

Castlefield Viaduct

Glare Potential Appraisal

LTG001

Issue 1 | 14 February 2022

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

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1 Introduction

1.1 Background

The Castlefield Viaduct development is located alongside four railway tracks and two Metrolink tracks. Arup was commissioned by the National Trust to investigate whether the proposed electric lighting installation to the viaduct could be experienced by train drivers in central Manchester (53.48°N , -2.26°E).

Figure 1 describes the site location of the development. The proposed development site is highlighted in red.

Figure 2 below is a perspective view of the proposed development illustrating the massing within the local terrain/context.

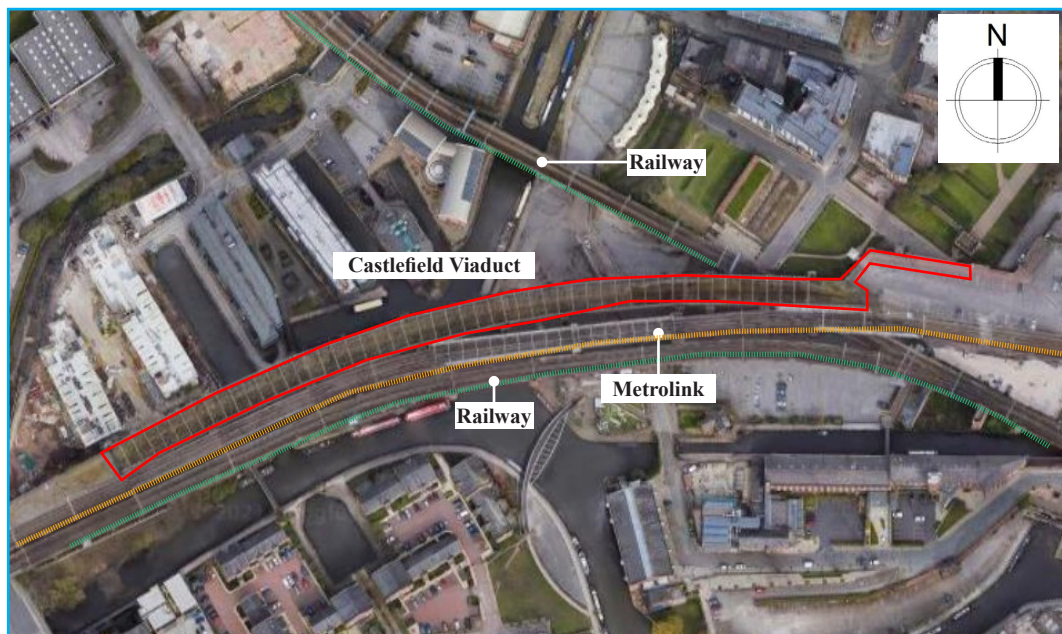


Figure 1 Site location

This study is to inform Manchester City Council, the local planning authority, that there will be no adverse effect on the Metrolink and Network Rail drivers' ability to read signals due to the electric lighting installation.

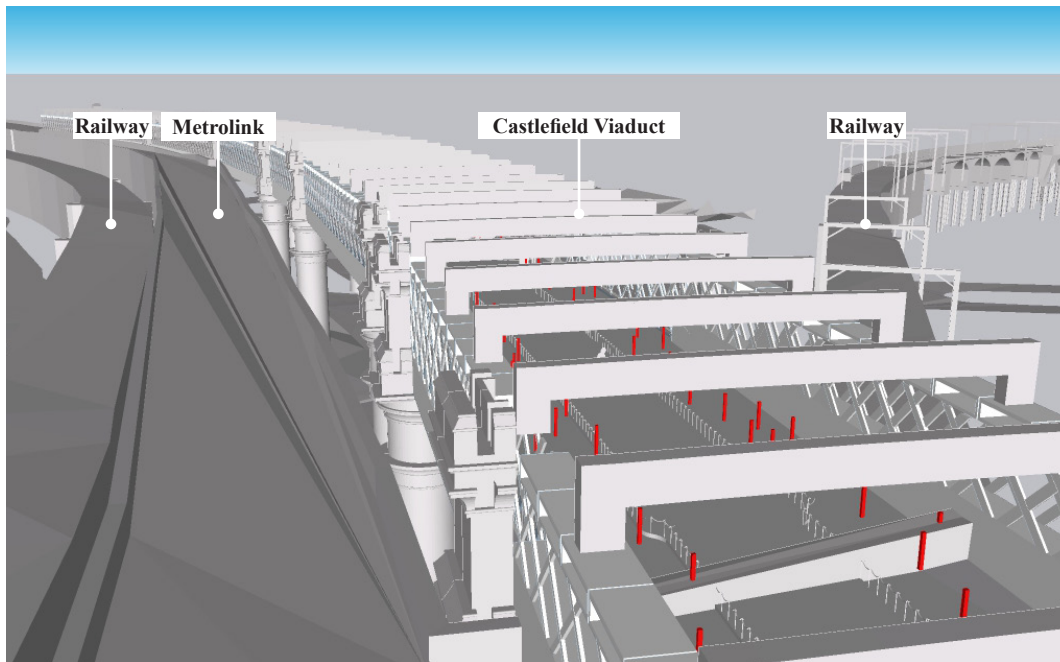


Figure 2 Proposed development perspective view

1.2 Report Objectives

The purpose of the study is to investigate the experience of the train drivers from the proposed lighting strategy. The study will aid planners, Network Rail and Metrolink to understand the visibility of light sources from the development by the train drivers.

The study will use 3D simulations to provide a visual representation of the potential for glare effects.

1.3 Scope

To assess the potential for glare from the proposed development on the safety and functionality of the adjacent railway tracks, the following activities have been undertaken:

- 1 Collect all relevant baseline data and 3D models.
- 2 Collect signal and speed information from Network Rail/Metrolink.
- 3 Add the lighting positions into the 3D model. The lighting positions are highlighted in red and all other geometry is grey scale.
- 4 Position viewpoints along the six tracks at 2.75m eye level (eye height for driver).
- 5 Run animation that simulates train driver travelling along tracks.
- 6 Assess the visibility and location of lights in relation to driver's field of view.

1.4 Data Sources

For the purpose of the analysis, Arup has utilised the following 3D model files:

- CVI-ARUP-ZZ-ZZ-M3-N-000001.rvt (*Arup MEP 11.01.2022*)
- 122019 Castlefield_13-01-2022.rvt (*Twelve Architects 13.01.2022*).

The model of the local terrain, roads, railway tracks and neighbouring properties were provided from the Manchester 3D city model.

1.5 Site Context

The direction of the train movement will affect the potential for exposure to glare. In this study, six tracks pass the site and the trains travel either eastbound or westbound. A 30mph speed has been assumed for the journeys. A slower speed is considered the worst case scenario as the duration of exposure to any light source will be longer. The tracks referred to in this document are described in Table 1 below:

Track Ref.	Typical Train Direction	Operator
Track 1	Eastbound	Network Rail
Track 2	Westbound	Network Rail
Track 3	Eastbound	Metrolink
Track 4	Westbound	Metrolink
Track 5	Eastbound	Network Rail
Track 6	Westbound	Network Rail

Table 1 Railway tracks assessed

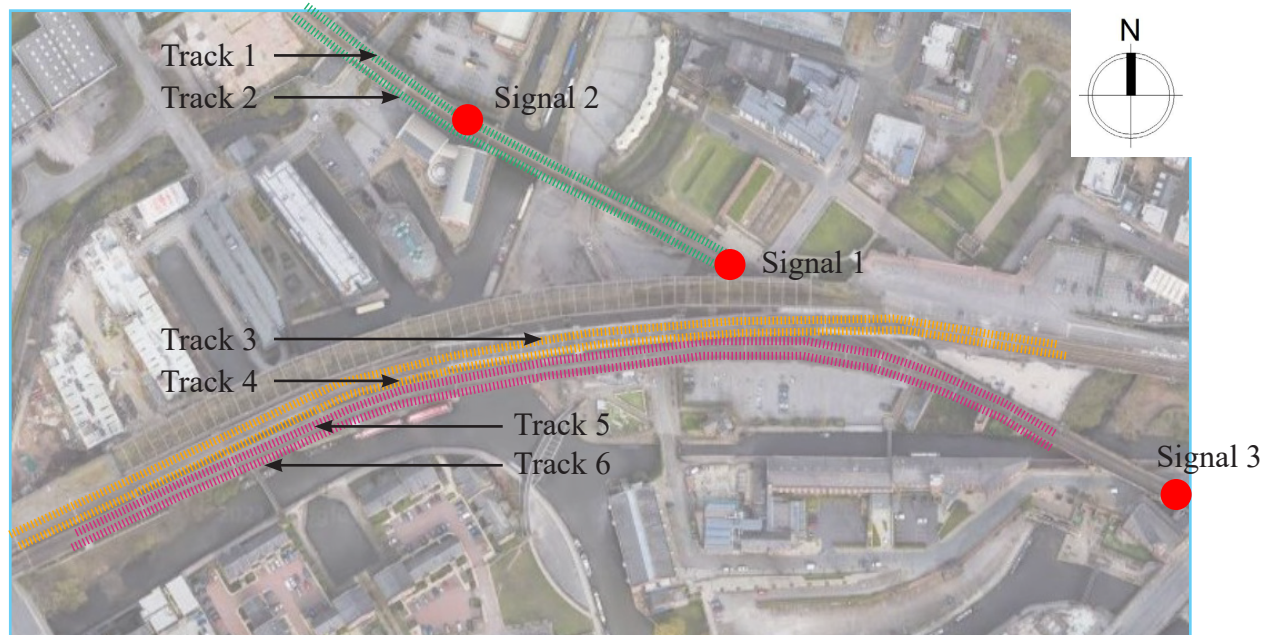


Figure 3 Railway track diagram & Signal Location

1.6 Signals

There are three signals within the vicinity of the proposed development. Signal one and two are located along track 1. There is also one signal along the Metrolink tracks but this is approximately 100m east of the development and next to Deansgate Station.



