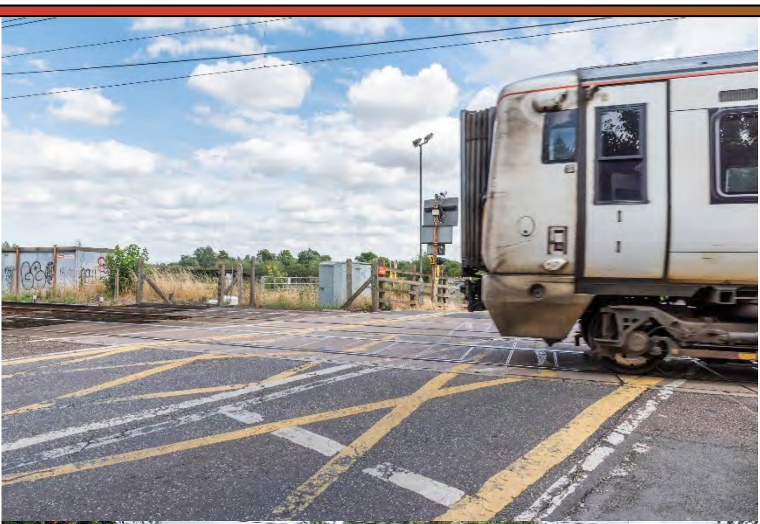

Risk Assessment for Waterbeach AHB Level Crossing

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REVISIONS

Revision No	Prepared by	Checked by	Issue date	Comments
Issue 00	David Harris	Chris Chapman	-	Working draft
Issue 01	David Harris	Chris Chapman	01/05/19	Issued to Network Rail for review
Issue 02	David Harris	Chris Chapman	17/06/19	Issued to Network Rail
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APPROVAL

Approved by: 	Name: David Harris
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	Date: 15th November 2019
Accepted By: (RLCM)	Name:
	Date:
Accepted By: (RAM Signalling)	Name:
	Date:

CONTENTS

ACRONYMS AND ABBREVIATIONS

Acronym	Description	Comments
ABCL	Automatic Barrier Level Crossing, Locally-monitored	
AHB	Automatic Half-Barrier (level crossing)	
ALARP	As Low As Reasonably Practicable	
ALCRM	The All Level Crossing Risk Model	A tool for assessing the risk at particular level crossings.
AOCL	Automatic Open Level Crossing, Locally-monitored	
AOCL+B	Automatic Open Level Crossing, Locally-monitored with retrofitted half barriers	
BAP	Biodiversity Action Plan	
BOAT	Byway Open to All Traffic	
BPM	Barrier Protection Management	A solution for auto-lower crossings that delays barrier lowering should there be a road vehicle underneath a barrier.
CBA	Cost Benefit Analysis	A numerical comparison of the monetised advantages and disadvantages of undertaking a particular course of action.
CCU / LCU	Crossing Control Unit	
COD	Complementary Obstacle Detector	
CCTV	Closed Circuit Television	
DIA	Diversity Impact Assessment	
EA	Equality Act 2010	
EACE	Ely Area Capacity Enhancement (project)	
ELR	Engineering Line Reference	
ERTMS	European Rail Traffic Management System	A system of train control that allows for automatic train protection and cab based signalling.
ETCS	European Train Control System	
FWI	Fatalities and Weighted Injuries	A measure of safety performance where the predicted rate of fatalities and minor and minor injuries are combined into an overall measure of risk.
HGV	Heavy Goods Vehicle	
LCM	Level Crossing Manager	

