3 lighting classification (BS5489). No alternations to the existing lighting are envisaged.

Figure 2-46 View 3.5 East – Mannaberg Way

2.7.6 Mannaberg Way is an illuminated section of carriageway with lighting columns located on the both of the roadside verges. Considered to be illuminated within a Category M4 lighting classification (BS5489). No alternations to the existing lighting are envisaged.

2.8 Site Survey and Baseline Conditions Summary

2.8.1 The existing external lighting of the industrial estate utilises various light sources, predominantly LED and metal halide with a few sources entertaining sodium lamps. An element of glare is present from the existing lighting together with excessive light spill onto the River Trent. Other than the light spill onto the River Trent the existing lighting does not appear to exceed the permissible levels of light spill beyond the boundary of the industrial estate, however there is an element of upward light present, which contributes toward light pollution onto the naked sky.

2.8.2 The rural lands south of the Flixborough Industrial Estate are predominantly unilluminated.

2.8.3 Stather Road currently providing the main form of vehicular and pedestrian access to the Flixborough Industrial Estate is unilluminated.

2.8.4 The Flixborough Industrial Estate is identified as being within a Lighting Environmental Classification of Zone 3 – Suburban, Medium district brightness (ILP GN01:20). The area of brownfield land south of the estate is identified as beign within a Lighting Environmental Classification of Zone 2 – Rural, low district brightness (ILP GN01:20).

2.8.5 Please refer to section 3.2 denoting the exisitng enviromental lighting classification of areas withint the Application Land.

2.9 Sensitive Receptors

2.9.1 In order to establish the parameters by which spill light from artificial lighting is to be assessed, all relevant sensitive receptors must be identified.

2.9.2 As the Application Land and surrounding areas are assumed to be in Environmental Zone E2 to E3, with ecological receptors identified in the surrounding areas.

2.9.3 Sensitive receptors in this case are:

Internal to Order Limits

2.9.4 **1. Badger setts:** Culverted areas and drainage channels are potential home to badgers and their nests. Plausible effects of artificial lighting on mammals include and are not limited to:

- disruption of foraging behaviour and increased risk of predation
- disruption of the animal's biological clock and reduction of melatonin production
- higher probability of roadkill and road accidents; and
- disruption of dispersal movement and corridor use

2.9.5 Badgers are nocturnal animals and have a rod-dominated visual system, which makes them highly sensitive to lighting. Very intense artificial lighting cast onto their environment has the potential of severely impact their life cycle by temporarily blinding them because the rods in their eyes become unresponsive.

2.9.6 Permanent artificial lighting in areas where badgers live also has the potential of confusing their biological clock by making them believe that it is permanently daytime and therefore leading them to avoid leaving their nests for food foraging, which can lead to body-mass loss and starvation.

2.9.7 **2. River Trent:** Impact of light on the water surface and surrounding areas. Lighting impact to be assessed to avoid potential conflict between vessels from navigational signalling using the River Trent. The River Trent and network of ditches provide commuting and foraging habitats for bats. Artificial lighting without the proper control has the potential to disrupt these behaviours and reduce the suitability of habitats.

2.9.8 **3. New wetland habitats:** These newly created wetland habitats will require minimal light spillage as they will be a potential new habitat for protected species such as the water vole, otters, some nesting birds and foraging and commuting bats and badgers.

2.9.9 **4. Existing woodlands:** Existing areas with diverse tree species that serve as a

refuge and habitat for some protected species and for foraging and commuting bats and badgers

2.9.10 External to the Order Limits. These sensitive receptors have been informed by the ecology team

2.9.11 **1. Amcotts:** Residential buildings near the Application Land. The wider neighbourhood won't be considered within the lighting computational analysis further developed in this document, as it is not immediately adjacent to the Application Land. However, the visual impact of the high-level luminaires should be considered by the wider design team.

2.9.12 **2. Atkinson's Warren:** Semi-natural woodland with scattered and dense scrub.

2.9.13 **3. Phoenix Parkway:** Semi-natural woodland with scattered and dense scrub.

2.9.14 **4. Conesby Quarry:** This is most of a very large ironstone quarry, the western and central parts of which have already been in-filled, leaving a deep depression in the east that is currently being infilled. The diverse flora and fauna is associated with the following main habitats: sparsely vegetated spoil and rock outcrops; dry and damp grassland swards; gorse scrub; invading young grey willow, developing birch woodland; and standing and running water. No habitat management takes place, other than that caused by a large population of rabbits

2.9.15 **5. Dragonby Gullet:** Scrub, semi-improved natural grassland area with lakes.

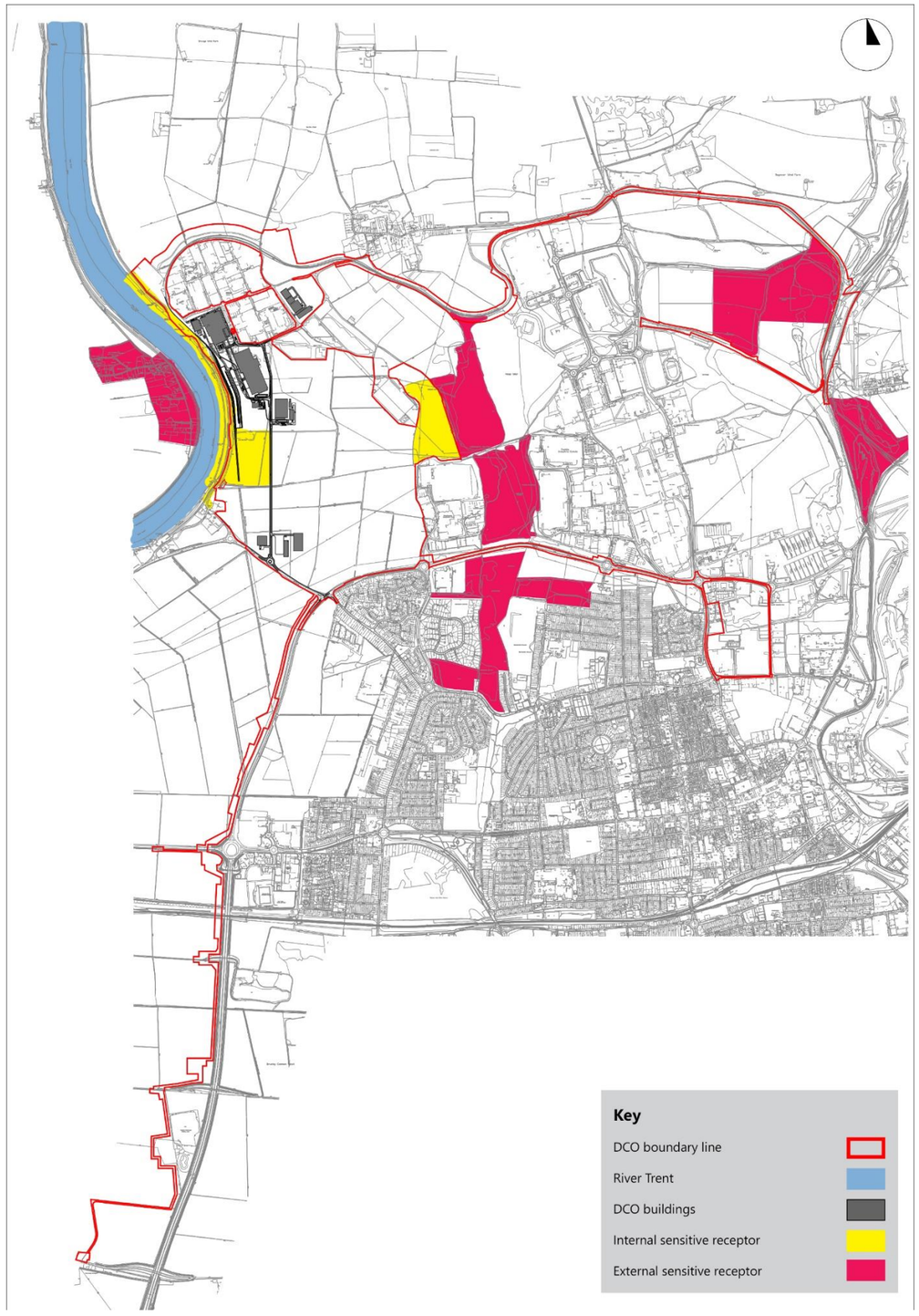


Figure 2-47. Sensitive receptors identified in the area

3 Regulatory Framework

3.1 Lighting Standards, Legislation, and Guidance

Legislative Framework

3.1.2 The Clean Neighbourhoods and Environment Act 2005 gives local authorities and the Environment Agency additional powers to deal with a wide range of issues by classifying light pollution as a statutory nuisance.

3.1.3 The statutory nuisance regime does not include light emitted from light sources which are used for transport purposes and other premises where high levels of light are required for safety and security reasons.

3.1.4 It is expected that the following sources are those with greatest potential to generate issues relating to artificial lighting:

- industrial and commercial security lights
- industrial and commercial external operational lights
- external floodlit facilities; and
- exterior lighting of buildings.

Planning Policy

3.1.5 The National Planning Policy Framework (NPPF 2021) by the Ministry of Housing, Communities and Local Government which seeks to minimise the negative effects of artificial lighting.

3.1.6 Paragraph 180 of the NPPF states, *"Planning policies and decisions should also ensure that new development is appropriate for its location considering the likely effects (including cumulative effects) of pollution on health, living conditions and the natural environment, as well as the potential sensitivity of the site or the wider area to impacts that could arise from the development. In doing so they should: (excerpt C) limit the impact of light pollution from artificial light on local amenity, intrinsically dark landscapes and nature conservation"*.

3.1.7 NPPF is supported by Planning Practice Guidance (PPG), which provides further guidance and makes the following references to light pollution:

- Paragraph 001 (Reference ID 31-001-20191101) states, *"Artificial light provides valuable benefits to society, including through extending opportunities for sport and recreation, and can be essential to a new development. Artificial light is not always necessary, it has the potential to become what is termed 'light pollution' or 'obtrusive light' and not all modern lighting is suitable in all locations. It can be a source of annoyance to people, harmful to wildlife, undermine enjoyment of the countryside or detract from enjoyment of the night sky. However, for maximum benefit, it is important to get the right light, in the right place and for it to be used at the right time"*.
- Paragraph 001 (Reference ID: 31-002-20191101) states, *"Is a proposal likely to have a significant impact on a protected site or species? This could be a particular concern where forms of artificial light with a potentially high impact on wildlife and ecosystems (e.g. white or ultraviolet light) are being proposed close to protected sites, sensitive wildlife receptors or areas, including where the light is likely to shine on water where bats feed"*.
- Paragraph 002 (Reference ID: 31-001-20191101) states, *"Light intrusion occurs when the light 'spills' beyond the boundary of the area being lit. These adverse effects can usually be avoided with careful lamp and luminaire selection and positioning"*.
- Paragraph 003 (Reference ID: 31-001-20191101) states, *"The use of lighting only when the light is required can have a number of benefits, including minimising light pollution, reducing energy consumption, reducing harm to wildlife and improving people's ability to enjoy the night sky. Impacts on sensitive ecological receptors throughout the year, or at particular times (e.g. during bird migrations) may be mitigated by the design of the lighting or by turning it off or down at sensitive times"*.
- Paragraph 005 (Reference ID: 31-001-20191101) of the PPG considers the character of the area and surrounding environment with reference to how these may affect what is an appropriate level of lighting for that type of development proposed. It cautions to avoid glare and an appropriate selection of lighting so that it fulfils its purpose without over-lighting.

Port of Trent Authority

3.1.8 The Port Authority establishes guidance for lighting of the riverbank. The following notes apply to the Project:

- artificial lighting application local to the riverbank, the ferry port or any lighting which may impact on the waterway and naval navigation shall agree with the recommendations of the Port Authority together with the recommendations of the ILP
- illumination directly onto the River Trent shall be avoided, and light spill limited to no more than 2lux, unless deemed required to the purposes of safety and function such as the ferry port in agreement with the Port Authority; and
- as a rule, the use of red, green, and white light onto or near the waterway shall be avoided. It is however expected that the use of white light would be required for the illumination of the ferry port to ensure suitable level of illumination for safe operation.

International Dark-Sky Association

3.1.9 The International Dark-Sky Association is an organisation that provides guidelines for the creation of dark-sky reserves around the world. Its aim is to preserve and protect the night-time environment and our heritage of dark skies through environmentally responsible outdoor lighting. **Although it is not the aim of the Project to obtain recognition from International Dark-Sky Association (IDA), it is important to follow the principles established by this organisation in order to reduce light pollution and generate a night-sky friendly environment.**

3.1.10 The general lighting principles of the IDA should be followed to ensure good lighting that reduces light pollution and its impact on dark skies. Some of the principles established are as follows:

- new lighting should not adversely degrade the sky quality beyond the immediate area to be lit
- angle light downward. No unnecessary light above or near the horizontal
- luminaires should be aimed towards where the light is needed, carefully considering the spill on the natural environment and neighbouring properties
- luminaires should be switched off when not needed. The use of smart control systems is highly recommended
- do not over illuminate
- avoid bright white and cooler temperature LED's (anything above 3000K); and
- install luminaires at lowest possible height to achieve lighting levels.

Figure 3-1 Example of luminaire types approved by the IDA - (Source IDA)

Impact of Light Pollution

3.1.11 The IDA guidance notes also contain information about the impact of light pollution in other areas. The impact of light pollution is not only confined to the visibility of stars at night and obtrusive light. It also affects the following animals:

Bats

3.1.12 As nocturnal specialists, most bat species are susceptible to artificial light. Due to the decline in numbers, all bat species are protected by the Wildlife & Countryside Act (1981) and the Conservations Regulations (1994). This makes it illegal to kill, capture or disturb bats, obstruct access to roosts or damage/destroy roosts. Lighting in the vicinity of bat roosts causing disturbance could constitute an offence. When working in an area where there are bat habitats, developers should:

- refer to Ecological report for identification of sensitive locations for bat habitats and roosting
- not directly illuminate bat roosts; and
- avoid illuminating foraging areas and route

Birds

3.1.13 Evidence shows that artificial light can reduce sleep in birds, which disrupts the long-term circadian rhythm that dictates the onset of breeding. Birds are likely to be disrupted by changes to insect behaviour due to artificial lights. In general:

- do not directly illuminate important areas for nesting birds – probably wildlife sites

Invertebrates

3.1.14 Moths attracted to lights are a familiar sight. Artificial light, particularly blue UV rich, significantly impacts invertebrates, disturbing feeding, breeding and movement which may reduce and fragment populations. It is estimated that a third of insects that are attracted to lights will die as a result of their encounter. Evidence also shows that pollination rates in illuminated plans can be reduced by 62% - (Knop et al 2017. Nature 548). In general:

- avoid illuminating water or reflective surfaces
- do not illuminate ecologically sensitive areas
- use colour temperature, CCTs of less than 3000K; and
- use narrow band minimal UV source

The ILP (Institute of Lighting Professionals) notes for the reduction of obtrusive light GN01

3.1.15 The Institute of Lighting Professionals (ILP) has produced the '*Guidance Notes for the Reduction of Obtrusive Light* (Guidance Note GN01:20), along with the '*SLL Code for Lighting 2012*' provide guidance for local authorities with a recommendation that they are incorporated at the local plan level. The guidance defines various forms of light pollution and describes a series of environmental zones and how to provide external lighting in each of these zones to mitigate unwanted light. The ILP guidance notes provide suitable criteria against which the effects of artificial lighting can be assessed and have been used in this assessment

3.1.16 The main potential issues with artificial lighting within a site of this environmental context are:

- poorly controlled sources
- where light is not directed into the required area and is lit with excessive amounts of light; and
- where an area is lit too brightly for its purpose, and excess light is reflected upwards.