Figure 4 Signal 1- located on track 1 eastbound



Figure 5 Signal 2- located on track 1 eastbound



Figure 6 Signal 3- located outside Deansgate Station on track 6 westbound

2 Glare Assessment

2.1 Methodology

Computer animations of the lighting strategy in a 3D model of the proposed development and surrounding landscape have been undertaken to assess where and when the lighting strategy may be visible in the drivers' field of view.

Simulations were completed at train driver eye height (2.75m above track).

2.2 Modelling

The 3D modelling has been created using the information received as detailed in the data sources section.

All 3D models have been compiled into a single model representing the development and surrounding landscape including the railway tracks. The proposed lighting installation has been highlighted in red in the model so that the luminaires can easily be identified.

Tree planting and vegetation is not contained within the model as it subject to change during different seasons and future development of the area. Thus, the results also represent the worst case scenario.

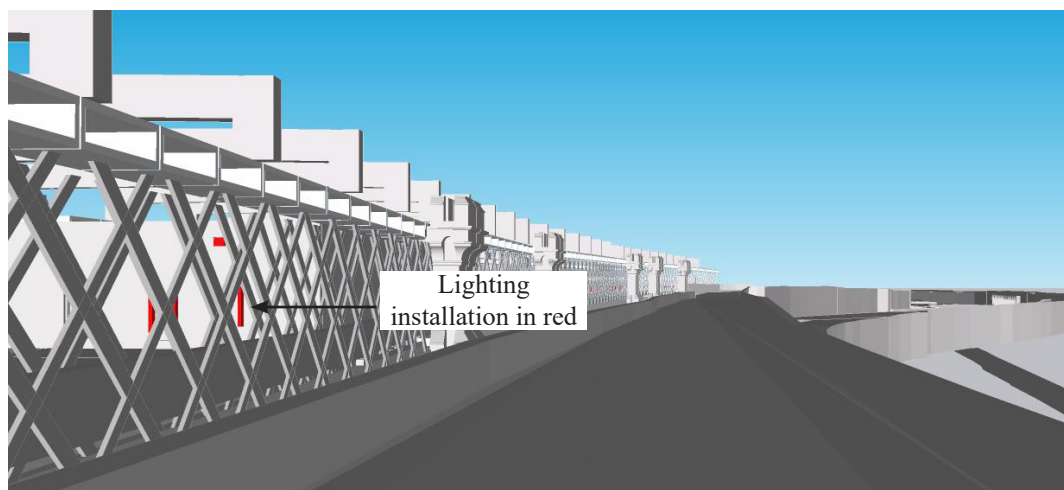


Figure 7 Lighting installation modelling in red

2.3 Glare Potential Appraisal

The objective of this appraisal is to establish if the proposed lighting installation to Castlefield Viaduct could be observed in the train drivers' field of view.

Various viewpoints along the railway tracks were tested to illustrate where the possible glare sources may originate.

Each viewpoint is overlaid with an indicator of the typical 30° field of view as calculated for a train driver looking directly ahead. The extent of the drivers' field of view is shown as a red circle in Figure 8. Refer to 2.3.1 for a description of the paracentral and macular field of view.

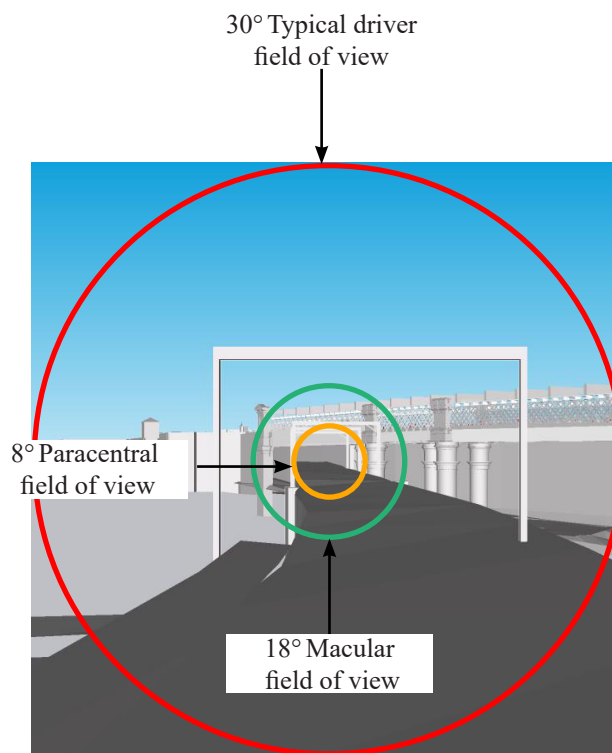


Figure 8 Driver field of view diagram

For example, by inspection of Figure 8, which represents track 1 travelling eastbound, the following can be observed:

- Light sources are barely visible within drivers field of view and not within the paracentral view where signal is observed.

2.3.1 Driving Cabs of Railway Vehicles

In order to understand the train driver's field of view it is essential to review the train driver cabin. Figure 9 is a typical example of interior train driver cabin. It illustrates the front window when looking ahead with a visor on the top and two side windows to the left and right.



Figure 9 Example of interior train driver cabin

The field of view is defined as *“the number of degrees of visual angle during stable fixation of the eyes”* (Figure 10). Peripheral vision is part of the vision that occurs only on the side gaze (Figure 11). The dividing line between near and mid peripheral vision at 30° radius is based on several features of visual performance. Visual acuity declines by about 50% every 2.5° from the centre up to 30°, at which point visual acuity declines more steeply. The train driver will be located at 30° angle from the direction of view looking ahead.

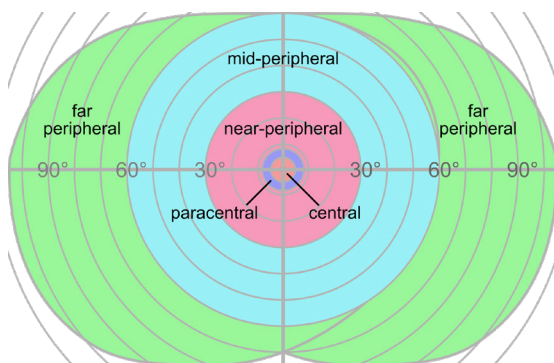


Figure 10 Field of view of the human eye

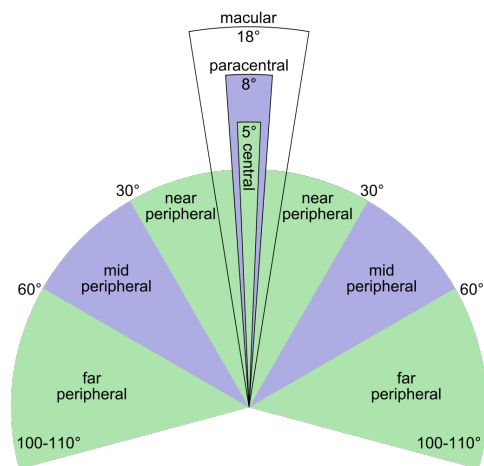


Figure 11 Peripheral vision of the human eye

3 Glare Potential Findings

3.1 Glare Potential Overview

The glare effects are considered likely to have minimal impact on the drivers' vision when observed outside of the 30° field of view. By inspection of the simulations (Appendix A) a series of observations were made. These have been summarised below, with key images on the following pages.

Track 1, 3 and 4 primarily observe the artificial lighting from the proposed development from within the drivers' 30° field of view but the cross-bracing structure to the viaduct obscures the visibility of the installation. The visibility of any one light source is transient in its effect due to the cross-bracing and never visible within the paracentral field of view.

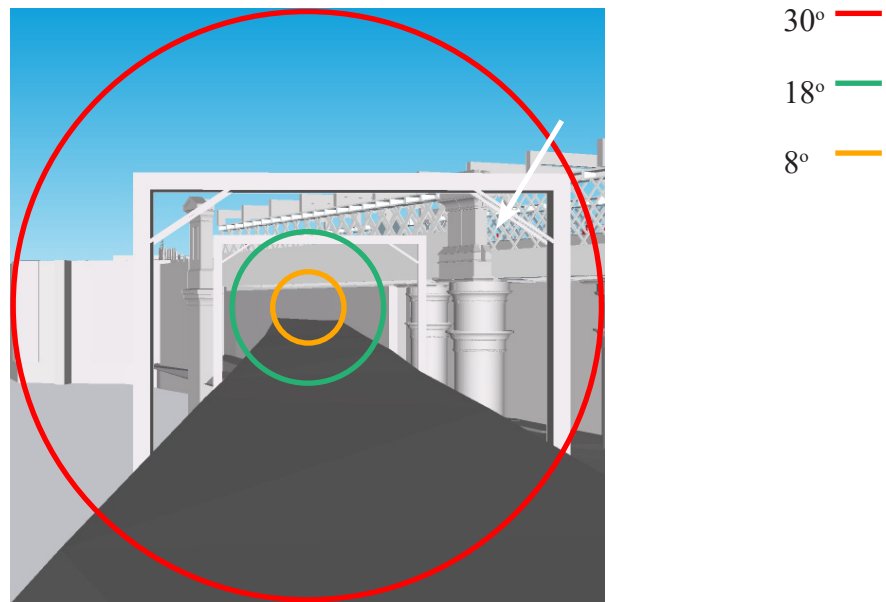


Figure 12 Eastbound, Track 1 - viaduct lighting partially visible within field of view