Acronym	Description	Comments
LED	Light Emitting Diode	
MCB-CCTV	Manually-Controlled Barrier Level Crossing with CCTV	
MCB-OD	Controlled Barrier Level Crossing with Obstacle Detection	
MCG	Manually-Controlled Gate Level Crossing	
NPV	Net Present Value	
ORCC	Operations Risk Control Coordinator	
ORR	Office of Rail and Road	
PHI	Priority Habitat Inventory	
POD	Primary Obstacle Detector	
PROW	Public Right of Way	
PSB	Power Signal Box	
RAM	Route Asset Manager	
ROC	Regional Operations Centre	
RLSE	Red light static enforcement cameras	
RSSB	Rail Safety and Standards Board	
RTL	Road Traffic Light	
SAC	Special Area of Conservation	
S&SRA	Suitable and Sufficient Risk Assessment	
SEU	Signalling Equivalent Unit	A measure of signalling cost
SLL	Stop, Look and Listen sign	Signage normally used for footpath or user-worked crossings that require pedestrians to check whether a train is approaching before deciding whether it is safe to cross
SMIS	Safety Management Information System	The database used by the UK rail industry for reporting accidents and near misses
SPAD	Signal Passed at Danger	
SRM	Safety Risk Model	The rail risk model managed on behalf of the industry by RSSB
SSSI	Sites of Special Scientific Interest	

Acronym	Description	Comments
TMOB	Trainman Operated Barrier crossing	
TOC	Train Operating Company	
TPV	Train Pedestrian Value	A measure of used based on pedestrian usage and train frequency
TTRO	Temporary Traffic Regulation Order	
TWAO	Transport & Works Act Order	
VAS	Vehicle Activated Sign	A sign that illuminates in the event of blocking back ahead, reminding drivers to keep the crossing clear
VpF	Value of Preventing a Fatality	A value used to express safety risk in financial terms
YN, YO, ZN, ZO	Denotes the corner of the crossing.	Y is closest to the Up line; Z the Down line; N is the nearside (for traffic); O the offside.

REFERENCE DOCUMENTS

The following documents have been used to support the production of this report:

Ref	Document Name	Number
1.	Level Crossings: A guide for managers, designers and operators (ORR)	Railway Safety Publication 7 December 2011
2.	Internal Guidance On Cost Benefit Analysis (CBA) IN Support Of Safety-related Investment Decisions	ORR, April 2015
3.	Network Rail Authority Paper (for LXEU and SEU costs)	V6.15 – 1st July 2015
4.	Census Report for Waterbeach Level Crossing	Tracsis 1167-WTR Site 27 – June 2018
5.	South Cambridgeshire Local Plan	Adopted September 2018
6.	Level Crossing Guidance Document: Applying Risk Reduction Bednefits in ALCRM When Modelling Safety Enhancements	LCG 14 March 2016
7.	Transforming Level Crossings: A vision-led long-term strategy to improve safety and level crossings on Great Britain's railways	NR17
8.	Waterbeach New Town East Planning & Delivery Statement	Boyer – May 2018
9.	Waterbeach New Town Supplementary Planning Document	Adopted February 2019
10.	Manually Controlled Barriers Obstacle Detection: MCB-OD Selection and Risk Mitigation Guidance	Signalling Design Group NR/IP/SDG York/MCB-OD/02 August 2014 Version 3.1
11.	MCB-OD Pedestrian Risk Tool	AD Little V1
12.	AHB+ HAZID Report	AES/1739/R03, Issue 2, 09/07/19
13.	AHB+ System Definition	AES/1739/R01, Issue 1, 29/03/19
14.	AHB+ Option 2 Feasibility Analysis Extract	
15.	RSSB, Safety Risk Model	V8.5.0.2, March 2018

1 INTRODUCTION

1.1 Background

The renewal of level crossings on the UK network must be supported by appropriate and robust risk assessment. This level crossing risk assessment was originally produced in support of the Cambridge Area Interlocking Renewals (CAIR) project in 2013. The Cambridge – Dullingham – Bury Re-Signalling (CBD) Project started out being called Cambridge Inner Re-Signalling (CIRS) with a smaller geographical scope. A further scope of works Cambridge Outer Re-Control and Life Extension (CORCLE) was added to the CIRS scope partway through GRIP 1 in order to gain efficiencies. An update to this level crossing risk assessment is required in order to take into account the latest project information. As part of this process, Network Rail has tasked Sotera Risk Solutions to update the suitable and sufficient risk assessment of the closure and renewal options for Waterbeach AHB level crossing.