3.1.17 Figure 3-2 shows the key characteristics of how the artificial lighting design for a development should be developed – 'Useful Light' (as required for functional use), 'Spill Light', and 'Light Trespass' (Light that is not wanted or required. This light may be a nuisance to others, a waste of energy, and an unnecessary source of greenhouse gases).

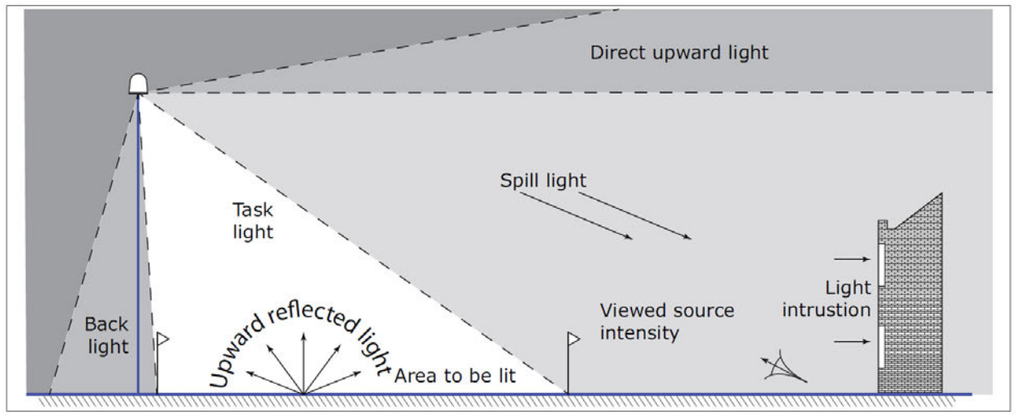


Figure 3-2 - Types of obtrusive light – (Source: ILP GN01/20)

3.2 Lighting Environmental Zones

3.2.1 The classification of Lighting Environmental Zones in the UK are established within the documents GN01/20, 'Guidance notes for the reduction of obtrusive light' published by the Institute of Lighting Professionals (ILP).

3.2.2 As with any new development, there is a risk that the proposed lighting strategy may have a negative impact on the surrounding environment and residents, in terms of light spillage, brightness or glare. The identification of four environmental zones have been established as a basis for outdoor lighting regulations.

3.2.3 The environmental zone rating can be used to help ensure that the lighting goals of an environment are appropriately defined and met, considering the context and relevant surroundings.

Table 2: Environmental zones

Zone	Surrounding	Lighting environment	Examples
E0	Protected	Dark (SQM 20.5+)	Astronomical Observable dark skies, UNESCO starlight reserves, IDA dark sky places
E1	Natural	Dark (SQM 20 to 20.5)	Relatively uninhabited rural areas, National Parks, Areas of Outstanding Natural Beauty, IDA buffer zones etc.
E2	Rural	Low district brightness (SQM ~15 to 20)	Sparsely inhabited rural areas, village or relatively dark outer suburban locations
E3	Suburban	Medium district brightness	Well inhabited rural and urban settlements, small town centres of suburban locations
E4	Urban	High district brightness	Town/city centres with high levels of night-time activity

Notes:

1. 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.
2. Rural zones under protected designations should use a higher standard of policy.
3. Zone E0 must always be surrounded by an E1 Zone.
4. Zoning should be agreed with the local planning authority and due to local requirements a more stringent zone classification may be applied to protect special/specific areas.
5. SQM (Sky Quality Measurements) referenced by the International Dark-Sky Association (IDA), the criteria for E0 being revised in mid 2019 but not retrospective.
6. Astronomical observable dark skies will offer clearer views of the Milky Way and of other objects such as the Andromeda galaxy and the Orion Nebula.
7. Although values of SQM 20 to 20.5 may not offer clear views of astronomical dark sky objects such as the Milky Way, these skies will have their own relative intrinsic value in the UK.

Figure 3-3 - Extract table on guidance for the reduction of obtrusive lighting – (Source: ILP GN01/20)

3.2.4 The Application Land has been subdivided into different Lighting Environmental Zones that will set the conditions for the lighting in the external areas with the main purpose of protecting the natural environment and neighbouring communities.

3.2.5 Figure 3-4, denotes the valuation of environmental zones for the Application Land is based upon the ILP GN01:20. The final confirmation of Environmental Zones are to be determined by the Local Planning Authorities. The above provides an indication of zone classifications based on the review of existing areas and the Application Land with reference to the ILP GN01:20.

3.2.6 Most of the Application Land areas are classified as E3 suburban areas. Despite being in a rural area, the industrial nature of the Project requires lighting levels to be higher than those used in a E2 lighting environmental zone.

3.2.7 The lighting classification for the river edge and proposed Wetland habitat is noted as Environmental Lighting Zone E2 in order to keep these areas relatively dark but acknowledging that there are tasks that must be performed in them. however additional considerations are also to be considered and compliance with the requirement of the local marine authority and the boat operators are also required to be adhered to.

3.2.8 Finally, the river and the enhanced woodland areas have been classified as E1 in order to keep them as naturally dark areas.

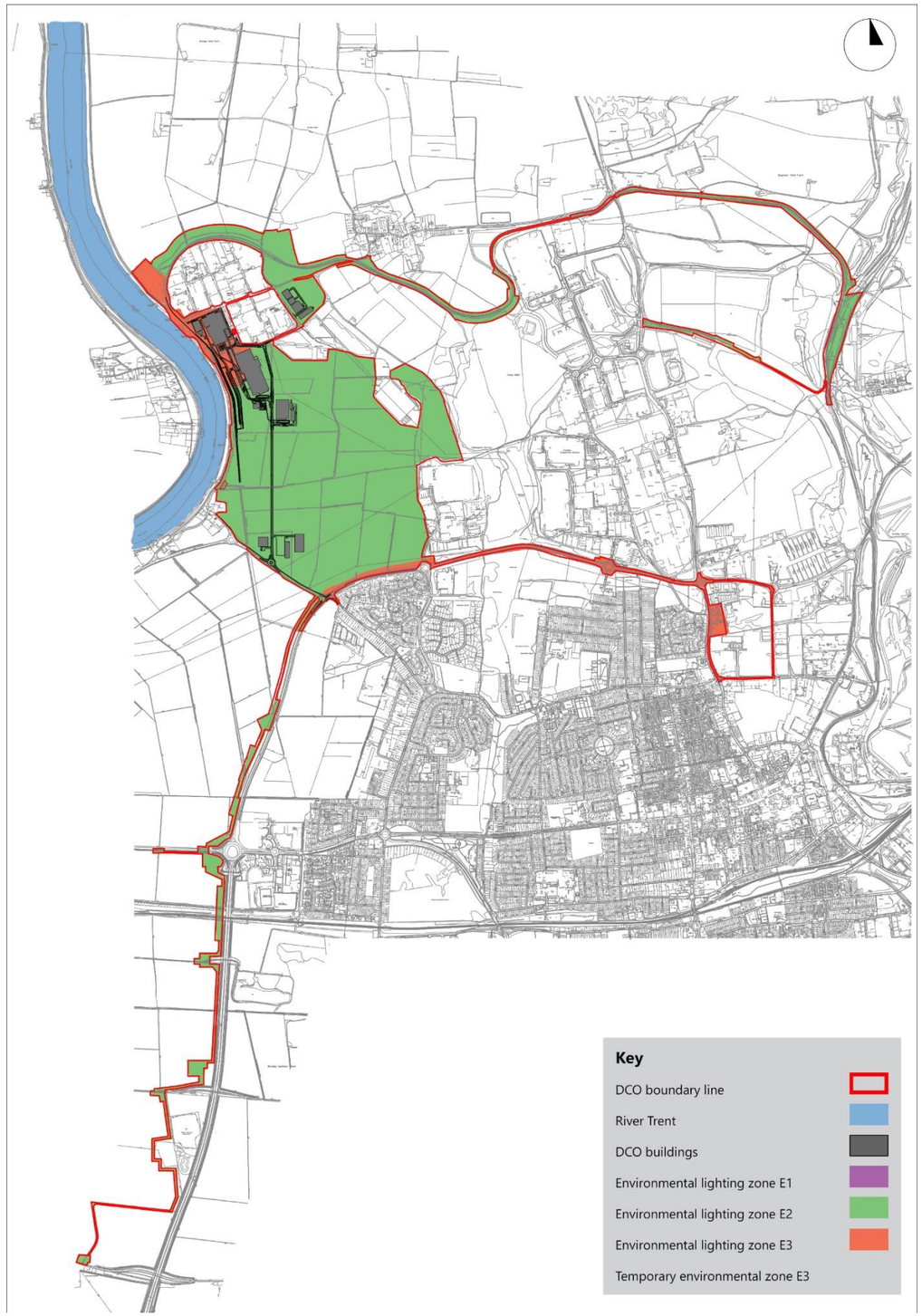


Figure 3-4 Current environmental lighting zones across the Order Limits

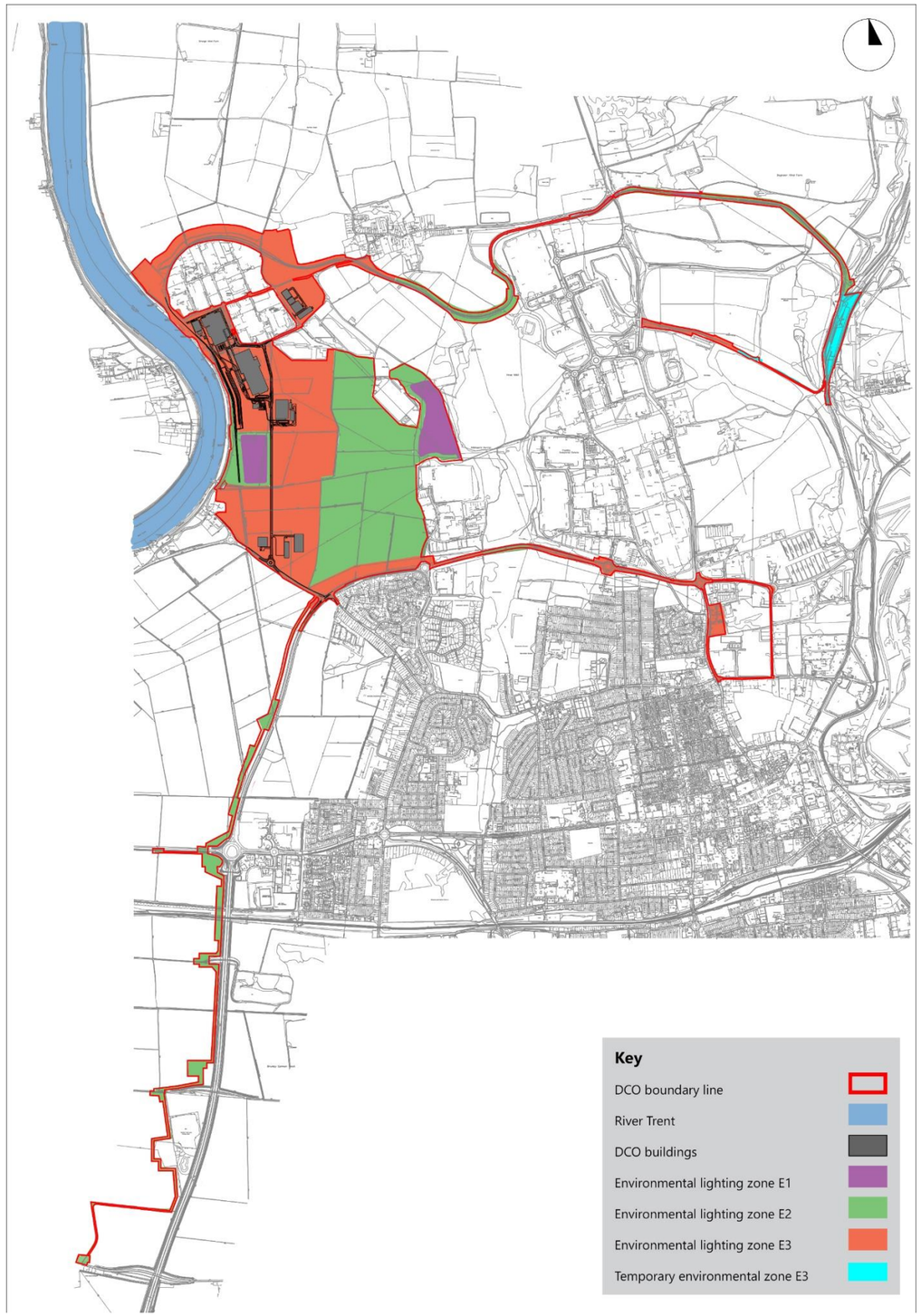


Figure 3-5 Proposed environmental lighting zones across the Order Limits

Table 3-1 – Lighting design criteria for environment lighting zones (Source: ILP GN01/20)

Environmental Zone	Sky Glow ULR (Max %)	Maximum values of vertical illuminance on properties		Luminaire Intensity I (cd)		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	2500	0	0
E2	2.5	5	1	7500	500	5
E3	5	10	2	10,000	1000	10
E4	15	25	5	25,000	2500	25

3.2.9 The ILP has produced guidance on the maximum permissible light spill into windows of adjacent properties, before and after the curfew time, based on which environmental zone the development is located in. Table 3-1 above illustrates the various lighting design criteria associated with meeting the recommendations set out in achieving lighting compliance.

Objective of lighting environmental lighting zones

Environmental Zone E1

3.2.10 No artificial lighting. Maintain the river in its current condition.. The other zones that are classified as E1 are the new wetland habitats and the woodland to the east of the Application Land. This classification aims to avoid the spill of unnecessary lighting onto the water and woodlands possibly affecting the current and improved natural environment.

Environmental Zone E2

3.2.11 This environmental zone is applied to mitigate the glow coming from the Project and neighbouring communities to protect the natural areas that are to be conserved and enhanced. The aim is also to mitigate lighting in such a way that no lighting sources (lamps) are visible from animal habitats, as well as to reduce glow and minimise glare to create a comfortable and safe environment for visitors and the local fauna.

Environmental Zone E3

3.2.12 This environmental zone is designated to areas of the Application Land that have lower levels of intensity and activity. The objective is to provide the necessary levels of light to create a safe and comfortable environment without over illuminating and reducing the spill of light onto buildings and areas of the E2 Environmental Lighting Zone.

Temporary environmental zone E3

3.2.13 This is lighting environmental zone is temporary applied to the area on the east of the Application Land where construction logistics will take place. Once construction is done, it is recommended that the area reverts to environmental lighting zone E2.

4 Lighting Strategy

4.1 Lighting Strategy Objectives

4.1.1 The Project is an innovative proposal that seeks to ensure that as much energy as possible is recovered from waste that can't be recycled. Lighting should be able to help the client visualise this main objective by being considered as an important aspect for the whole area.

4.1.2 Overall, lighting should aim to be appropriate to the local context and will mitigate lighting impacts upon identified habitats, neighbouring occupiers and the wider landscape.

4.1.3 Below are some of the Applicants and the Projects specific objectives and next to them is a description of how lighting can contribute towards the achievement of such objective:

Table 4-1 Lighting strategy objectives against the Project objectives.