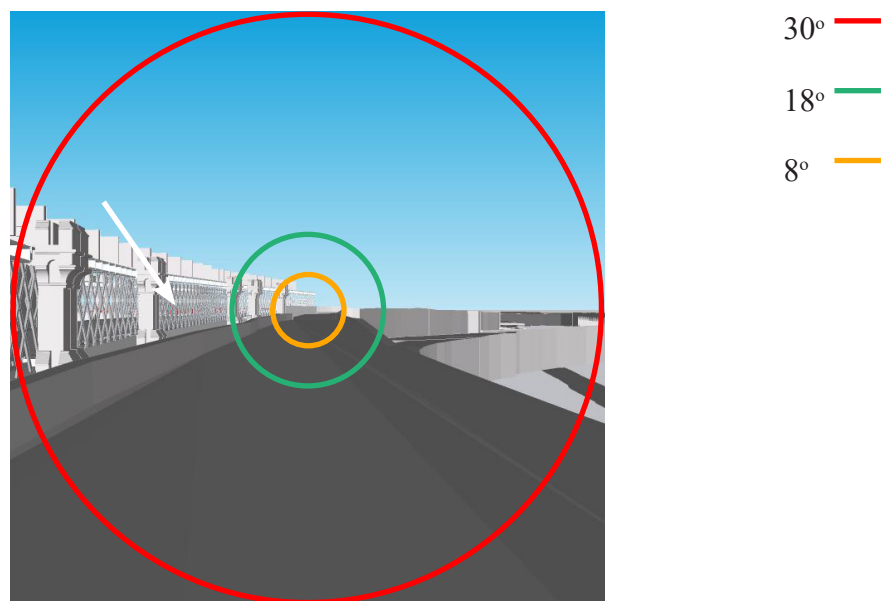


Figure 13 Eastbound, Track 3 - viaduct lighting partially visible within field of view

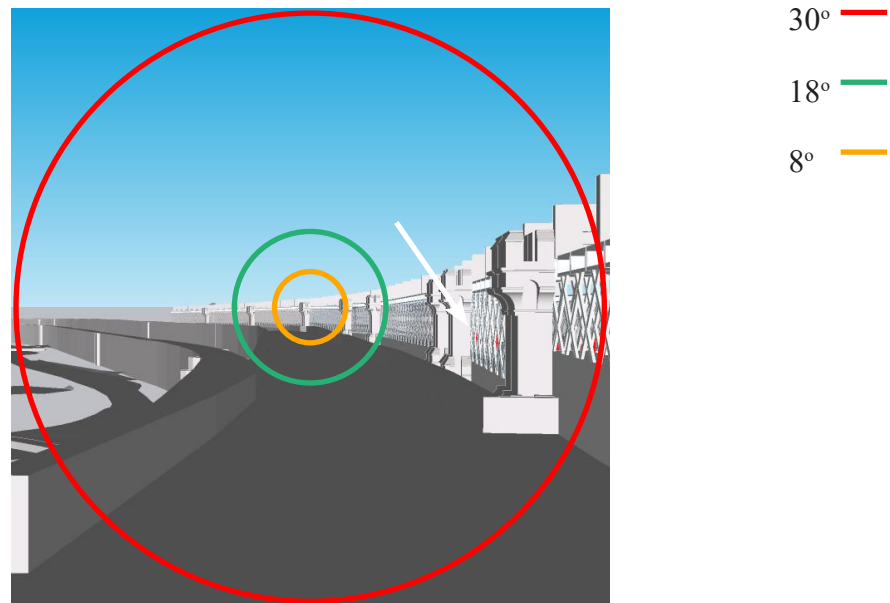


Figure 14 Westbound, Track 4 - viaduct lighting partially visible within field of view

Track 2 westbound has not been assessed as the train is travelling away from the development and the lighting installation is not visible.

The artificial lighting from the proposed development is obstructed when travelling on track 5 and 6 eastbound and westbound. Track 5 and 6 are positioned lower than the development and obstructed by Metrolink tracks 3 and 4.

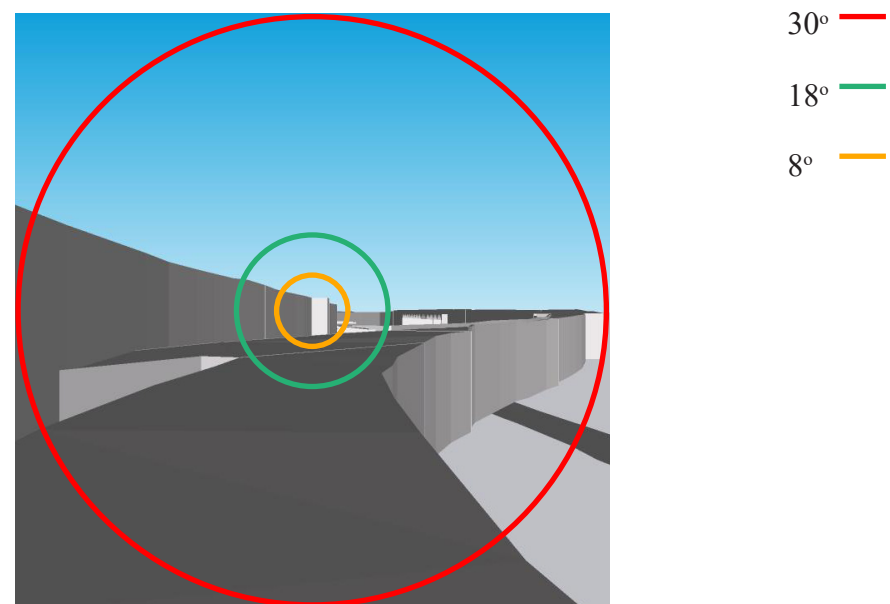


Figure 15 Eastbound, Track 5 - viaduct lighting obstructed

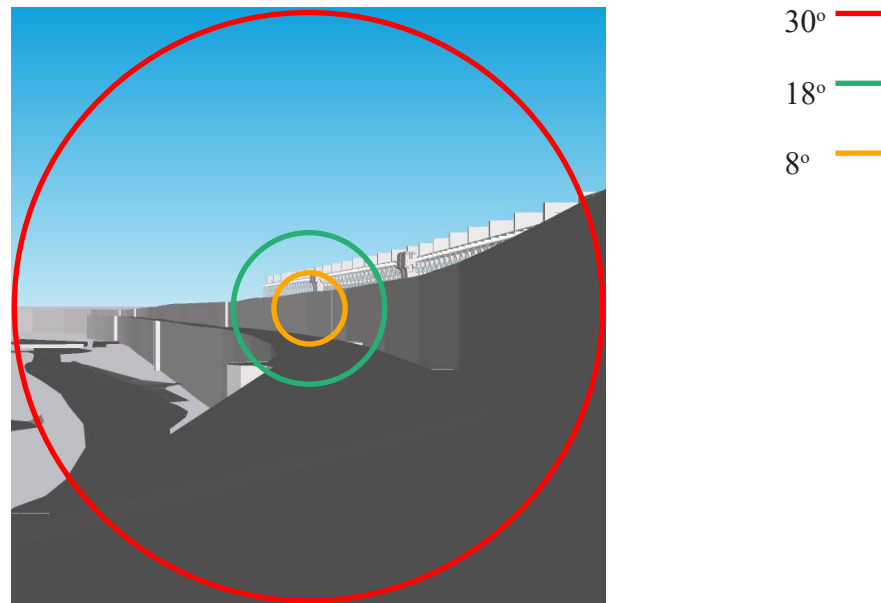


Figure 16 Westbound, Track 6 - viaduct lighting obstructed

3.2 Summary Findings

The following table summarises the potential exposure to glare.

Track	Direction	Operator	Potential glare exposure
1	Eastbound	Network Rail	Viaduct lighting visible within 30° field of view but lighting obscured by cross-bracing structure. Appearance of any lighting is transient.
2	Westbound	Network Rail	Not assessed- train driver travelling away from viaduct
3	Eastbound	Metrolink	Viaduct lighting partially visible within outer boundary of 30° field of view but lighting obscured by cross-bracing structure. Appearance of any lighting is transient.
4	Westbound	Metrolink	Viaduct lighting partially visible within outer boundary of 30° field of view but lighting obscured by cross-bracing structure and no signals in vicinity. Appearance of any lighting is transient.
5	Eastbound	Network Rail	Viaduct lighting obscured by raised Metrolink tracks 3 and 4
6	Westbound	Network Rail	Viaduct lighting obscured by raised Metrolink tracks 3 and 4

Refer to Appendix A for further examples of the driver field of view.