1.1 Approach to risk assessment

In order to carry out the risk assessments, Sotera has:

- Reviewed available information pertinent to the level crossing (including, SMIS event data, and input data to the All Level Crossings Risk Model (ALCRM)).
- Analysed national level crossing risk information to compare the main level crossing type options.
- Undertaken a site visit to the crossing to assess its current operation, to determine the existing controls, identify local hazards, to measure distances key to the risk assessment and make a photographic record of any issues.
- Specified and carried assessments of the crossing type options using the ALCRM.
- Carried out an initial options assessment which considered the available crossing type options from a safety, cost and feasibility perspective
- Facilitated an options assessment workshop, which reviewed the initial options assessment, supplementing it with additional information and ideas as appropriate.

2 DESCRIPTION OF THE SITE AND THE EXISTING LEVEL CROSSINGS

2.1 Current level crossing detail

Waterbeach is an AHB crossing, with two half-width barriers and four RTLs. The RTLs are LED type. In addition, the crossing has two Standing Red Men (*Figure 2*). There are Red Light Enforcement cameras on both sides of the crossing, and yellow box hatching on the crossing surface.

The crossing is monitored from Cambridge signal box.

The maximum line speed is 75 mph over this line. The line is electrified with overhead lines.

Figure 1 shows the configuration of the crossing, viewed from the east. *Figure 3* provides the relevant extract from the sectional appendix covering the crossing. *Table 1* presents details of the location and operation of the crossing.

Figure 1 Current crossing equipment

Figure 2 Standing Red Man

Table 1 Current Level Crossing Details

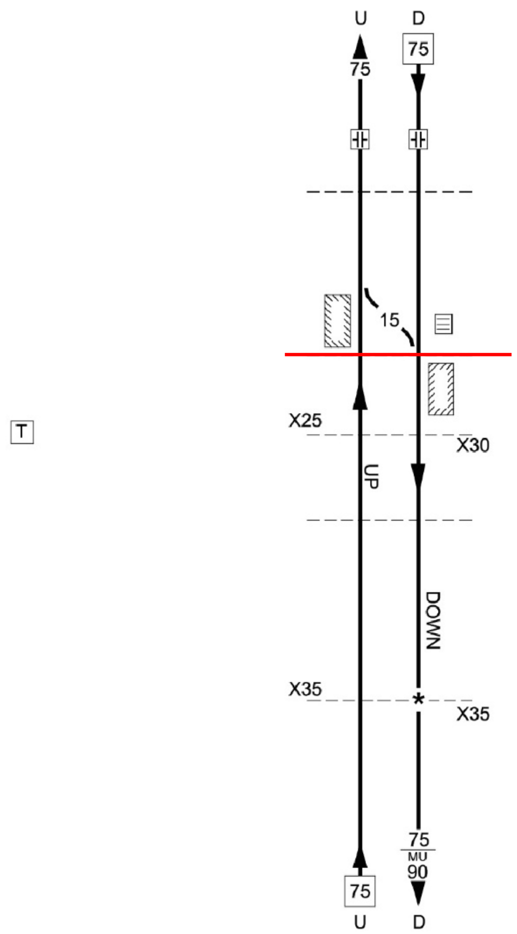
Level crossing names	Waterbeach
Level crossing type	AHB
ELR and mileage	BGK 61m 0ch
Status	Public Road
Number of running lines	2
Permissible speed over crossing (Up)	75mph
Permissible speed over crossing (Down)	75mph
OS grid reference	TL500649
Postcode	CB5 9HS
Road name and type	Station Road/Clayhithe Road (undesignated)
Local Authority	Cambridgeshire County Council
Supervising signal box	Cambridge PSB
Electrification and type	Overhead Line

Figure 3 Extract from the sectional appendix

LOR	Seq.	Line of Route Description	ELR	Route	Last Updated
EA1161	011	Bishops Stortford to Ely North Jn	BGK	Anglia	12/11/2016

Location	Mileage M	Mileage Ch	
OHNS	58	71	
Milton Fen LC (AHBC)	59	10	
Waterbeach GSP	60	78	
Waterbeach LC (AHBC)	61	00	
WATERBEACH	61	01	
Burgess Drove LC (R/G-X)	61	20	
Bottisham Road LC (AHBC)	61	48	
Bannolds LC (AHBC-X)	62	70	*