Project Specific Objectives (for the external areas)	Lighting Strategy Objectives
Improve cycle and pedestrian connectivity and creation of a New Access Road	Lighting should carefully consider the appropriate illumination of new roads, cycle paths and pedestrian pavements without over illuminating and generating light spill onto the adjacent natural environment. A carefully considered design for new link routes should provide a secure and safe environment, accessible and improve legibility so navigability across the Project can be easy.
Keep the port operational	Lighting to the port should not only keep the port operational by providing the necessary light levels to allow workers to perform a safe and secure job, but it should emphasise the location and selection of luminaires to: • reduce the amount of light spillage onto the river and adjacent natural environment • reduce the amount of light spillage onto the night sky • have accurate optics to direct light where is strictly necessary • have accurate glare control accessories and appropriate shielding to minimise light spillage and glare; and • have smart control systems that allow the client and operator to minimise waste following the spirit of the Project.
Reinstatement of railway line	Lighting to the reinstated railway lines should aim to: • provide the necessary levels of light without over illuminating; and • luminaires should use accurate optical distribution and glare control elements to direct the light where it is strictly necessary.
Continued well-being and safety of employees and the local community	The lighting proposal for the area should aim to: • be designed to provide an overall sense of security supporting both active and general passive surveillance. Lighting should provide adequate recognition and modelling of people where required • support the needs of all people visiting, working and passing through after dark. Design measures must include the avoidance of high contrasts, direct and reflected sources of glare, and confusing upward lighting; and • be designed to keep a safe environment. The positive definition of potential hazards such as level changes and borders, and the adequate illumination of areas where pedestrians are likely to encounter moving vehicles should take priority in the lighting design for the external areas of the Project.

4.2 Lighting Principles

Colour Temperature and Colour Rendering Index

4.2.2 Warm light is proposed to be used across all the Application Land area with special importance in the Trent Shoreline and the wetland habitats for the following reasons:

- any type of light could suppress the secretion of melatonin in human beings and different animals, however the exposure to blue light at night does so more powerfully as retina is more sensitive to blue light wavelength. Red light has very small impact on the melanopsin receptors, and they do no stimulate wakefulness. Warm light has higher quantities of red light, therefore is the appropriate light to generate a relaxed environment
- according to different scientific studies and the International Dark Sky Association (IDA) blue light brightens the night sky more than any other colour of light, so it is important to minimize the amount emitted.

- red, amber and yellow light, and light up to 2200K have a shorter wavelength than 3000K, 4000K light. This is beneficial for the animals as they are less attracted to this type of light therefore generating less disturbance on the natural environment at night; and
- as high CRI is required in this project due to its industrial nature, we recommend a set colour temperature overall of **2700K for circulation areas, and areas around the river edge, and 3000K for building-mounted luminaires in areas around buildings.**

4.2.3 The Colour Rendering Index provides an objective indication of the ability of a light source to render the colours of various objects faithfully, in comparison with a natural light source. The general colour rendering index Ra has been introduced to specify the colour rendering properties of a light source. The maximum value of Ra is 100. This figure decreases with decreasing colour rendering quality.

4.2.4 It is important for visual performance and the feeling of comfort and well-being that colours of objects and of human skin are rendered naturally, correctly and in a way that makes people look attractive and healthy.

4.2.5 In principle, exterior lighting applications do not have the same requirements as interior environments in terms of colour rendition. Over the last 20 years, 60-70 CRI value was commonly encountered in exterior lighting schemes. As technology progresses, the light quality of LEDs improves rapidly. Long-standing high-quality lighting manufacturers now provide a minimum of CRI 80 for outdoor products.

Figure 4-1 Differences between CRI levels

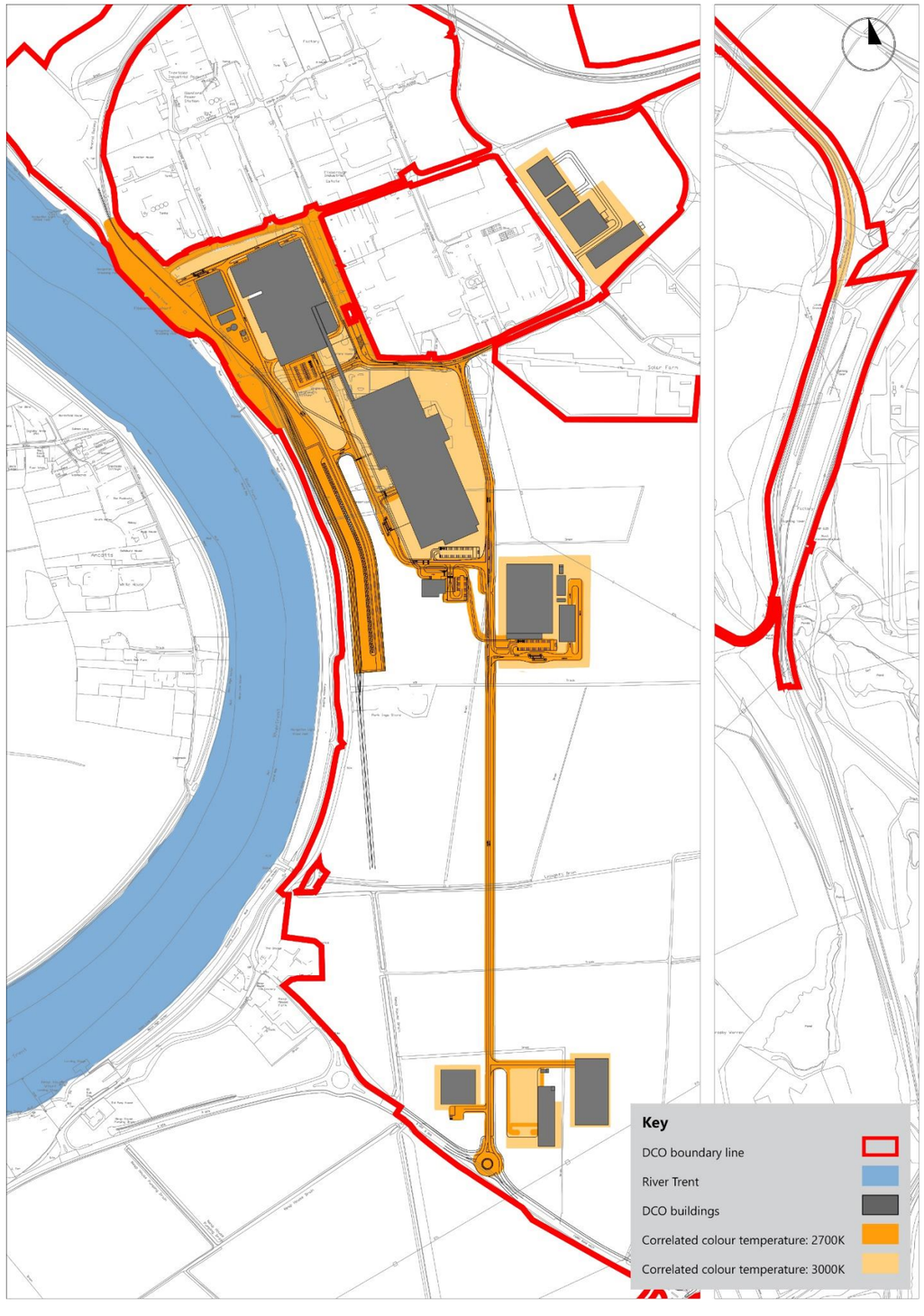


Figure 4-2 Proposed light colour temperature across the Project.

Intensity

4.2.6 The intensity of light across the Application Land must be appropriately considered from the brightest thoroughfares to the dimmest landscaped areas, both for the area in question, and in relation to adjacent areas.

4.2.7 Users' safety, security and comfort is of primary importance and a considered approach to the amount of light employed across the Application Land will help improve all these measures. Varied levels of light intensity will act to increase the legibility of the area, improving peoples' orientation as they move through the site.

Mounting Height and Shielding

4.2.8 The mounting height of the lighting equipment will contribute to the perceived scale of spaces. Mounting luminaires too high on columns or buildings risks creating an environment that feels unwelcoming and scale-less for pedestrians and an increased proportion of spilled and uncontrolled light on the natural environment, however the industrial characteristic and use of the site requires so.

4.2.9 Therefore, shielding is required in certain lighting fixtures. It helps to minimise the amount of light that can spill onto the night sky and the surrounding natural environment

4.2.10 In principle luminaires across the Order Limits should:

- have integrated or integrated and additional external shielding
- always point downwards; and
- have forward-throwing light distribution with a reduced kickback.

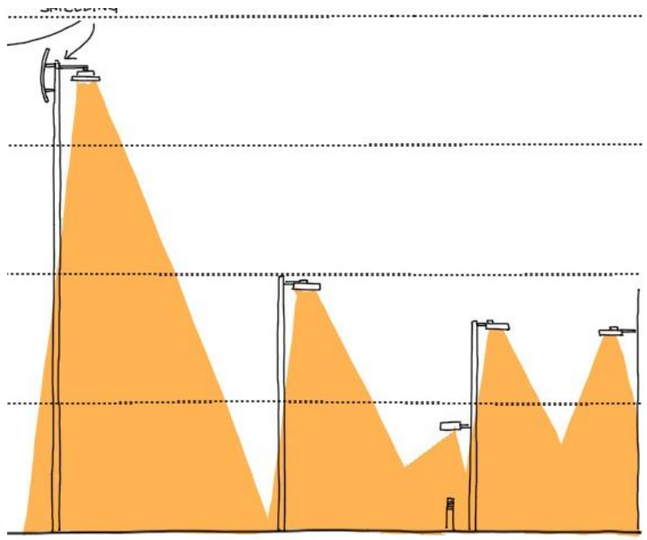


Figure 4-3 Different mounting heights and proposed additional external shielding for high level luminaires.

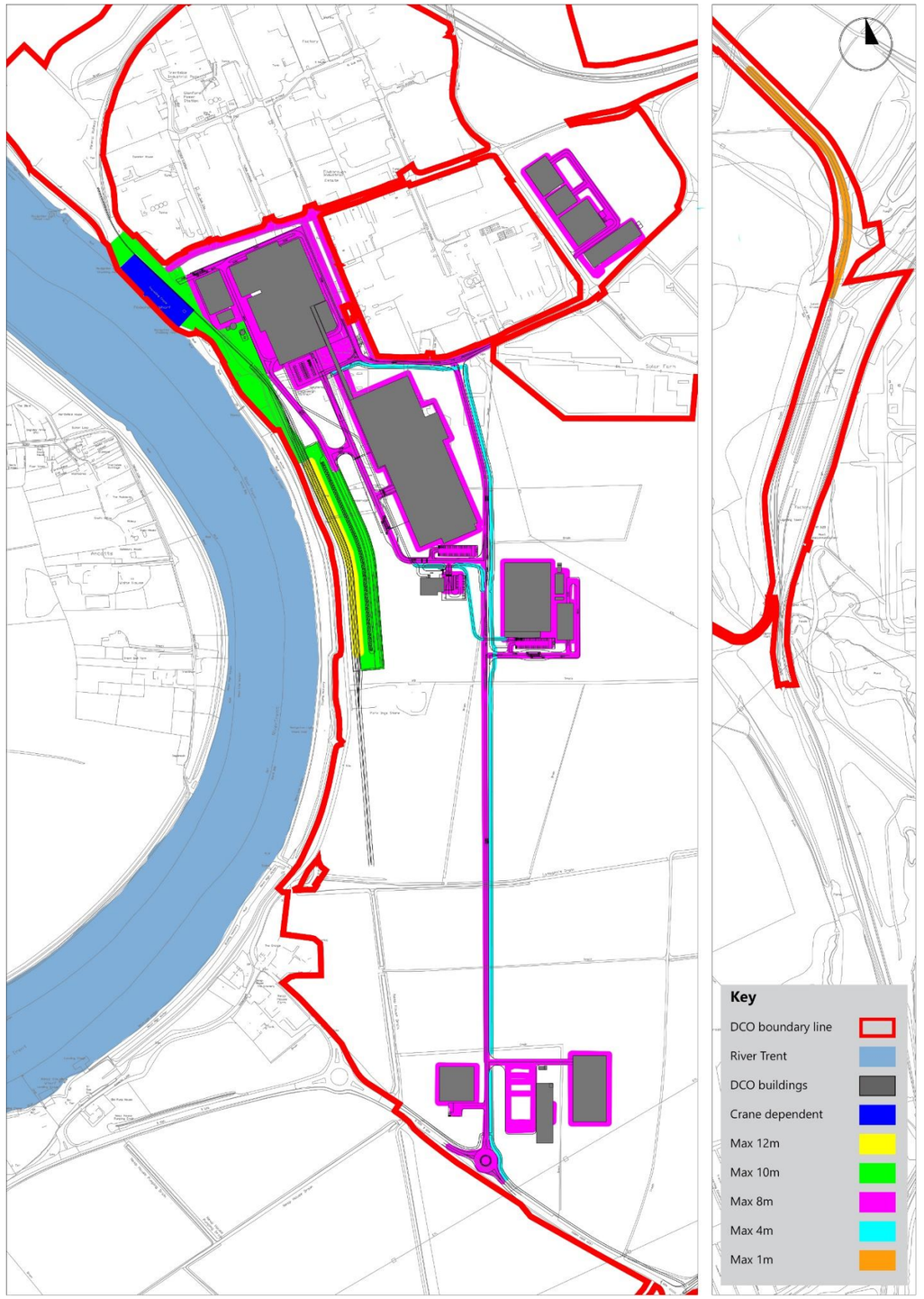


Figure 4-4 Proposed mounting height levels across the Application Land.

Table 4-2 Recommended mounting height summary chart

Proposed maximum height	Location
+20m	Luminaires located to the underside of the travelling crane. **Height is assumed and needs to be re-assessed once definitive design of the wharf is presented.**
Max 12m	Luminaires located on west of the railhead
Max 10m	Luminaires providing infill/additional light to railhead and dock areas
Max 8m	Roads, internal factory roads, parking lots, EV charging points (if uncovered) and building facades
Max 1m	Rail tracks where the rail operator deems necessary the use of lighting. Low-level lighting bollards at either end of a train track where any coupling / uncoupling or shunting work might be involved.

Integrated Shielding

4.2.11 A full cut-off shielded light fixture has an integrated solid barrier at the top, located over the light source (lamp) such that it is covered. The solid housing should not have any translucent parts or diffused materials which will allow for lighting escaping towards the dark sky. These luminaires allow light to be accurately cast downwards into the desired area without major levels of light spill. Spread lenses, snoots, internal/external louvres, honeycomb louvres and other glare mitigation and light control measures can be used in these luminaires to further limit the spread of light beyond a targeted area.

Integrated and External Shielding

4.2.12 Areas within the Lighting Environmental Zones E1 and E2 need further mitigation measures to be adopted in order to fully shield the light from direct line of sight from the marshes and Trent shoreline. 100% light source shielding can be achieved using physical landscape and architectural barriers (such as: dense shrubs and trees and dense low-level vegetation, dunes, bunds, berms, etc.) and, furniture-integrated (or otherwise recessed) luminaires, solid balustrade, solid or very dense screens, and dunes and others, in combination with full cut-off fixtures.

4.2.13 In the case of fixtures mounted at height (more than 10 metres), back shielding shall be used to avoid and minimise the light kickback effect on the ground and direct view of the light source.