3.2.1 Detailed Findings

The following section summarises the findings of the glare potential appraisal simulation for train drivers:

Track Ref	Viewpoint	Observations
1	1	Lighting visible in distance within field of view but obscured by the cross-bracing structure. No lighting within paracentral field of view.
	2	Lighting visible in distance within field of view but obscured by the cross-bracing structure. Signal within field of view but no lighting visible in signal location and paracentral field of view. Driver approaching increasing brightness of city night-time skyline.
	3	
	4	
	5	
	6	
	7	No lighting from proposed development visible in field of view.
	8	
3	1	Lighting visible within field of view but obscured by the cross-bracing structure. No signals in field of view and no lighting within paracentral field of view. Driver approaching increasing brightness of city night-time skyline.
	2	
	3	
	4	
	5	
	6	No lighting from proposed development visible in field of view.
	7	
4	1	Lighting visible within field of view but obscured by the cross-bracing structure. No signals in field of view and no lighting within paracentral field of view.
	2	
	3	
	4	
	5	No lighting from proposed development visible in field of view.
	6	
	7	
	8	
5	1	No lighting from proposed development visible in field of view- obstructed by track 3 and 4
	2	
	3	
6	1	No lighting from proposed development visible in field of view- obstructed by track 3 and 4
	2	
	3	

Table 2 Glare potential appraisal findings

3.2.2 Lighting Specification

The lighting specification for the proposed development comprises five different types of fixed luminaires: integrated furniture lighting, planting illumination, reed lighting, festoon lighting and wall-washing lighting. There are also portable lanterns for the visitors to use when moving along the viaduct.

The lighting strategy has been designed to provide an ambient setting to allow clear views across the city and a pocket of tranquillity amongst the brightly illuminated city.

The lighting is aimed in a downward direction to minimise light obtrusion, protect the ecology and prevent glare to train drivers with low output light sources specified. See Table 3 for a comparison between the light output specified in the development versus the light output of typical city centre lighting installations.

Development light output	Typical city centre light output
Integrated furniture: 499lm per metre (not visible from train)	Road, platform, car park lighting: >2000lm per column
Planting: 233lm per spotlight	
Reed: 597lm per bollard (aimed downwards)	
Festoon: 45lm per globe	

Table 3 Light output comparisons

The colour of lighting is white with no coloured lighting specified across the installation. This will avoid any confusion between the coloured signals and the white lighting installation.

4 Glare Potential Conclusion

This study indicates when the lighting strategy to the proposed development will be visible within the drivers' field of view and any potential glare effects.

In summary, the findings from the glare potential appraisal are the following:

- The cross-bracing of the viaduct structure obscures the visibility of the artificial lighting on all viewpoints. This will be further obscured when driving along Metrolink tracks 3 and 4 due to the additional cross-bracing on the bridge (not modelled). See Figure 17.
- When the signal along track 1 is within the drivers' field of view, there are no luminaires visible from the proposed development and in the paracentral field of view. The other two signals in the vicinity of the proposed development are outside of the drivers' field of view.



Figure 17 Metrolink (Track 3 and 4) cross-bracing structure

- When travelling Eastbound, the driver will be increasingly exposed to the city night scene with high levels of brightness. The lighting strategy to the proposed development will have low illumination levels in comparison to local street lighting. Therefore the drivers' eyes will be already adapted to the surrounding brightness levels.
- The lighting strategy to the proposed development comprises low level lighting with luminaires aimed in a downward direction, no lighting will be directing towards the drivers. The light sources also have a reduced lumen output, in comparison with city centre road lighting, with low intensity light sources specified due to the required illumination levels within the development.
- The glare animations represent a worst-case scenario as the full height of the luminaire is identified in red. The luminaires that are partially visible coloured red in the animations only have three discrete light sources which will be

directed to the ground. Therefore the visibility of the light sources will be further reduced. See Figure 18.

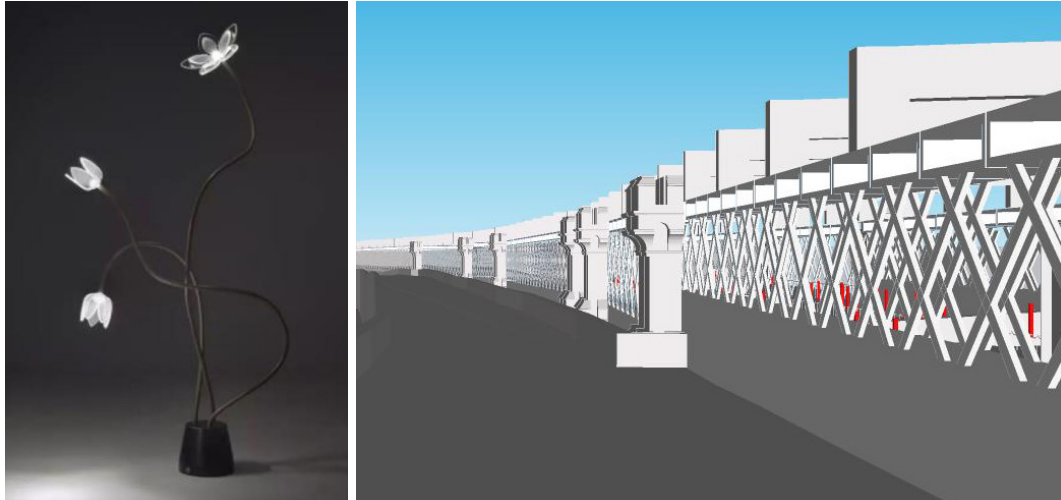


Figure 18 Luminaire light sources versus 3D modelling

- Only white light will be implemented in the scheme to prevent coloured light being confused with train signals.

In summary, it is concluded that the lighting strategy to the proposed development will not result in glare effects causing distraction or discomfort to train drivers. This is due to the obstruction from the cross-bracing structure, the locations of the signals and tracks in relation to the development, the specification of the lighting equipment and the low ambient lighting strategy proposed.

Appendix A

Appendix A

Glare Visualisations

Viewpoints Examined

The plan below highlights the six tracks surrounding the Castlefield Viaduct development. Two signals have been identified on track 1 and track 2.

Simulations were completed along the railway lines at train driver eye height (2.75m above track) and simulated in a real-time animation at 30mph.

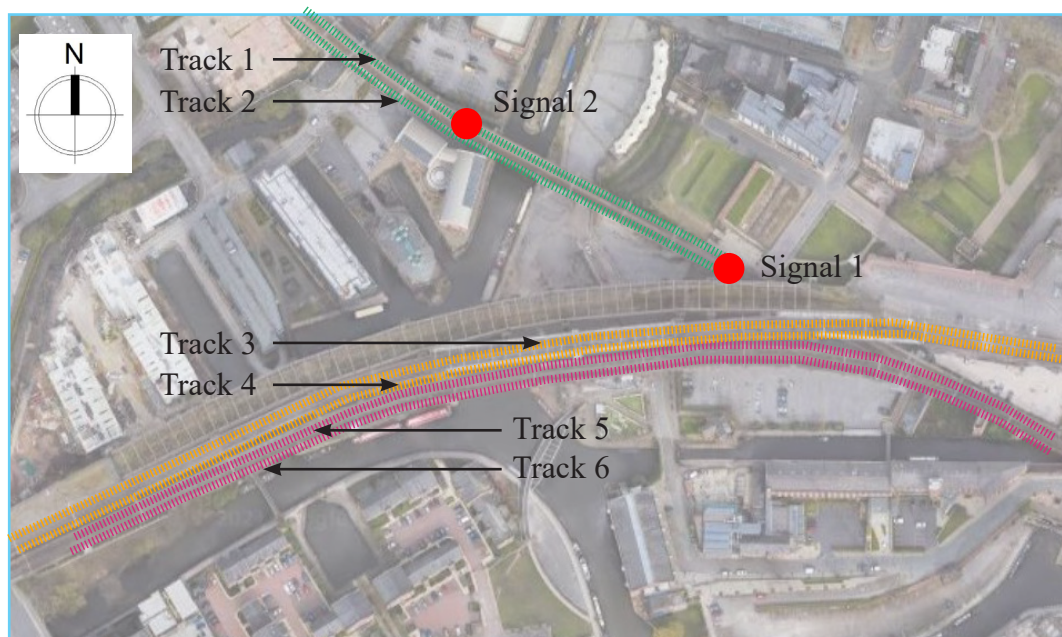


Figure 1 Plan view of the proposed development, surroundings and railway tracks

Track Ref.	Typical Train Direction	Operator
Track 1	Eastbound	Network Rail
Track 2	Westbound	Network Rail
Track 3	Eastbound	Metrolink
Track 4	Westbound	Metrolink
Track 5	Eastbound	Network Rail
Track 6	Westbound	Network Rail

Table 1 Railway tracks assessed

Viewpoint Details

Each viewpoint is overlaid with an indicator of the typical 30° field of view as calculated for a train driver looking directly ahead. The extent of the driver's field of view is shown as a red circle in Figure 3.

For example, the figure below represents viewpoint track 1 travelling eastbound, the following can be observed:

- Light sources are barely visible within drivers field of view
- Light sources are barely visible outside drivers field of view

For the purpose of clarity, the luminaires have been coloured in red so that they can be easily identified.