Running lines & speed restrictions



Signalling & Remarks

TCB	Cambridge SB (CA)
RA8	AC: Romford

GSM-R

Up platform - 90m (97 yds)

Down platform - 86m (93 yds)

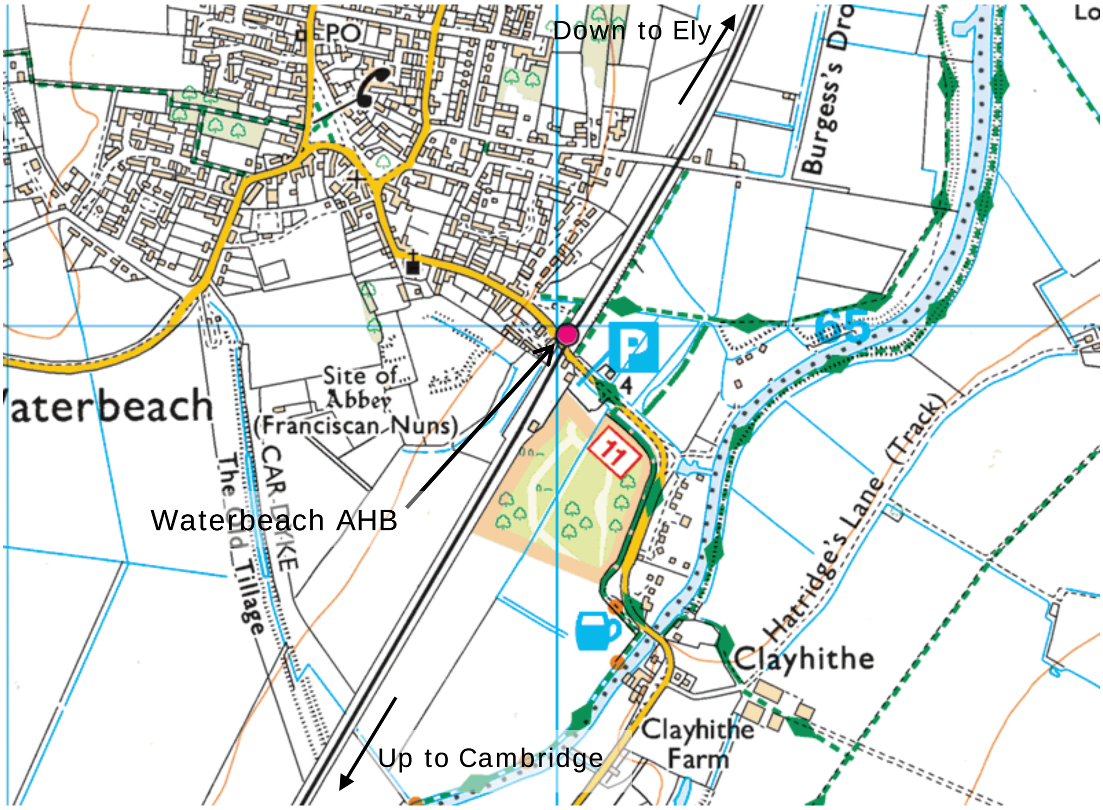
2.2 Environment

The crossing is located by Waterbeach Station on Station Road/Clayhithe Road on the east side of the town of Waterbeach, in Cambridgeshire as shown in *Figure 4*. The crossing allows access between Waterbeach and Clayhithe where there is a crossing over the River Cam; the road continues to join the A14 to the south, providing a convenient through route for many people as well as forming a diversionary route when there are problems on the A10. The crossing is between the platforms of Waterbeach Station, with the town to the west and the station car park to the east and is used by pedestrians to access the platforms.

Burgess Drove UWCMSL is 390m north of the crossing.

National Cycle Route 11 starts on the east side of the crossing.

Figure 4 Map showing an overview of the location of the crossing



A satellite view of the location is shown in *Figure 5*.

Environmentally significant sites are shown in *Figure 6*.

There are several Coastal and Floodplain PHIs near to the crossing, and a Deciduous Woodland PHI on the south east side of the crossing.