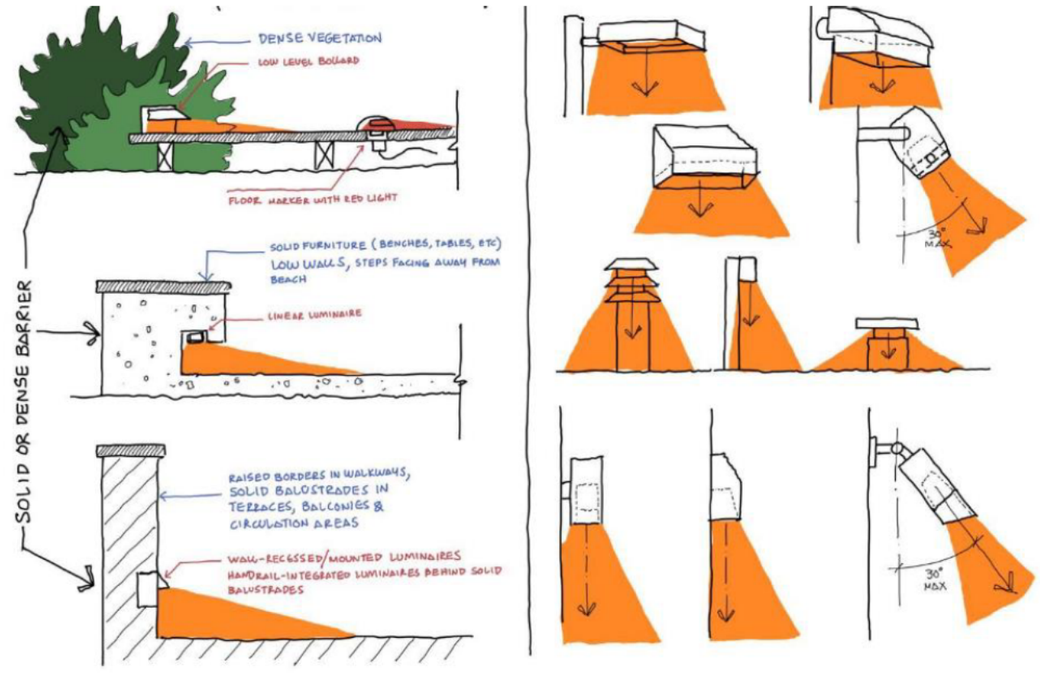


Figure 4-5 Sketches on the left on the above figure show examples of luminaires with integrated shielding and external shielding. The sketches on the right show luminaires with only integrated shielding.

4.3 Circulation and Area Lighting Strategy

4.3.1 The lighting design for the roads, circulation, and open working external areas around and inside the Order Limits should seek to minimise the amount and intensity of light applied to fulfil the various functional and aesthetic objectives demanded by each application. This will not only help to save energy and reduce light pollution, but more importantly it will contribute with the creation of a unique, appropriate, and legible character for each route.

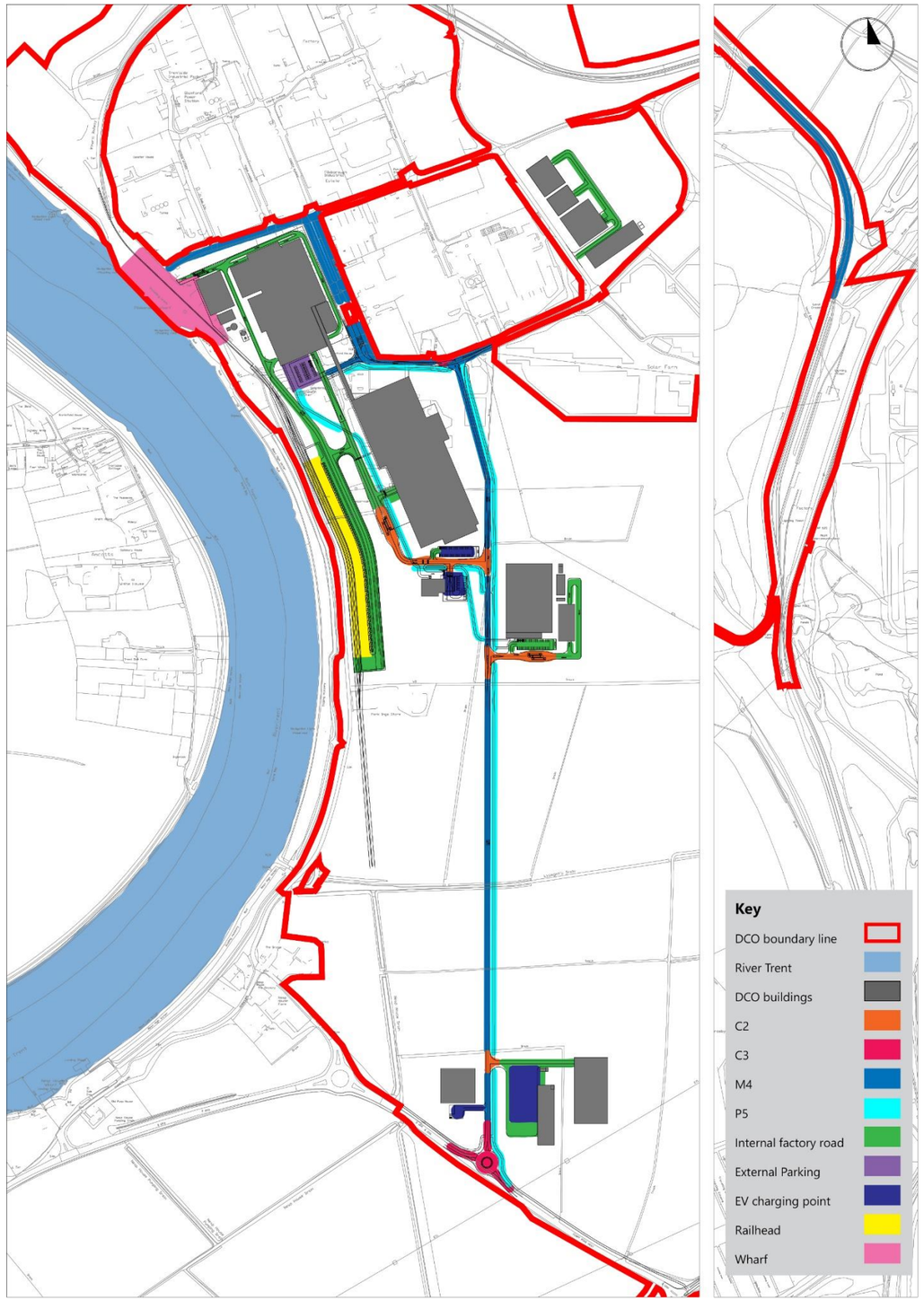


Figure 4-6 Proposed lighting classes around the Application Land

M4 vehicular routes and P5 shared path

4.3.2 This classification is applied to the whole extent of the proposed New Access Road, as it can be categorised as a road for motorised vehicles with a segregated shared path for pedestrians and cycles.

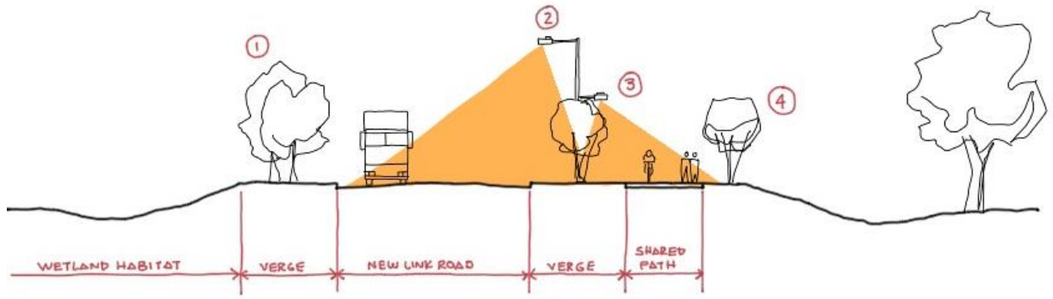


Figure 4-7 Section through New Access Road looking north.

4.3.3 Elements:

1. Planting new vegetation on the western verge of the road will help to decrease the direct visibility of the light source mounted at high level and reduce the light spillage onto the wetland habitat. Constant planting of trees will also reduce the visual impact of the luminaires along the road.
2. Road luminaire mounted at a maximum height of 8.0m. Luminaire should have controlled optical light distribution in order to keep the light to the road only.
3. Shared path luminaire mounted at a maximum height of 4.0m. Luminaire should have controlled optical light distribution to keep the light to the path only.
4. Enhanced planting on the eastern verge of the shared path will accomplish the same purposes as per the western planting.

Internal Factory Routes

4.3.4 This classification is applied to all routes around buildings inside the Order Limits excluding the New Access Road. The lighting levels in this classification are higher than the New Access Road as they will have a higher mixed traffic of motorised vehicles, pedestrians, bicycles and other industrial-type vehicles. Luminaires on these roads should always be facing away from the river.

C2 and C3 Areas

4.3.5 The C2 and C3 (Conflict zone) classification applies to the new roundabouts and junctions along the New Access Road. These classifications require a higher level of illumination in areas that can be prone to accidents.

Car Parks

4.3.6 The lighting classification that applies to this zone has the requirements for a car

park area with a high vehicular volume.

Figure 4-8 Precedent image of luminaires/columns used for car parks

Railheads

4.3.7 The lighting classification in this area follows the recommendations given by Rail consultants Intermodality. It is recommended that the 18m columns are located on the west side of the railhead facing east. This will reduce the amount of light received by the river and the neighbouring community on the opposite side.

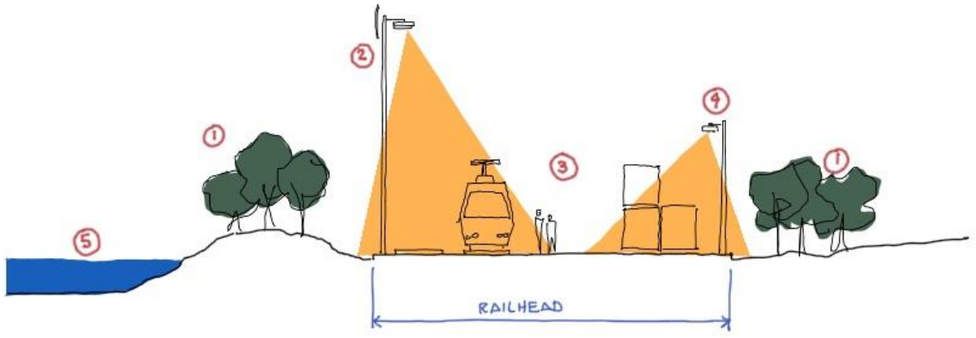


Figure 4-9 Section through railhead showing the two different types of luminaires.

4.3.8 Elements:

1. Tall vegetation proposed on edges of railhead to help mitigate and reduce possible light spill onto the River Trent shoreline and natural areas adjacent to the railhead. The vegetation on this side will also contribute to decrease the visual impact of the lighting columns. **Landscape designers to evaluate the possibility of planting on the embankment or areas around it.**
2. 12m lighting column to the west of the railhead
3. Railhead area
4. 10m lighting column to provide additional lighting if required
5. River Trent.

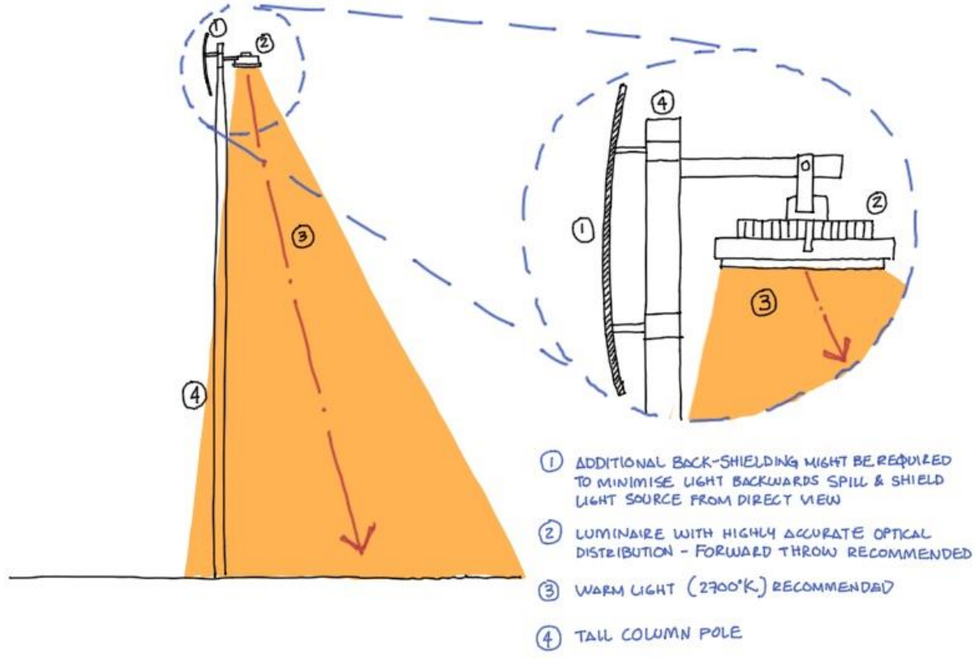


Figure 4-10 Sketch with potential back shielding for 18m columns located in railhead

Docks and EV charging points

4.3.9 The lighting classification in this area follows the recommendations of Table 5.4 – Canals, locks and harbours from the BS EN 12464-2:2014. The harbour and dock in the Order Limits are an external working area that requires higher levels of lighting than other circulation areas within the Application Land.

4.3.10 Same lighting levels apply to EV charging areas and security checkpoints.

External Areas Immediate to Buildings

4.3.11 The external areas to industrial buildings in this area are considered for this report as external working areas. The lighting recommendation provided by the BS-EN 12464-2 set the average lighting levels required on 50lux and a uniformity of 0.40.

4.3.12 It is recommended that the lighting is provided from building-mounted luminaires. They should be always facing downwards, and the optical distribution should be forward throw with a minimised kickback. To reduce the light bouncing on the

building façade, it is recommended that these luminaires are mounted at a maximum height of 8.0m on a bracket/arm that is no shorter than 500mm.

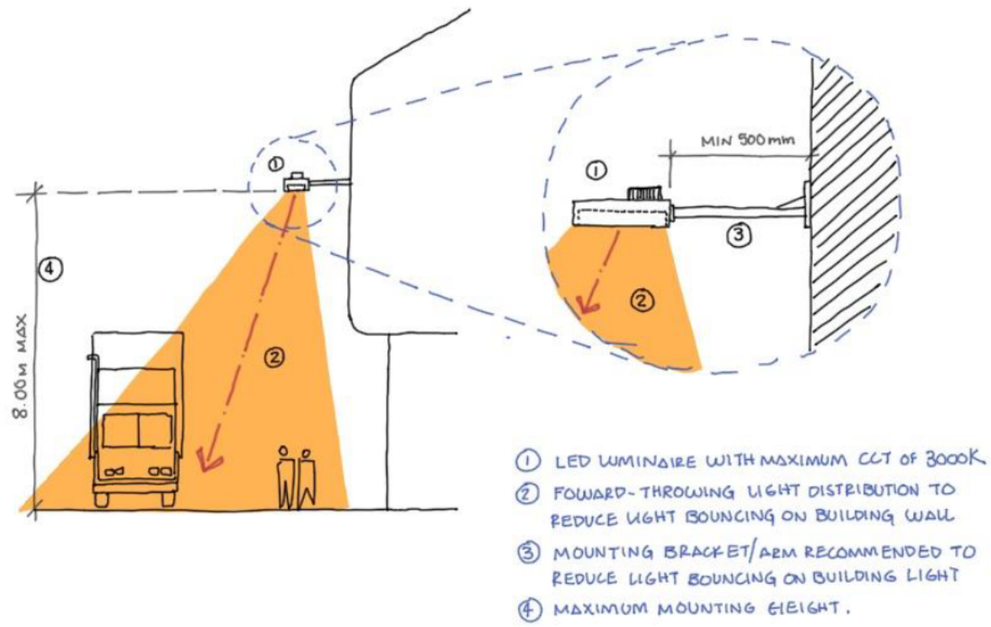


Figure 4-11 Sketch with potential back shielding for 18m columns located in railhead

4.4 Summary Classification Chart

Table 4-3 Summary Classification table

Lighting classification	Average horizontal illuminance	Uniformity	Preliminary strategy
M4	0.75cd/m2	0.40	The lighting for these routes can be provided from max 8m column. Final height dependent on the type of vehicular restrictions for these roads.
P5	3.00 lux	0.25	Lighting for shared paths can be provided from luminaires mounted at max 4.00m on the same columns used for road lighting
Internal factory roads.	20 lux	0.40	It is recommended that the lighting to these conflict areas is to be provided from max 8.00m columns in order to minimise the spill of light. Final height to be dependent on lighting design for the road, client and planning approval
Regular vehicular traffic			from max 8.00m columns in order to minimise the spill of light. Final height to be dependent on lighting design for the road, client and planning approval
C2	20 lux	0.40	It is recommended that the lighting to these conflict areas is to be provided from max 8.00m columns in order to minimise the spill of light. Final height to be dependent on lighting design for the road, client and planning approval
C3	15 lux	0.40	It is recommended that the lighting to these conflict areas is to be provided from max 8.00m columns in order to minimise the spill of light. Final height to be dependent on lighting design for the road, client and planning approval
Car park	20 lux	0.25	It is recommended that the lighting to these conflict areas is to be provided from max 8.00m columns in order to minimise the spill of light.
Railhead	50 lux	0.25	Lighting provided from max 12 and 10m high columns as per recommendation of Intermodality Transport Consultants. Final design should be confirmed by specialist consultant.
Dock, EV charging points and security checkpoints	50 lux	0.40	For the wharf, the lighting is provided from the travelling crane and adjacent columns. The lighting for the security checkpoints and EV charging areas can be provided from the roof structure (if existing) or 8.00m tall columns.
External area immediate to buildings	50 lux	0.40	These areas are categorised as external working environment and for the purpose of this report they are treated as loading/unloading external zones.