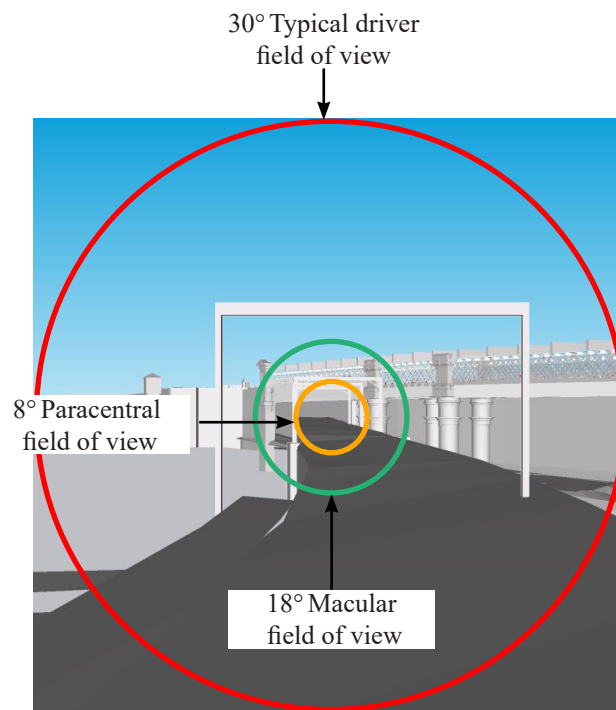


Figure 2 Driver field of view diagram

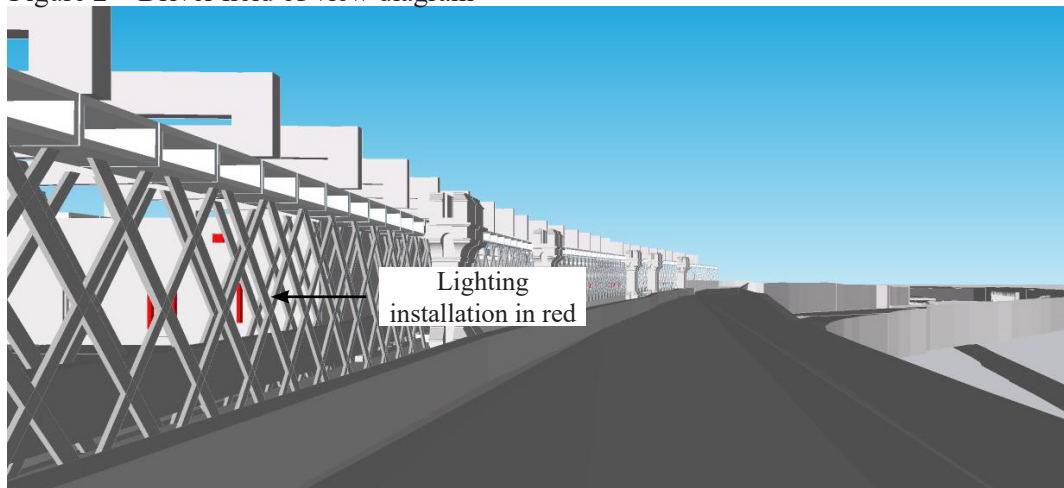


Figure 3 Lighting installation modelling in red

Viewpoints Sequence

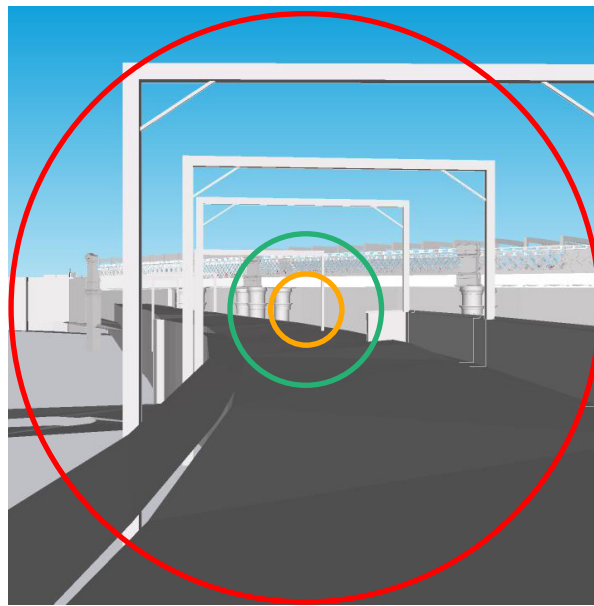
The viewpoints below demonstrate a selection of viewpoints along each of the rail tracks.