The site of the Franciscan Abbey and Carr Dyke, south west of the crossing, are Scheduled Monuments.

Figure 5 Satellite view showing the location of the crossing

Figure 6 Environmentally significant sites

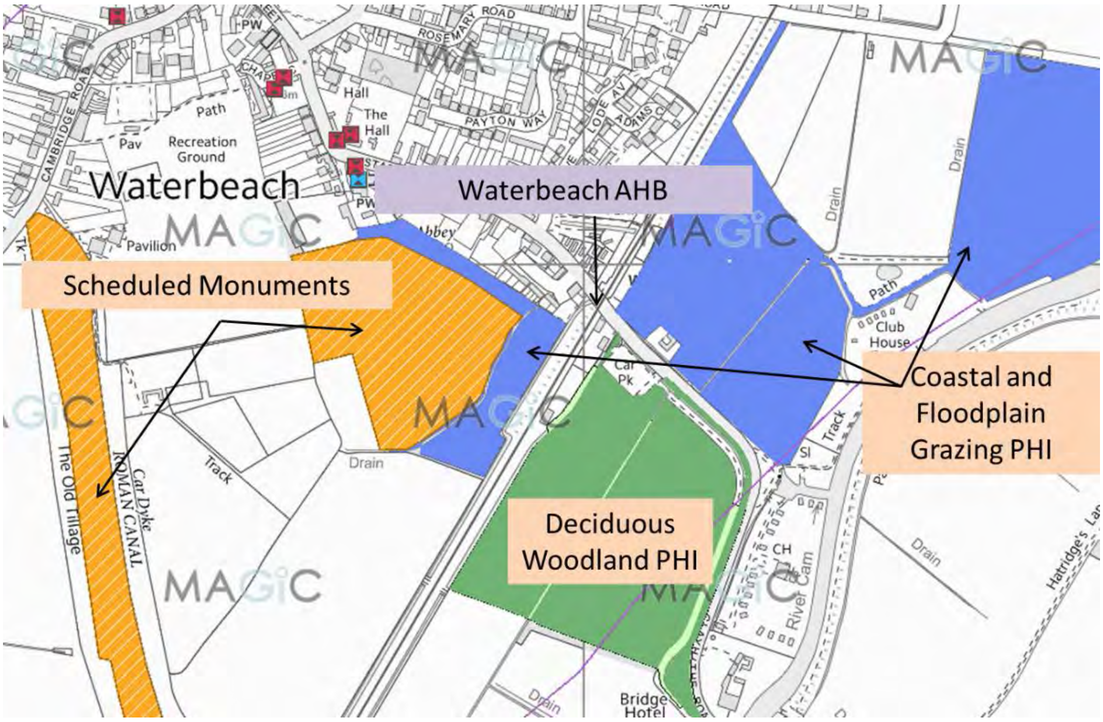


Figure 7 National Cycle Route 11

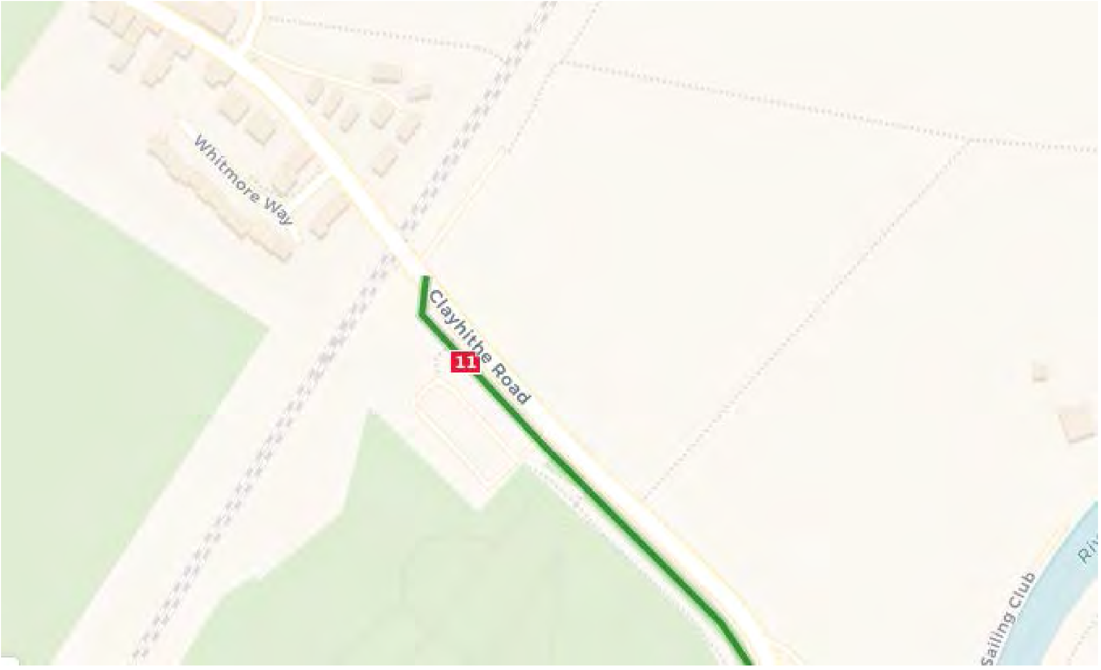


Figure 8 National Cycle Route 11

2.3 Footpath approaches

There are footways on both sides of the crossing as seen in *Figure 1*. The footway on the north side (*Figure 9*) varies between 1.37m and 1.05m wide (the footway is narrowed by the fence at the ZN corner). The footway on the south side (*Figure 10*) varies between 1.40m and 0.90m wide (the footway is narrowed by the grass at the ZO corner). There is a slight trip hazard at the west sill beam on the north footway (*Figure 12*).

The north footway is 13m long, the south footway is 12m long.

The census indicates a weekday average pedestrian frequency of 580 and a weekly average of 547.

Based upon ORR guidance[1], pedestrian footpaths over crossings are categorised into three classes based upon usage by pedestrians and the frequency of rail traffic. From the guidance the volume of pedestrian and train flow is determined by the train pedestrian value (TPV). The TPV is the product of the maximum number of pedestrians and the number of trains passing over the crossing within a period of 15 minutes. The TPV at Waterbeach, based upon a 9-day census, is 189. This places the crossing in the mid usage category – category 'B' (the criteria for class B being a TPV of between 151 and 450). In this class the ORR recommends that the footpaths are 1.8m wide.

The footways are, therefore, not in compliance with the minimum width of 1.8m specified in ORR guidance for a pedestrian category B crossing.

There are no tactile thresholds on the footways.

The north footway continues along pavement to the northwest. There is, however, no pavement for it to meet to the southeast.