Lighting Controls

4.4.2 Smart lighting control systems applied to the lighting equipment installed throughout the public realm in the Application Land can help to reduce energy consumption and operate the lighting schemes in a more efficient way. These systems can be linked to meteorological measurement devices, data collection and

artificial intelligence development centres to create smart operation cycles that will keep non-essential lighting off working 24 hours to minimise energy consumption and reduce lighting levels of essential illumination equipment whilst maintaining safe levels of illuminance overnight.

4.4.3 Advanced lighting technology can limit the operating hours of lighting equipment to reduce running costs and limit environmental impact by setting scenes, curfew times, and dimming levels and times.

4.5 Automatic Control Systems

Astronomical Timeclock

4.5.2 The astronomical timeclock or switch is a is an automatic time-switch control that controls lighting based on the time of day and astronomical events such as sunset and sunrise, accounting for geographic location and calendar date.

4.5.3 Timers with both astronomic and Daylight-Saving Time (DST) functionality automatically adjust to the seasonal day-to-night-time changes throughout the year. An electronic timer with astronomic functionality determines each day's sunrise and sunset times based on geographic location, while the automatic DST functionality resets the clock by one hour in the spring and fall.

Photocells

4.5.4 Photocells are devices that can be incorporated to luminaires or installed remotely and connected to a control system. Photocells can turn lighting on when the ambient light falls below a pre-set level, or automatically adjust the light output of luminaires depending on the amount of natural light available to a maintained illuminance level.

Motion Sensors

4.5.5 These devices can be used as energy-saving sensors in exterior and interior areas, turning of lights in empty zones and turning them on when someone moves along the space. Many of these products have adjustable sensing areas, allowing for different coverage areas in specific locations. They can also be integrated into general control systems and can be used to override lighting scenes.

4.6 Programable Control Systems

DALI

4.6.2 DALI stands for Digital Addressable Lighting Interface and is a manufacturer-independent standard for lighting control in external areas and buildings. It is specifically used in external areas and properties such as offices, shops, restaurants, and hotels, but can perfectly be used in industrial complexes.

4.6.3 It is a communication protocol for building lighting applications and is used for communication between lighting control devices, such as electronic ballasts, brightness sensors or motion detectors and lighting fixtures. It allows the creation and programming of lighting scenes and their triggering times.

4.6.4 The DALI systems can be programmable and connected via wired and wireless systems. They can also receive input from manual switches.

DALI 2

4.6.5 DALI-2 is the updated and improved version of the DALI lighting protocol, which includes more features and more product types and has a strong focus on product interoperability.

4.6.6 Compared with the original DALI version 1 standard, DALI-2 includes clearer specifications for control gear features such as timing, fading, power-on and start-up, as well as new features such as extended fade times. DALI-2 is designed for backwards compatibility, so DALI-2 control gear can be used in older systems.

4.6.7 DALI-2 certification is already available for a broad selection of product types, including LED drivers, control devices (single-master and multi-master application controllers), Further product types – notably sensors of different types, as well as control gear for emergency lighting systems – will follow when technological developers have created the necessary test sequences.

4.6.8 These control mechanisms guarantee that the maximum levels of light can be defined and never be more than 10% of the maximum defined level for specific zones.

5 Digital Lighting Analysis

5.1.1 Using 3D lighting calculation (Relux) and CAD software (AutoCAD) plans were created/extracted to create certain lighting conditions that would allow to demonstrate the effect of artificial lighting on the environment. The following factors and assumptions have been used in the calculation:

- surrounding trees have not been included in the calculation as the various species and shapes cannot be accurately modelled. It is assumed most will be deciduous and the amount of cover offered will be reduced during the winter season. However, it should be noted that the old and new trees in this area will provide further reduction to any spill light and visual impact of the brightness to the Application Land
- this assessment technique simulates and calculates the proposed combined total lighting lumen output (worst case scenario) of the Project. The assessment considers the street lighting, pathway lighting and ferry port lighting. All lighting has been assessed at 100% output
- the result renderings have been shown in 'pseudo colour' format. This visually demonstrates where the lighting (illuminance) will potentially be distributed and by how much
- virtual light metres have also been exported to clearly identify lighting levels (lux) on specific areas of the Application Land so a comparison can be made against the baseline study
- all lighting calculation areas are set at 0.00m (unless stated otherwise), on the same plane as the luminaires, considering this the worst-case scenario. In real conditions, different sensitive zones are at different height levels to the luminaires across the Application Land
- calculations were all done assuming a maintenance factor for luminaires of 0.67; and
- all calculations are facing north.

5.2 Calculation Planes

5.2.1 Three different types of calculation planes are placed to measure the effects of light:

- the plane where the lighting class applies corresponds to the area being lit
- the buffer zone: this calculation plane has been placed next to the lit area to measure the amount of light that this potential shielding zone receives. It has a width of 5.00m; and
- the protected environment. This calculation plane is placed to measure the maximum levels of light that the protected environment areas can receive.

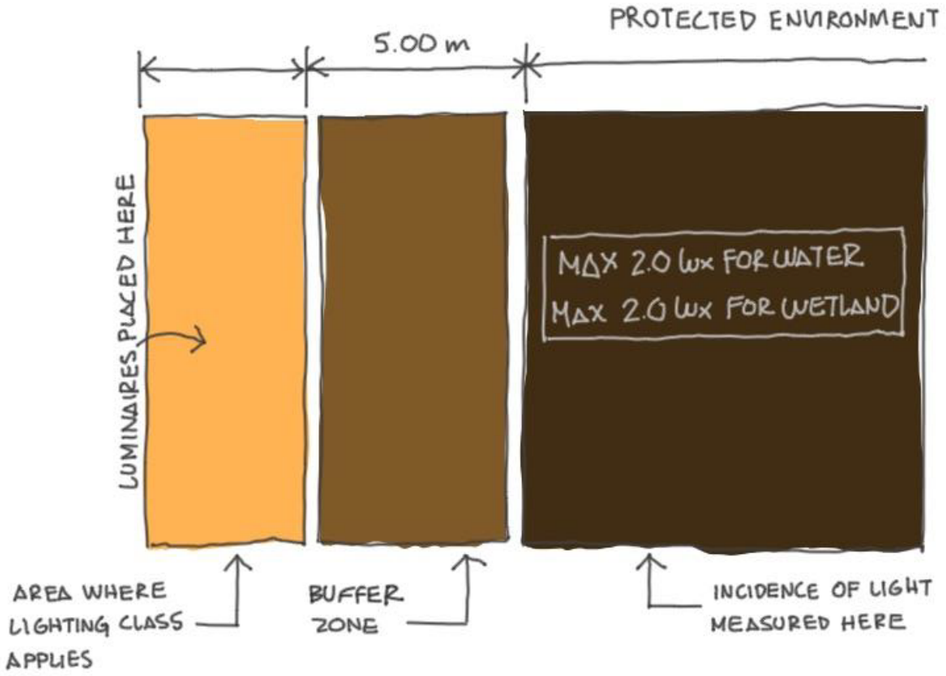


Figure 5-1 Scheme showing the different calculation planes and the threshold established for the natural protected zones

5.3 Areas to be Analysed

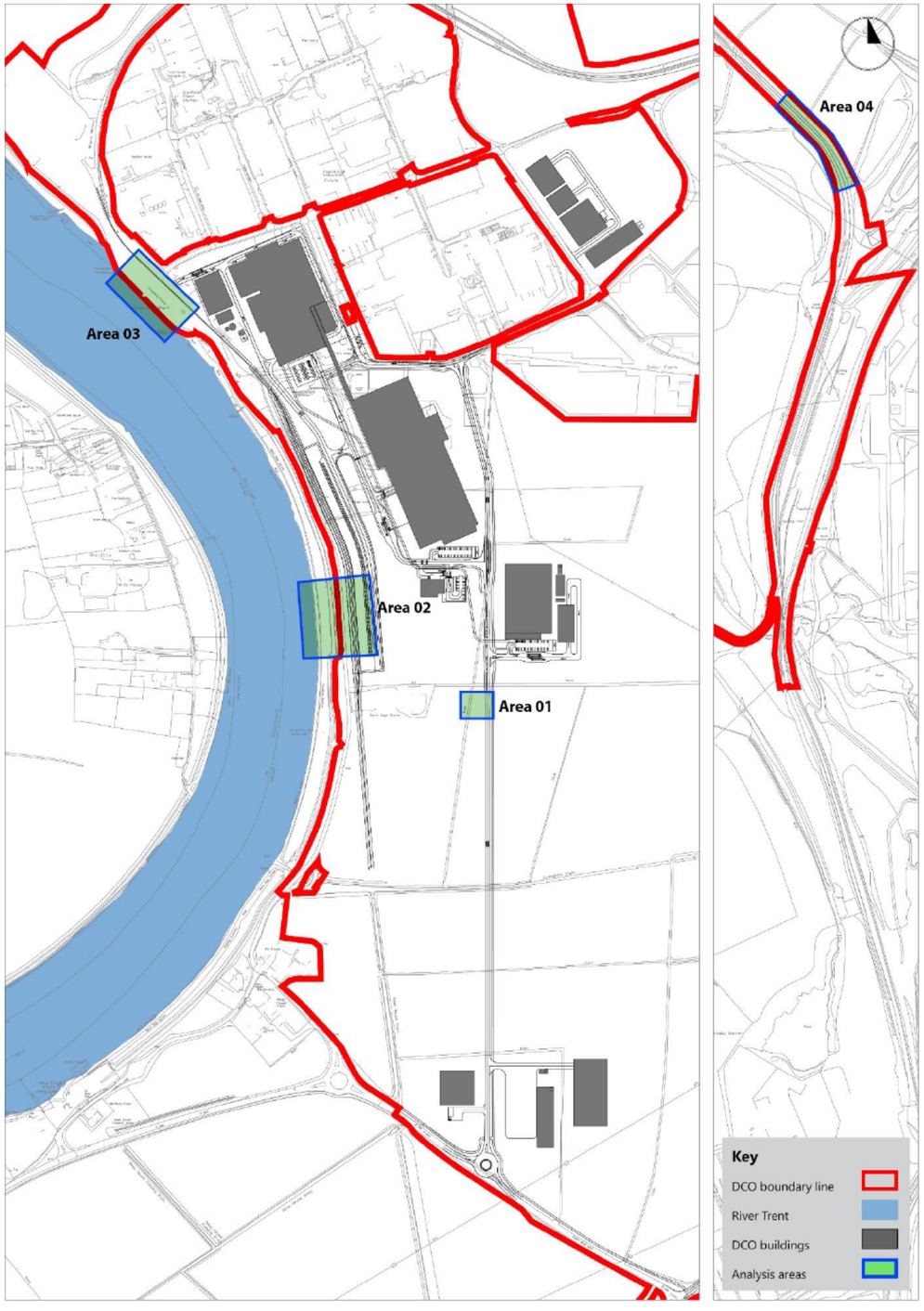


Figure 5-2 Areas of the Order Limits subject to digital analysis

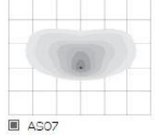
5.4 Area 01 – Calculation Results

Aim

5.4.1 To understand the potential impact of artificial lighting on the proposed **wetland habitat.** The proposed road is illuminated to reach a light intensity that satisfies the parameters of the M4 and P5 lighting classes.

5.4.2 Luminaires used:

Table 5-1 Luminaires used to illuminate New Access Road and the segregated shared path

Image	Make	Output	Light distribution	Mounting height	Spacing	Colour temperature
	EWO	4766 lumens	Asymmetrical forward throw  AS07	8.00m	20.00 m centre to centre	2700K
	EWO	1100 lumens	Asymmetrical forward throw  AS07	4.00m	20.00 m centre to centre	2700K

Results: Area 01 – New Access Road

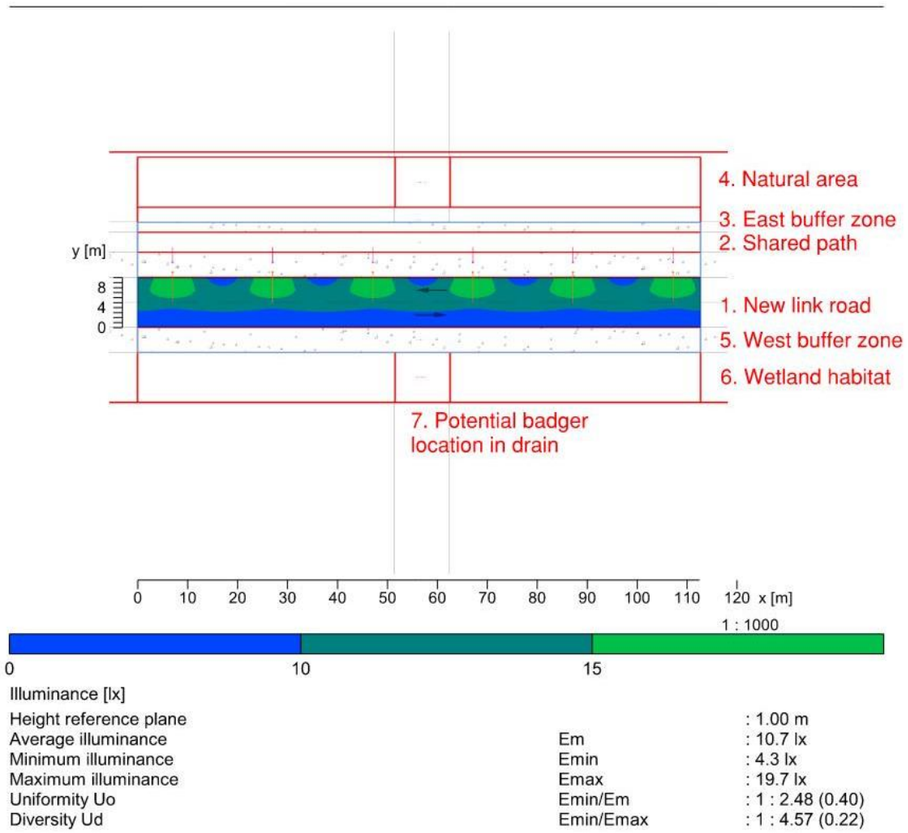


Figure 5-3 Calculation result for Access road.