Track 1

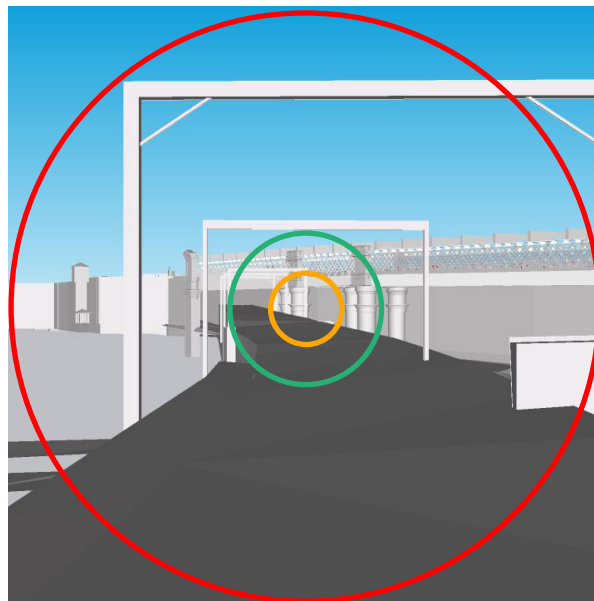
30° - field of view —

18° - macular —

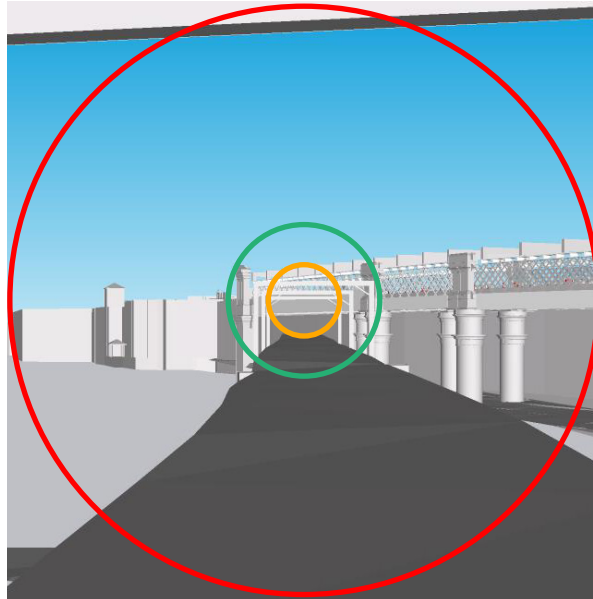
8° - paracentral —



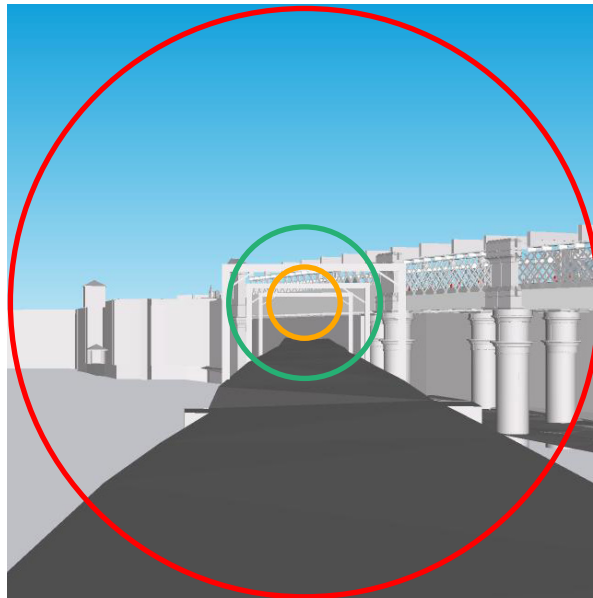
Viewpoint 1



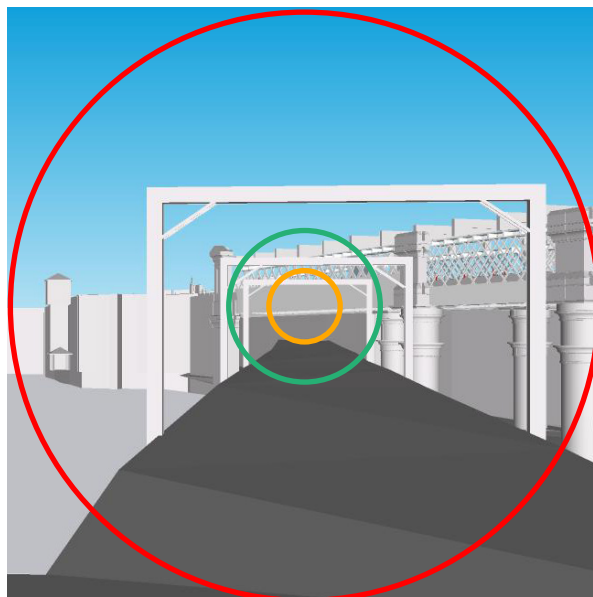
Viewpoint 2



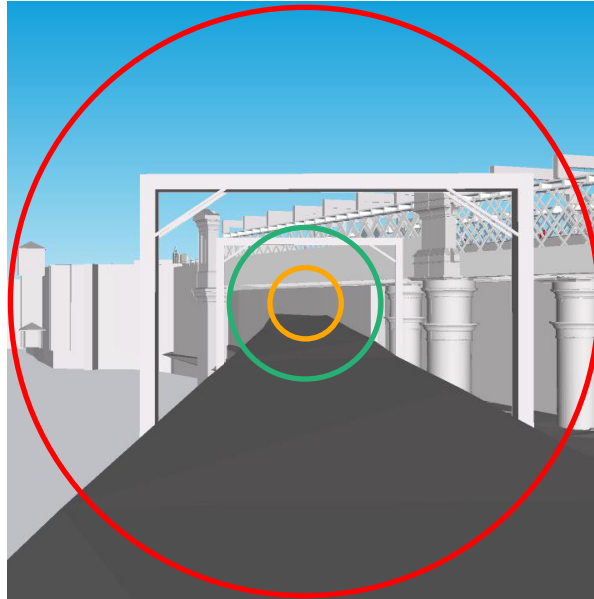
Viewpoint 3



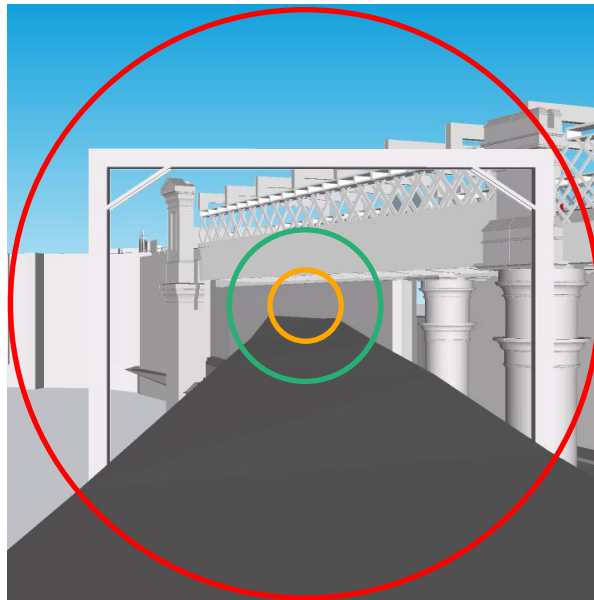
Viewpoint 4



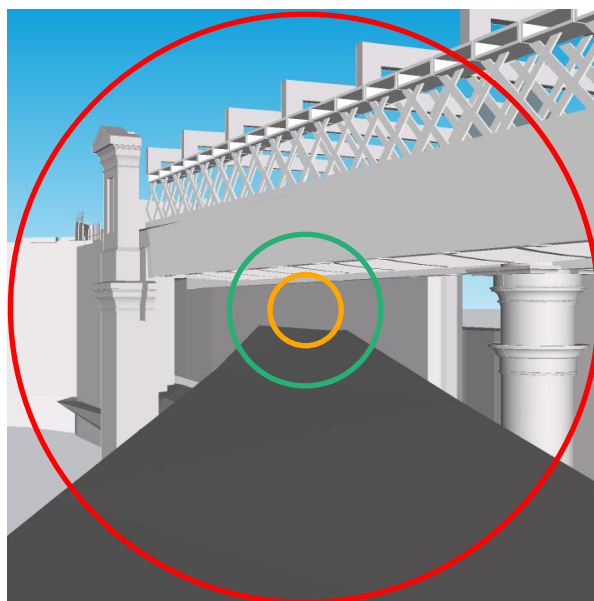
Viewpoint 5



Viewpoint 6



Viewpoint 7



Viewpoint 8

Track 2

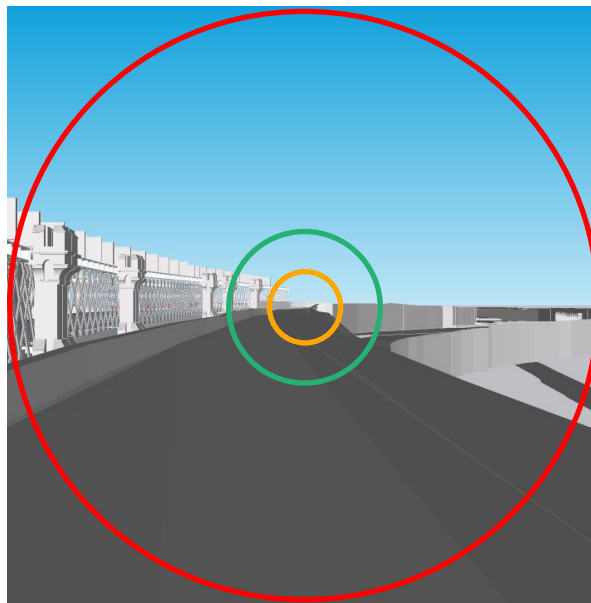
Not assessed- driver travelling westbound away from the development.

Track 3

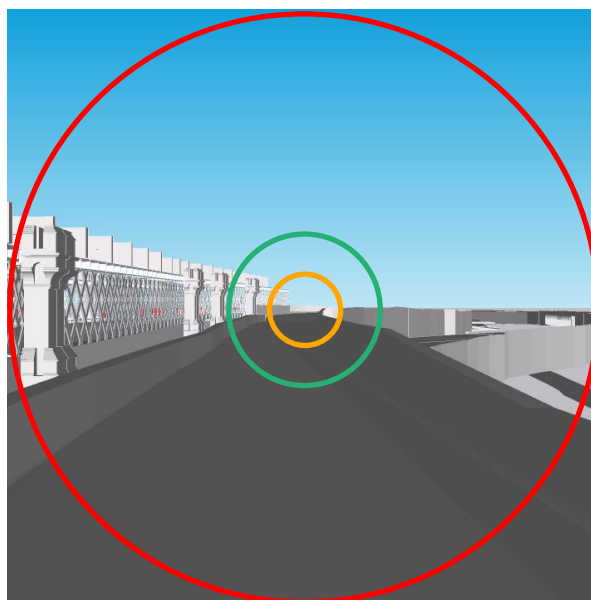
30°- field of view —

18° - macular —

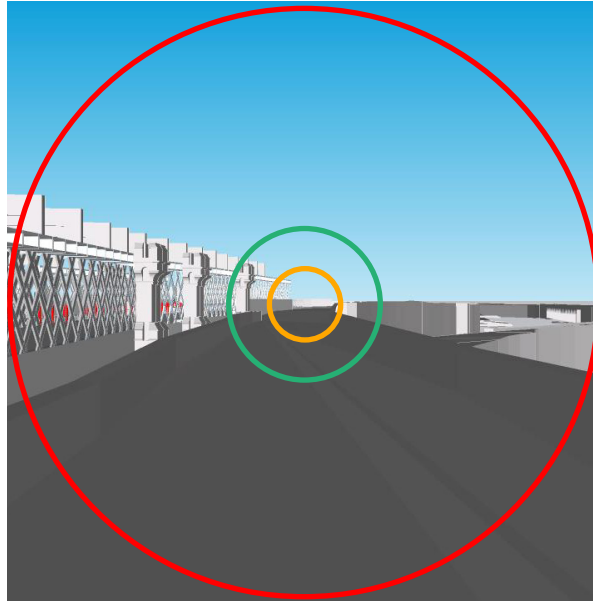
8° paracentral —



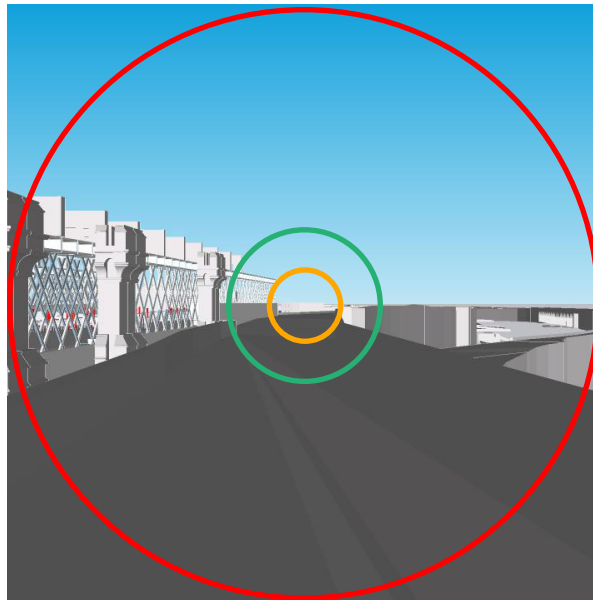
Viewpoint 1



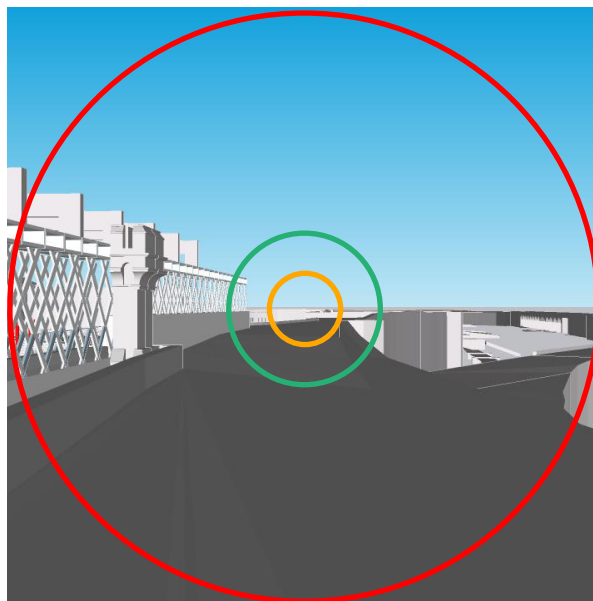
Viewpoint 2



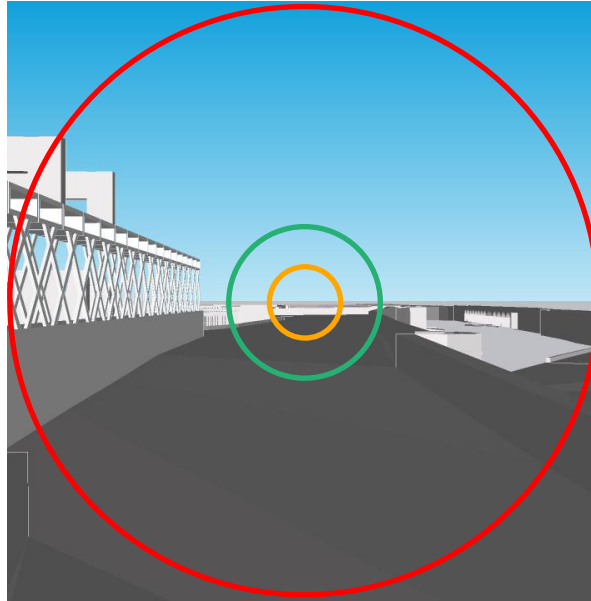
Viewpoint 3



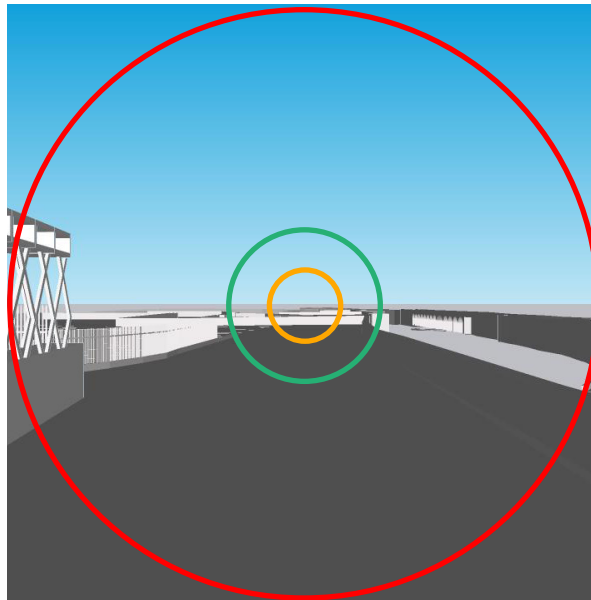
Viewpoint 4



Viewpoint 5



Viewpoint 6



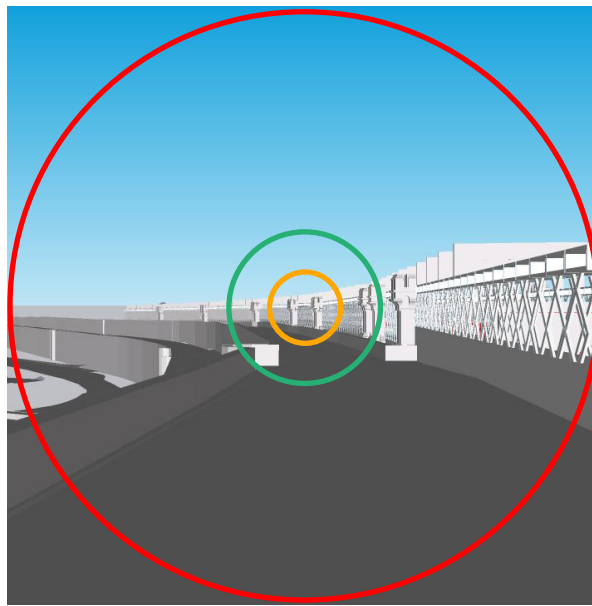
Viewpoint 7

Track 4

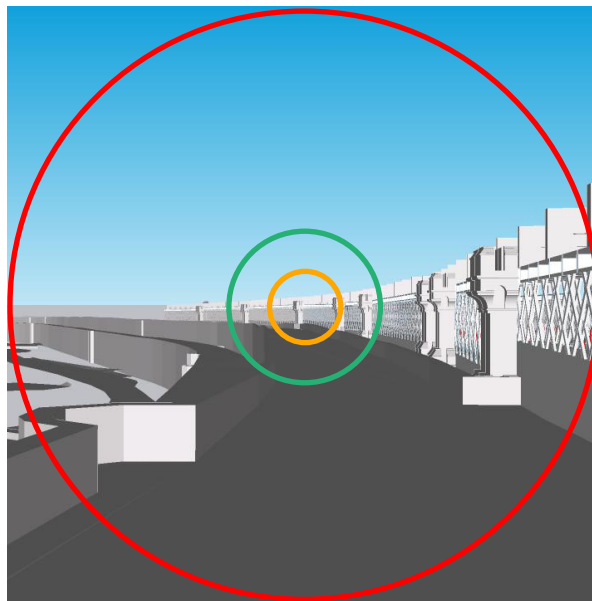
30° - field of view —

18° - macular —

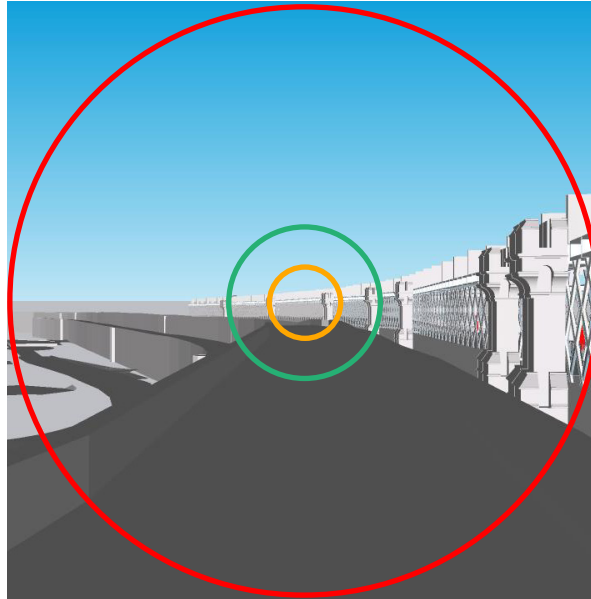
8° - paracentral —



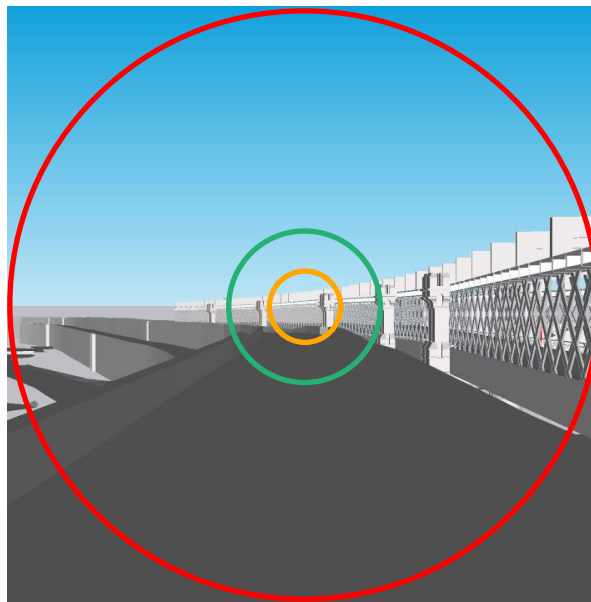
Viewpoint 1



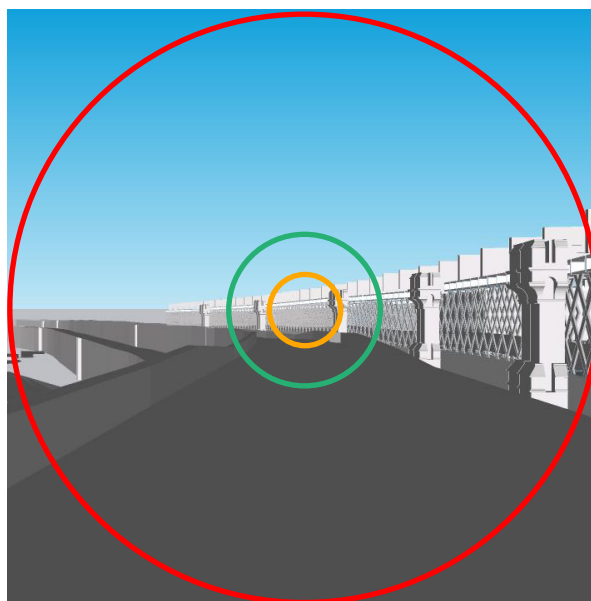