5.4.3 The New Access Road is classified as a M4 road, requiring an average maintained illuminance of 10lux. The calculation result shows that the road is currently receiving an average of 10.7 lux

Results: Area 01 – Shared Path

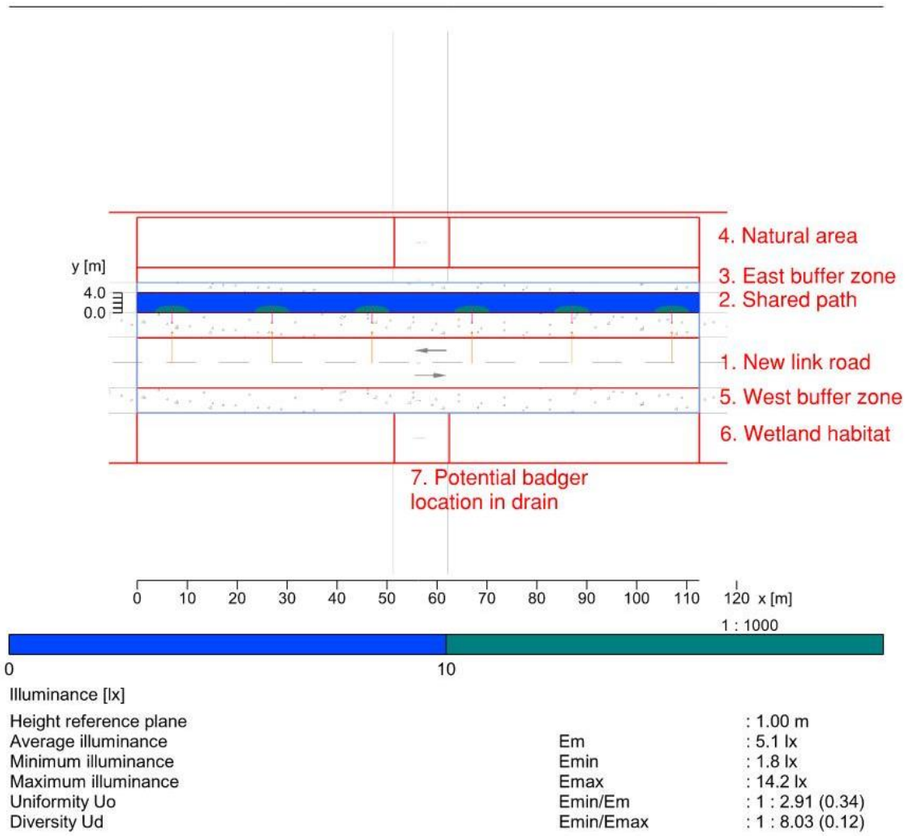


Figure 5-4 Calculation result

5.4.4 The shared path is classified as a P5 areas, requiring an average maintained illuminance of 3.0 lux. The calculation result shows that the path is currently receiving an average of 5.1 lux.

Results: Area 01 – East Buffer Zone

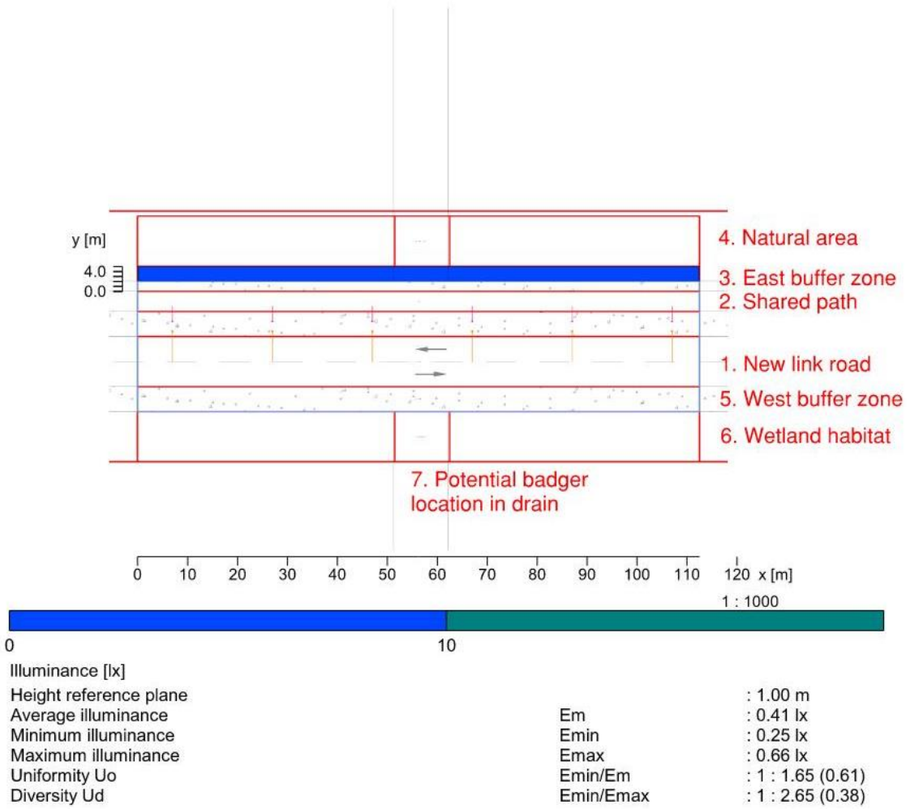


Figure 5-5 Calculation result

5.4.5 The calculation result indicates that the buffer area adjacent to the shared path is receiving 0.66lux. This area should act as a shield to minimise the light spill from the luminaires onto the open area and the potential badger habitat.

Results: Area 01 – Open Area

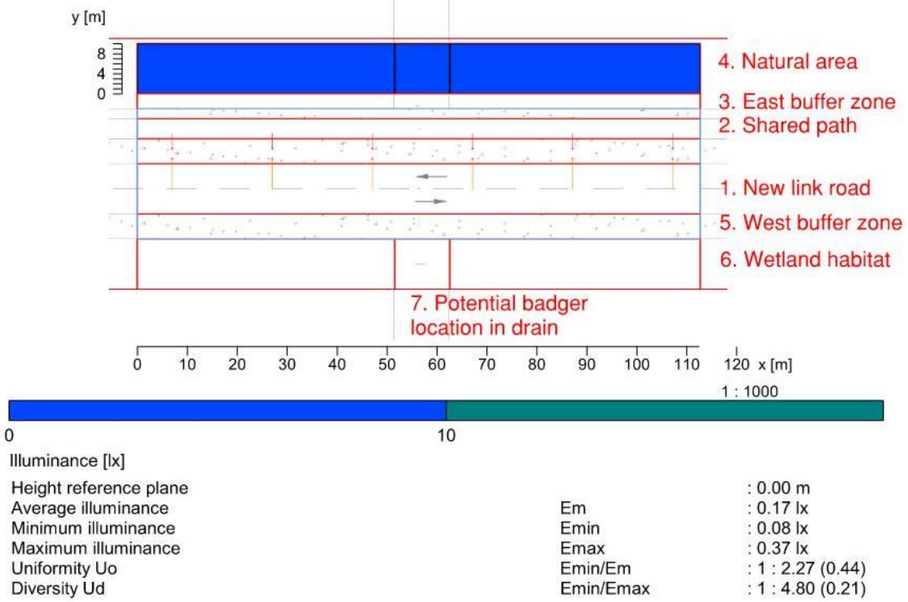


Figure 5-6 Calculation result

5.4.6 The calculation result indicates that the open area to the east of the buffer zone and shared path is receiving a maximum illumination of 0.37 lux. This is below the threshold of 2.0 lux established for these areas.

Results: Area 01 – West Buffer Zone

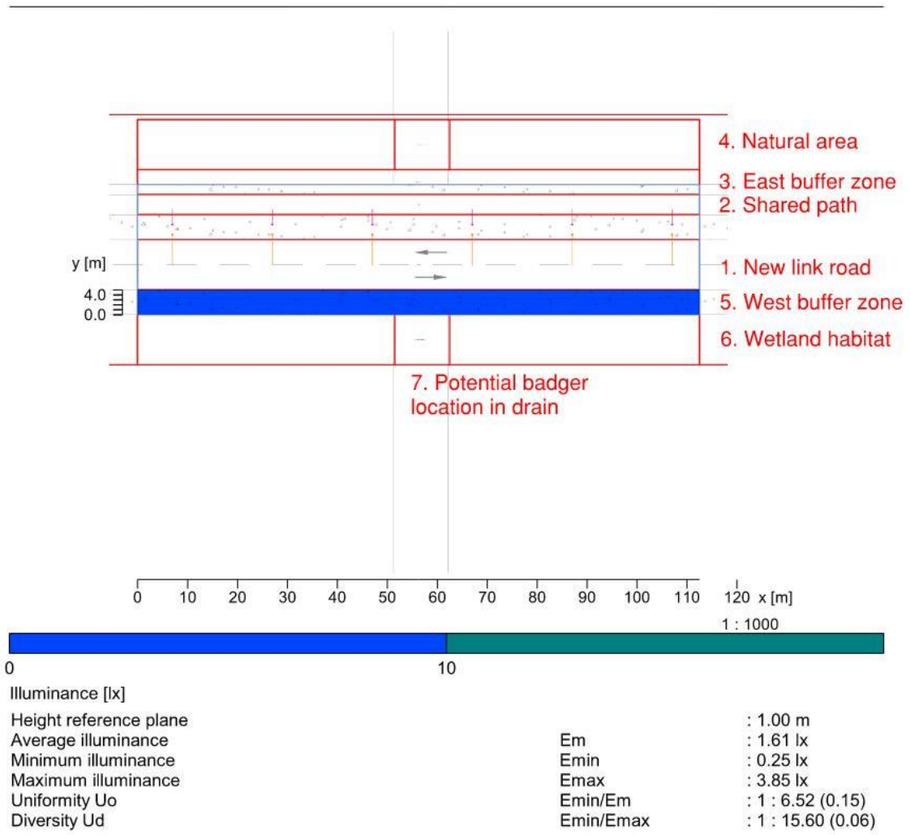


Figure 5-7 Calculation result

5.4.7 The calculation result for the west buffer zone shows a maximum of 3.85 lux being received by this area.

Results: Area 01 – Proposed Wetland Habitat

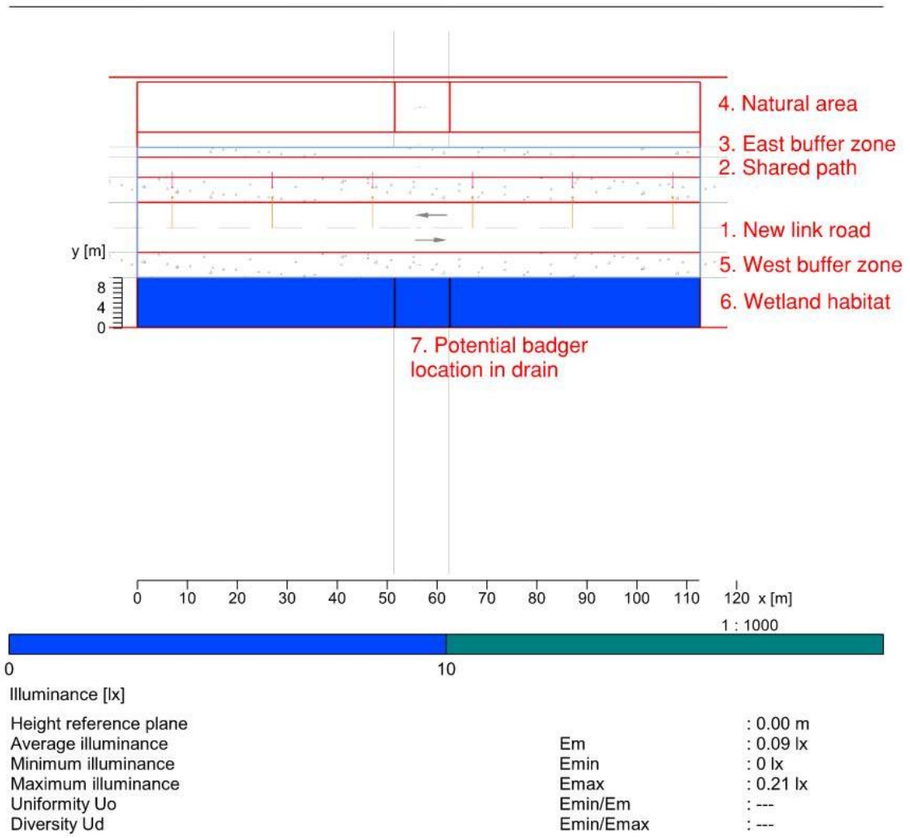


Figure 5-8 Calculation result

5.4.8 The calculation result for the proposed wetland habitat indicates that the current proposal of lighting for the New Access Road does not affect the wetland habitat. The maximum illuminance level reached is 0.21 lux, which is below the 2.0 lux threshold. **Therefore, the impact of lighting on this area can be considered as negligible**

Results: Area 01 – Potential Badger Location in Drain

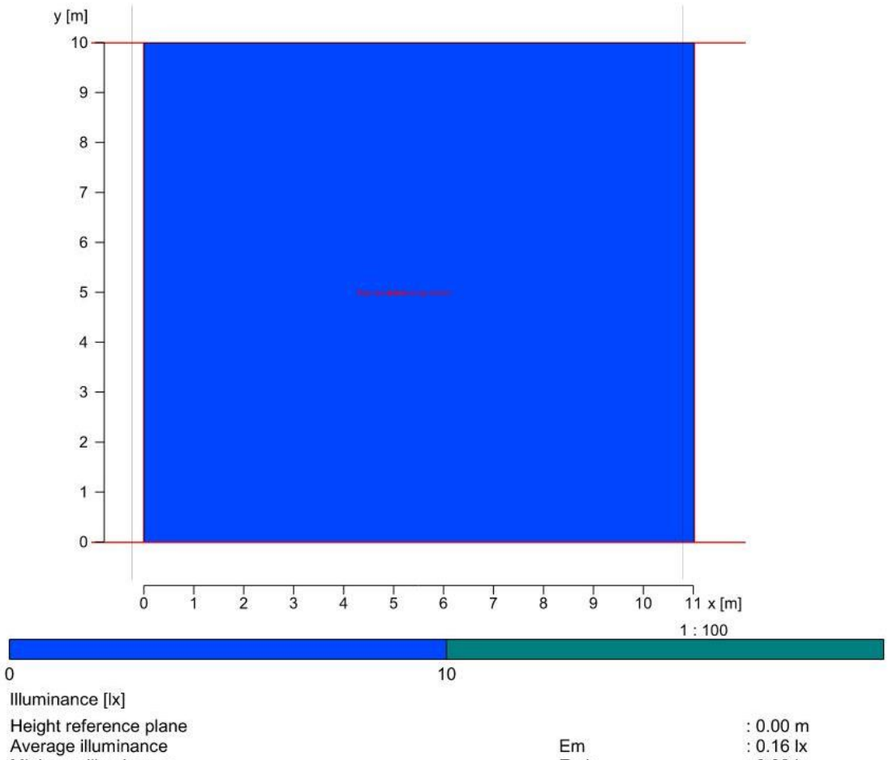


Figure 5-9 Calculation result

5.4.9 The calculation plane is located 1m below the rest of the planes to indicate a change of level. The area is receiving a maximum of 0.32 lux which is below the threshold established of 2.0lux, **Therefore, the impact of lighting on this area can be considered as negligible**

5.4.10 In order to further limit the potential impact on the badger's habitat, the wider design team should consider the following:

- enhanced vegetation shielding on both sides of the road and shared path; and
- solid tall barriers (1.1m) on bridges crossing over drains.