Viewpoint 2



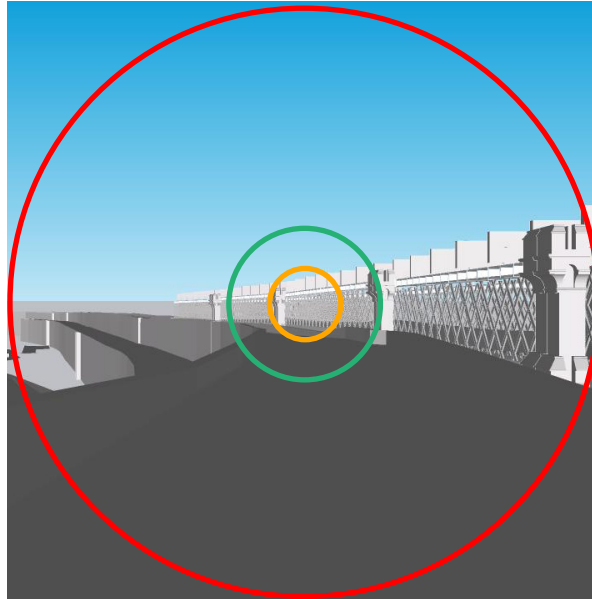
Viewpoint 3



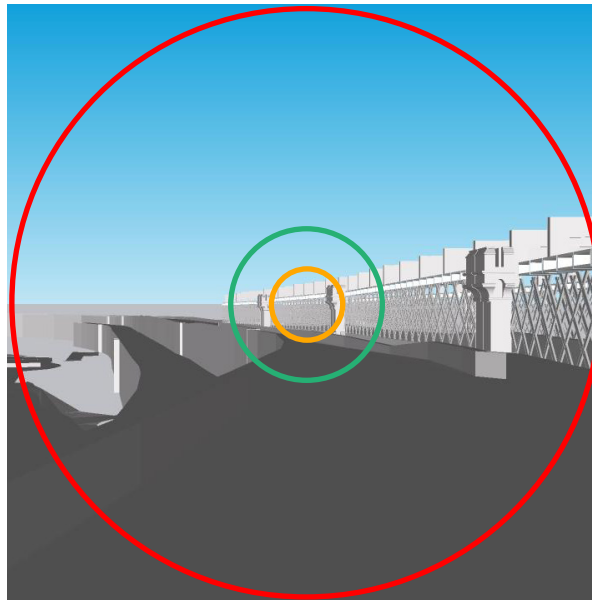
Viewpoint 4



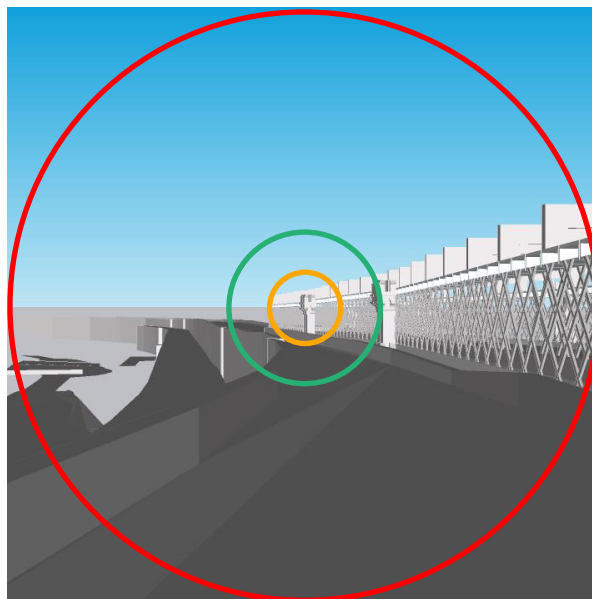
Viewpoint 5



Viewpoint 6



Viewpoint 7



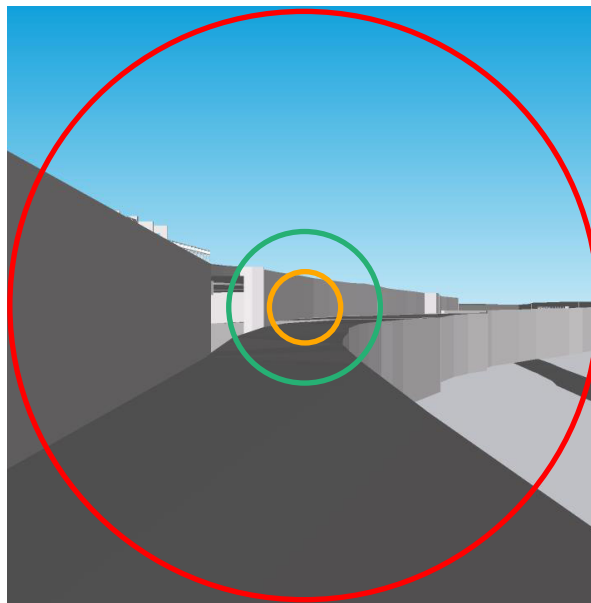
Viewpoint 8

Track 5

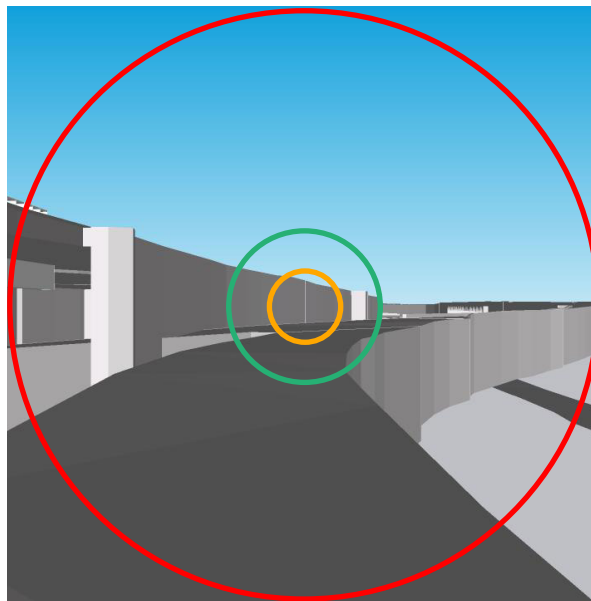
30°- field of view —

18° - macular —

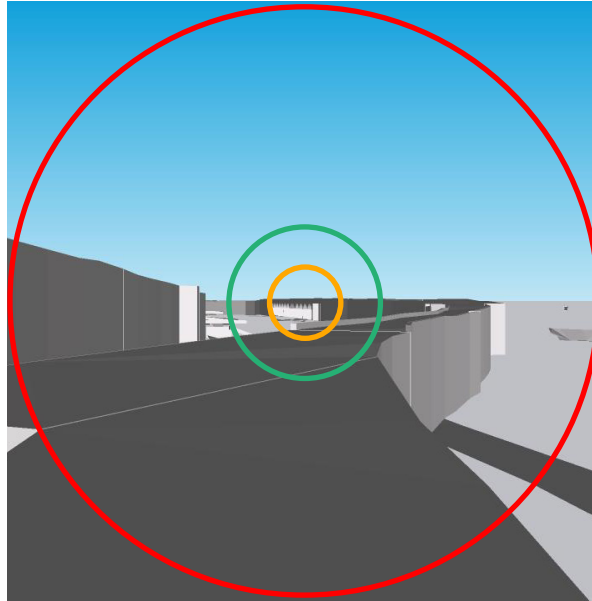
8°- paracentral —



Viewpoint 1



Viewpoint 2



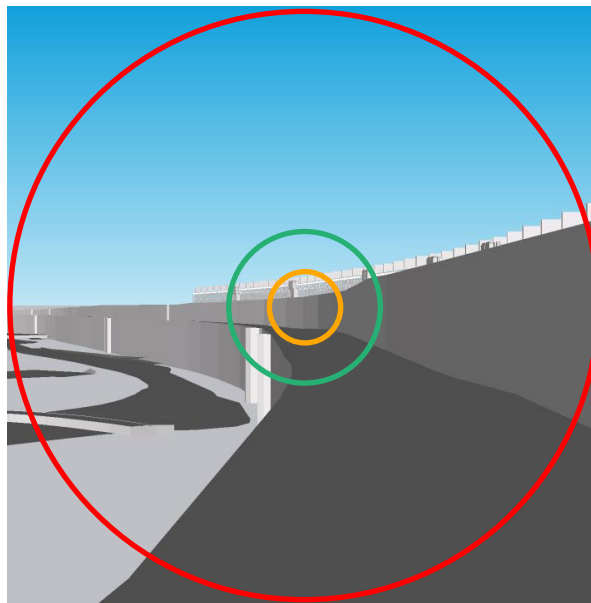
Viewpoint 3

Track 6

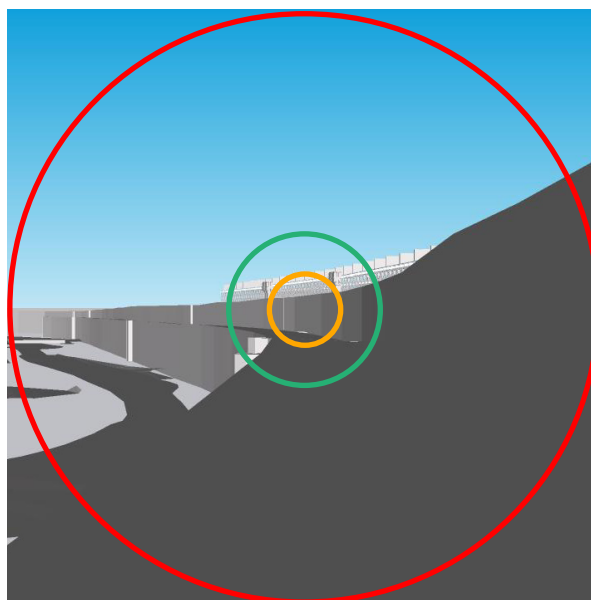
30°- field of view —

18° - macular —

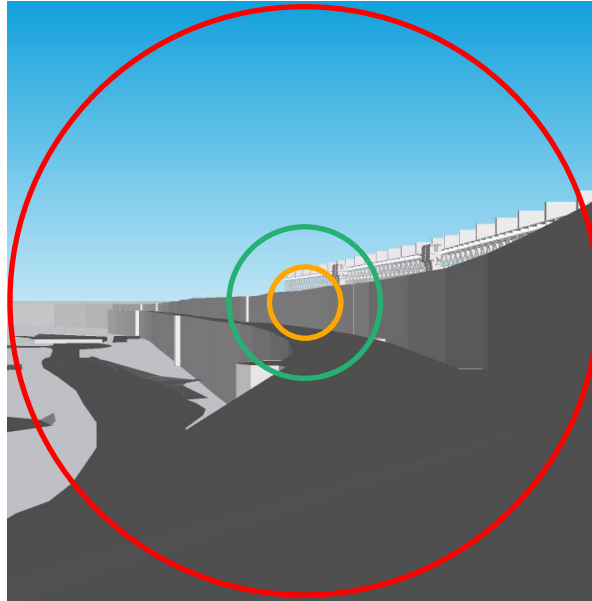
8° paracentral —



Viewpoint 1



Viewpoint 2



Viewpoint 3