5.5 Area 02 – Calculation Results

Aim

5.5.2 To understand the potential impact of artificial lighting on the River Trent water surface and shoreline. The proposed railhead is illuminated from 18m columns located on the west and 10m columns located on the east.

5.5.3 Luminaires used:

Table 5-2 Luminaires used in the calculation model

Image	Make	Output	Light distribution	Mounting height	Spacing	Colour temperature
	EWO	20412 lumens	Asymmetrical forward throw  AP07	12.00m 2No. units per column	18.00 m centre to centre	2700K
	EWO	20412 lumens	Asymmetrical forward throw  AP07	10.00m	12.00 m centre to centre	2700K
Note: the calculation has been performed with external shielding to the luminaires as per the sketches in Figure 4.2.3.5.2						

Results: Area 02 – Railhead

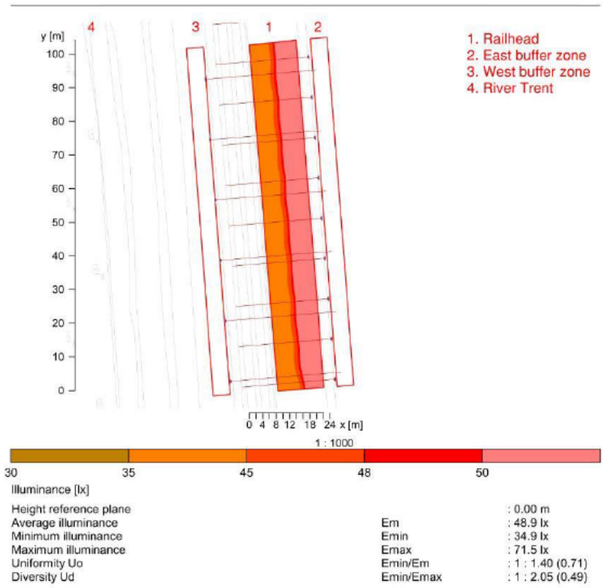


Figure 5-10 Calculation result

Results: Area 02 – East Buffer Zone

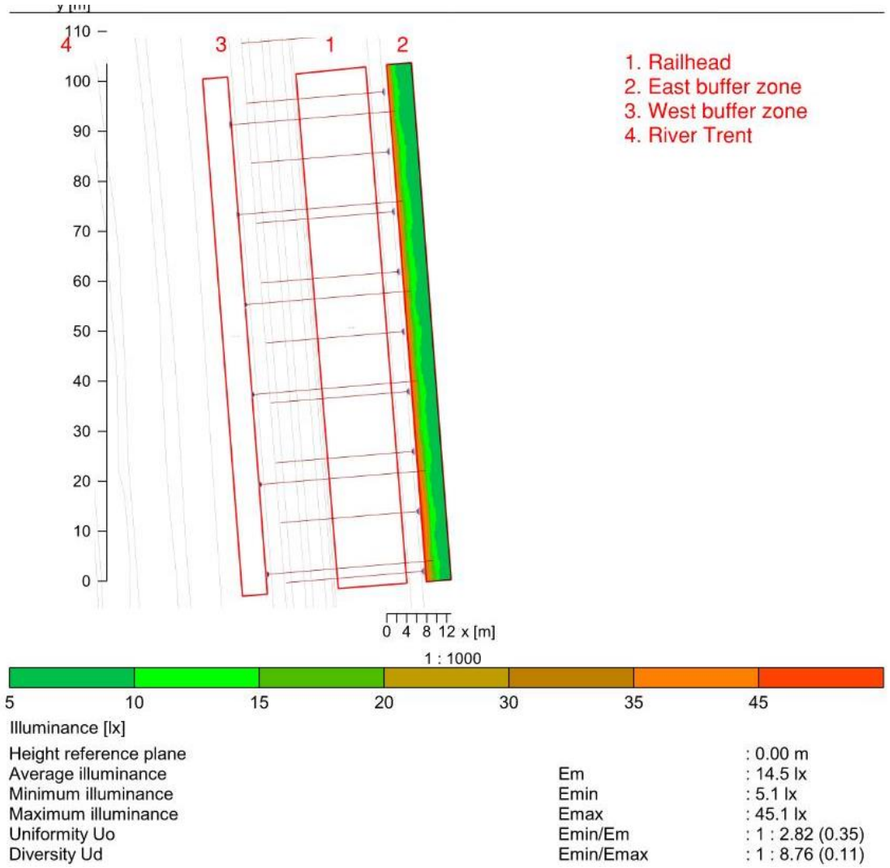


Figure 5-11 Calculation result

5.5.4 The calculation result indicates a maximum illuminance level of 48.7lux. This is very high, so it is recommended to use vegetation shielding on the west edge of the railhead to reduce levels of light in this area.

Results: Area 02 – West Buffer Zone

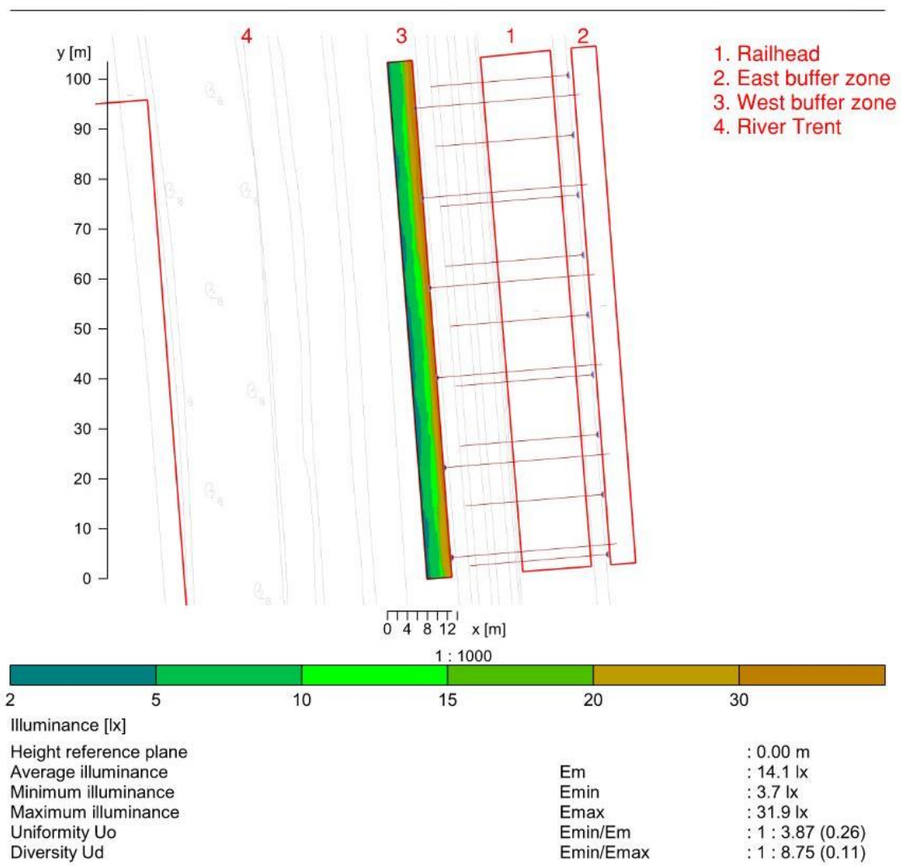


Figure 5-12 Calculation result

5.5.5 Like the east buffer zone, the west buffer zone is receiving high levels of light and it is recommended to use vegetation screening in this area to minimise the visual impact and amount of spilt light.

Results: Area 02 – River Trent Water Surface and Shoreline

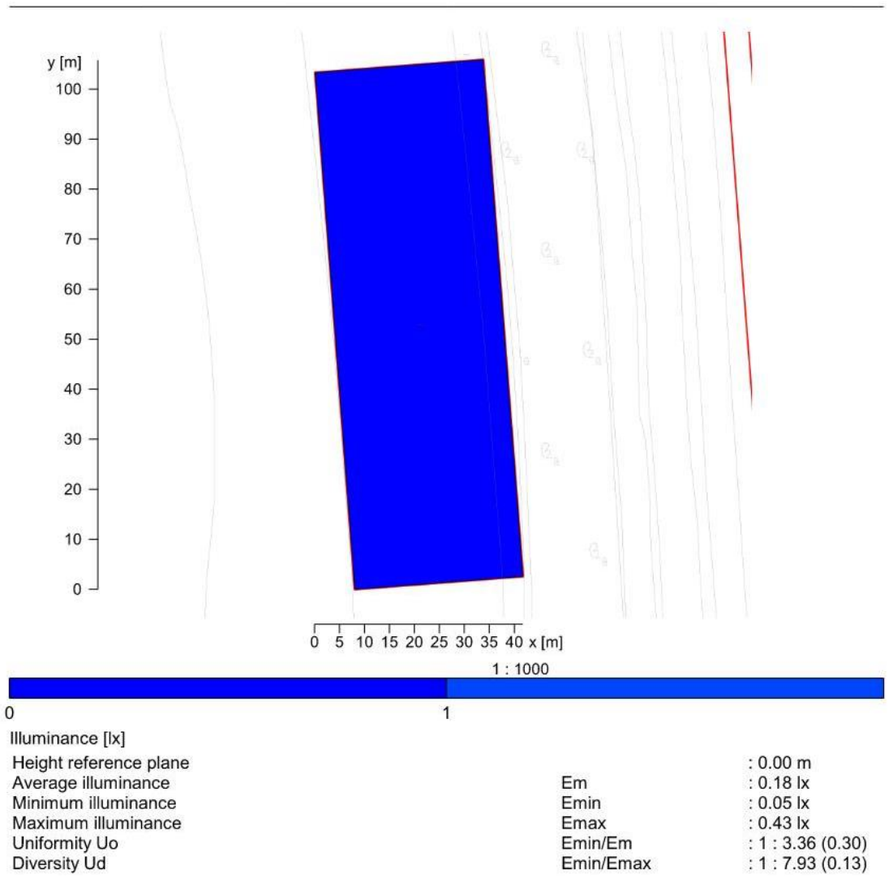


Figure 5-13 Calculation result

5.5.6 The calculation result for the River Trent water surface and shoreline habitat indicates that the current proposal of lighting for the railhead does not affect the wetland habitat. The maximum illuminance level reached is 0.43 lux, which is below the 2.0 lux threshold. **Therefore, the impact of lighting on this area can be considered as negligible.**

5.6 Area 03 – Calculation Result (benchmark crane specifications used for purposes of study).

Aim

5.6.1 To understand the potential impact of artificial lighting on the River Trent water surface and shoreline**.** The proposed wharf is illuminated from luminaires located at an assumed height of 20.00 (underside of travelling crane gantry) and a series of 10.00m columns providing additional required light from the east.

5.6.2 The calculation plane is located under the assumed travelling crane as it this is considered the worst-case scenario for light spilling onto the river surface. This calculation plane is located at 1.00 over the general plan level to account for the difference between the wharf surface and the water surface.

5.6.3 The water calculation planes are located at level 0.00.

5.6.4 Luminaires used:

Table 5-3 Luminaires used

Image	Make	Output	Light distribution	Mounting height	Spacing	Colour temperature
	EWO	42.800 lumens	Asymmetrical forward throw 	20.00m	3No luminaires located parallel to the river edge. Each luminaire has an external back shield	2700K
	EWO	42.800 lumens	Asymmetrical forward throw 	10.00m	20.00 m centre to centre. 2No luminaires per column	2700K
Note: the calculation has been performed with external shielding to the luminaires as per the sketches in Figure 4.2.3.5.2						

Results: Area 03 – Wharf Under Crane

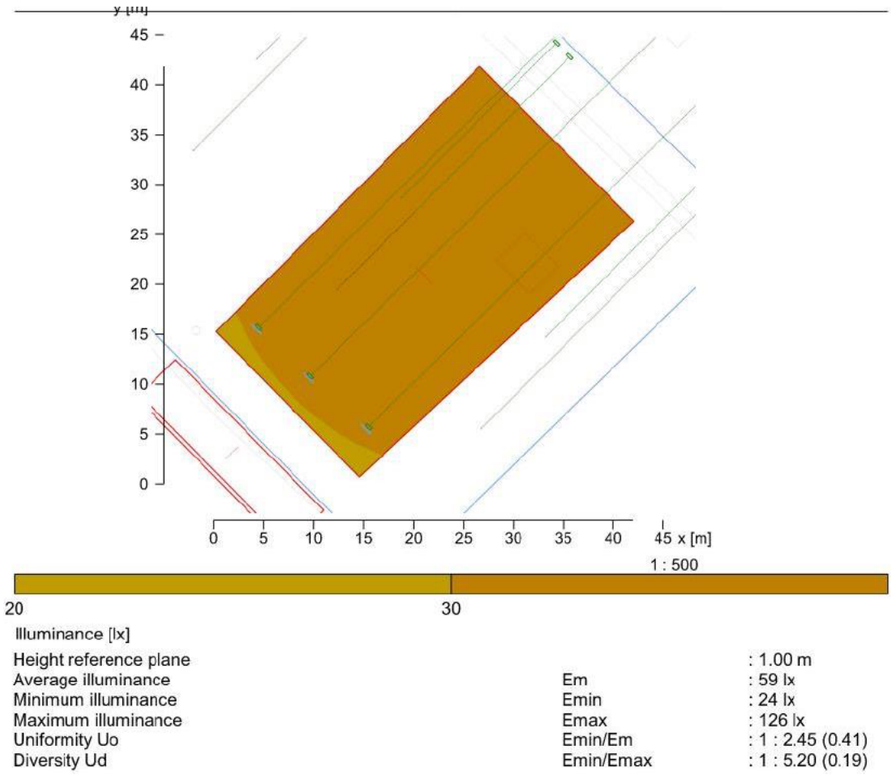
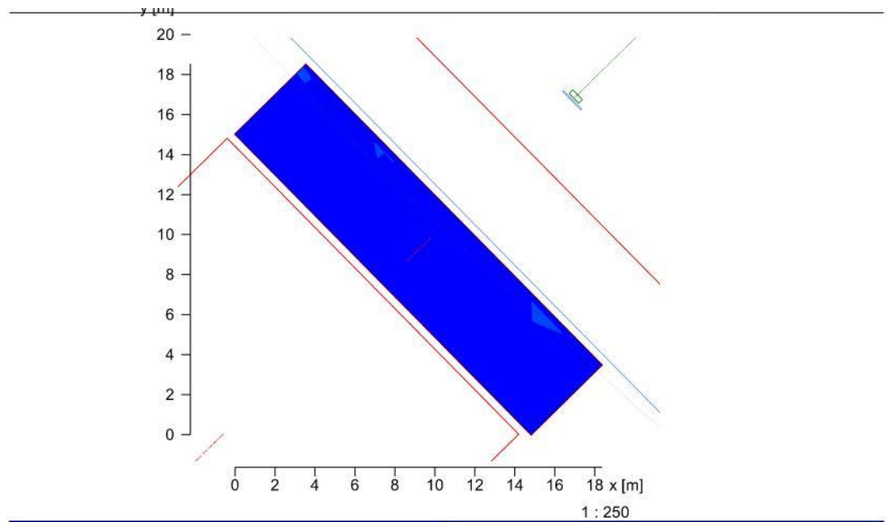


Figure 5-14 Calculation results

5.6.5 An assumed area under the crane is lit to the recommended levels by the BS-EN 12464-2. The area is illuminated using 3No luminaires with forward-throw light distribution and an additional external black shield. The levels are complemented by the 10m columns located behind the railway.

Results: Area 03 – Buffer Zone on Water



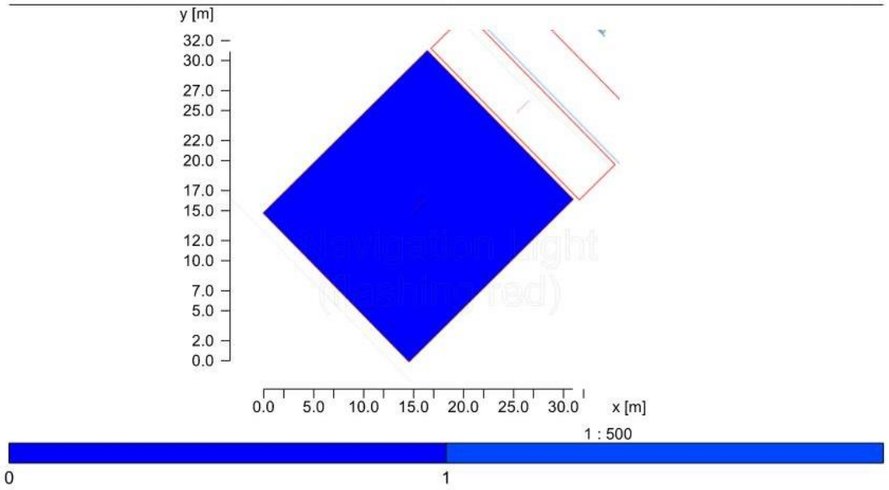
Illuminance [lx]

Height reference plane		: 0.00 m
Average illuminance	Em	: 0.26 lx
Minimum illuminance	Emin	: 0 lx
Maximum illuminance	Emax	: 1.38 lx
Uniformity Uo	Emin/Em	: ---
Diversity Ud	Emin/Emax	: ---

Figure 5-15 Calculation results

5.6.6 The buffer zone on the water corresponds at the area where the ships park.

Results: Area 03 – River Trent Water Surface



Illuminance [lx]

Height reference plane		: 0.00 m
Average illuminance	Em	: 0.1 lx
Minimum illuminance	Emin	: 0.06 lx
Maximum illuminance	Emax	: 0.18 lx
Uniformity Uo	Emin/Em	: 1 : 1.78 (0.56)
Diversity Ud	Emin/Emax	: 1 : 3.06 (0.33)

Figure 5-16 Calculation results

5.6.7 The calculation result shows that the water surface is receiving a maximum of 0.18lux. This result is below the 2.00 lux threshold established for this area. The special light distribution of the luminaires located under the crane guarantee that most of the light is directed towards the wharf surface, and only a small fraction kicks back.

5.6.8 However, additional external shield would have to be employed to further block the back light, as without these shields, the calculation area was receiving a maximum of 5.00 lux, which is over the allowed threshold.

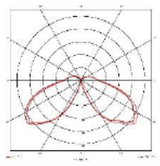
5.7 Area 04 – Calculation Result

Aim

5.7.2 To understand the potential impact of artificial lighting on the natural areas adjacent to the rail sections where the light is required.

5.7.3 Luminaires used:

Table 5-4 Luminaires used

Image	Make	Output	Light distribution	Mounting height	Spacing	Colour temperature
	ITAB Prolight	1501 lumens	Asymmetrical forward throw 	1.00m	5.00 m centre to centre	2700K

Results: Area 04 – Rail Tracks

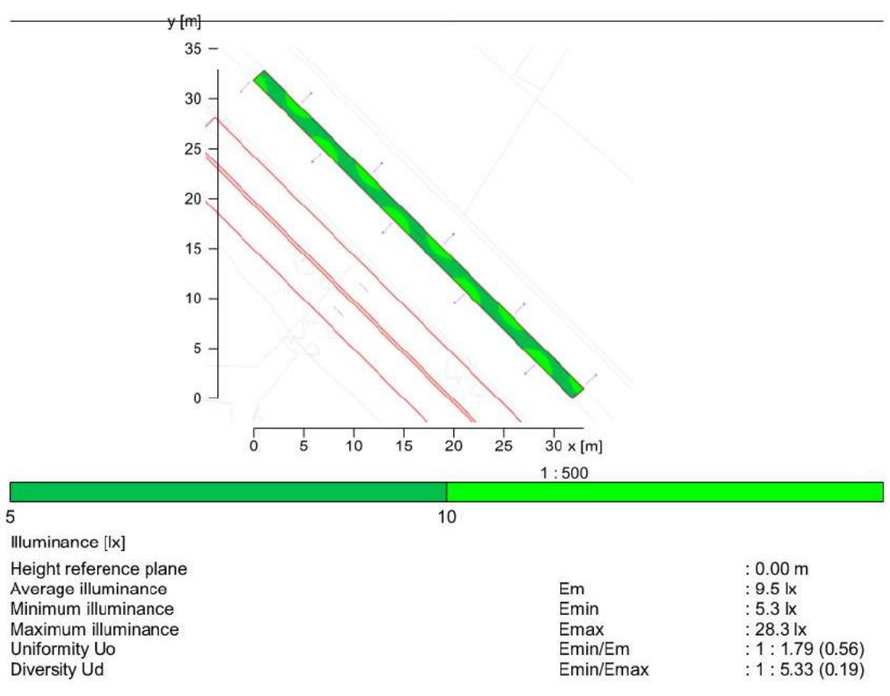


Figure 5-17 Calculation result

5.7.4 The result of this calculation shows the light on the rail tracks

Results: Area 04 – Buffer Zone

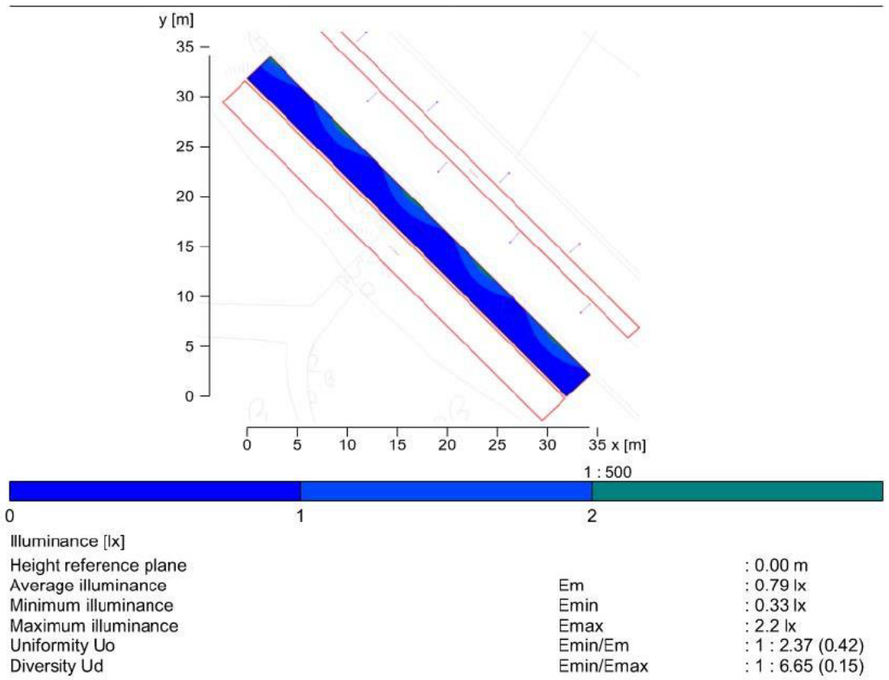


Figure 5-18 Calculation results

5.7.5 The light levels of the buffer zone adjacent to the tracks reach a maximum of 2.2lux. We assume this is within the clear area of movement for the working environment around the trains.

Results: Area 04 – Natural Area

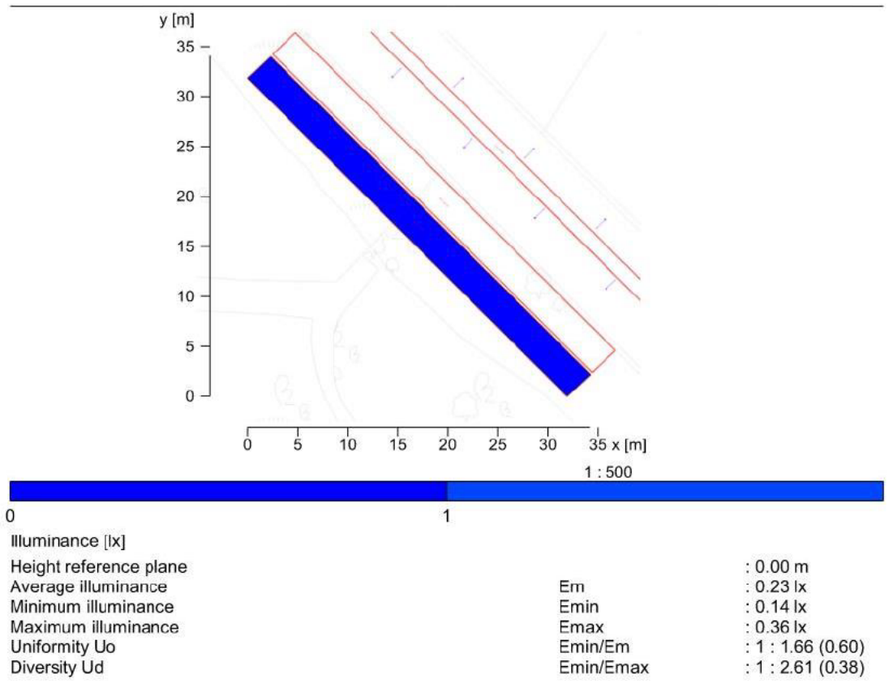


Figure 5-19 Calculation result

5.7.6 The calculation results show that the natural environment adjacent to the rail tracks is receiving a maximum of 0.36lux. This result is below the 2.00 lux threshold established for this area. **Therefore, the impact of lighting on this area can be considered as negligible**

5.8 Summary of Digital Analysis

Table 5-5 Summary of digital analysis

Area	Sensitive receptor	Average illuminance at target area	Max illuminance spill on protected area	Recommended max spill illuminance on protected area	Effect level	Mitigation measure
Area 01 – Wetland habitat	Wetland habitat	Road: 10.7 lux Path: 5.1 lux	0.31 lux	2 lux	Negligible	Vegetation shielding recommended on both sides of road and path
Area 01 – Badger location in drains	Badger nesting	Road: 10.7 lux Path: 5.1 lux	0.21 lux	2 lux	Negligible	Vegetation shielding recommended on both sides of road and path
Area 02 – River Trent water surface and shoreline	Water surface and shoreline	Railhead: 50 lux	0.43 lux	2 lux	Negligible	Vegetation shielding on both sides of railhead. External shielding to high-level luminaires
Area 03 – River Trent water surface	Water surface	Wharf: 50 lux	0.18 lux	2 lux	Negligible	External shielding required on high-level mounted luminaires.
Area 04 – Rail track	Natural area adjacent to rail track	9.5 lux	0.36 lux	2 lux	Negligible	Highly shielded bollards with directional optical distribution.

6 Conclusion

6.1 Existing Conditions

6.1.1 The Application Land is generally located within two typologies of existing areas: the Flixborough Industrial Estate and the area immediately south of the estate, consisting of rural and brownfield lands.

6.1.2 The area of the Application Land is generally within a lowered area of elevation to the surrounding areas and generally concealed from direct views to the north, east and south from raised elevations in landscape and trees lining most of the perimeter boundary. The area west of the Application Land is the River Trent and a small area of residential housing (Amcotts) located on the opposite of the river.

6.2 Flixborough Industrial Estate

6.2.1 The area of the Application Land within the Flixborough Industrial Estate, currently includes for lighting to maintain external operational tasks, vehicular access and pedestrian access in the absence to enough daylight contributions and hours of darkens during operation hours.

6.2.2 The proposed lighting strategy for the area the Application Land within the Flixborough Industrial Estate, shall provide an improvement to the existing lighting conditions with mitigation of glare and upward light spill.

6.2.3 The proposed lighting of the areas directly adjacent the River Trent to the industrial estate, shall mitigate the excessive light spill currently present and include for specific lighting treatments with appropriate shielding to ensure excessive light spill onto the River Trent is limited to those within acceptable limits.

6.2.4 Due to the requirements of health and safety for operational purposes, an area extending 5 meters from the port docking platform to the river, shall include for a higher level of illumination during hours of darkness.

6.2.5 Operations specific task lighting, to include such as the those at high level for the loading cranes, port loading area and rail head are to be made active only during periods of operation and switch off when not required, with requirements for general lighting in the area to be addressed as those noted within the lighting strategy.

6.3 Existing Rural Areas

6.3.1 The area of the Application Land south of the Flixborough Industrial Estate consisting predominantly of brownfield lands is unilluminated during the hours of darkness. Visible of some light sources are present around the perimeter of the Order Limits, consisting primarily of street lighting to the east and south of the development. Ferry Road West currently providing the main from of access to Flixborough Industrial Estate from the road network from the south is unilluminated.

6.3.2 The existing area of brownfield land is identified as, a Zone 2 – Rural, low district brightness Lighting Classification (ILP GN01:20). As the area is predominantly unilluminated during hours of darkness, the lighting requirements for the Project for operational, and health and safety during the hours of darkens would change the existing lighting classification from Zone 2 to Zone 3 – Suburban, Medium district brightness.

6.3.3 The Project consists of buildings for processing plant to the north and south of the area. A new interconnecting Access Road located centrally provides for the main means of access south for the Project as well as servicing Flixborough Industrial Estate. The New Access Road shall be illuminated during hours of darkness. It is expected much of the existing traffic from Stather Road running parallel to the River Trent would divert towards use of the new interconnecting road.

6.3.4 An area designated southwest of the Application Land enhancement and preservation for wildlife. The lighting from surroundings and those from the new roadway are addressed to mitigate any undue light spill. Where the New Access Road crosses existing water channels, such as Lysaght's Drain, the light distribution and location of lighting columns are positioned to avoid light spill onto the water channels.

6.4 Summary

6.4.1 The River Trent, the potential location of badger setts and the residential area Amcotts, are identified as the three main sensitive environmental and human receptors, which could be impacted by the Project. The lighting strategy with suitable applications and mitigation measures ensure these areas are not adversely affected.

6.4.2 The illumination of the port loading bay and extended section of railway to the railhead are addressed, with specific lighting treatments to avoid undue light spill onto the River Trent. The lighting requirements for the port loading crane is also addressed to avoid direct visibility of high intensity light sources from the Amcotts residential properties.

6.4.3 Considerations for the preservation of the existing ecology are also addressed and identified with this report. Suitable measures are provided to ensure these areas together with the introduction the area south of the development are to be preserved and enhanced to promote wildlife habitats.

6.4.4 The artificial lighting for the Project, would have an impact on existing rural areas that are currently unilluminated during the hours of darkness, due to the introduction of lighting within these areas for operational purposes and those of health and safety.

6.4.5 The Lighting Strategy states the requirements for compliance with the relevant regulations, recommendations and adaptation of best practice, ensure that the artificial lighting for the Project would not constitute or be a cause of nuisance or detrimental effect on health and safety.

6.4.6 The guidelines noted for compliance with the ILP GN01:20, ensure that the lighting shall not exceed the permissible levels of light spill outside the Order Limits of the Project onto the surrounding areas and adjacent properties, together with the mitigation of any undue light spill onto the naked sky.

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