The south footway continues along the normal roadway to the southeast, towards a path to the station car park. This crosses the entrance to a Network Rail depot. There are some bollards along the route between the end of the footway and the depot entrance to give some protection. There is no pavement for it to meet up with to the southwest - only a narrow strip of land, with slight protection from two bollards, which people may walk along to reach a pavement which starts 15m further on.

The Up platform of Waterbeach station and the station car park are on the south east side of the crossing and the Down platform is on the northwest side. The town is to west. There is no footbridge so pedestrian access between the platforms requires use of the crossing. The exits from both platforms are below the RTLs, however as standing red man lights are only provided on the offside of the road these are not well orientated for pedestrians exiting the platforms (*Figure 14* and *Figure 16*).

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[1] ORR, Level Crossing: A guide for managers, designers and operators, Railway Safety Publication 7, December 2011.

There is a public footpath on both the Up (path no. 247/21) and Down side (path no. 247/20) going north on either side of the railway (see *Figure 4*), which will tend to increase the pedestrian use of the crossing, and a footpath from the station car park going towards the river nearby.

A section of National Cycle Route 11 (Waterbeach to Great Shelford Greenway) starts on the east side of the crossing which may cause increased use of the crossing by cyclists.

Figure 9 Footway – North side

Figure 10 **Footway – South side**

Figure 11 **Footway trip hazard – North west side**

Figure 12 Footway narrows – South west side

Figure 13 Up Platform Exit – south east side

Figure 14 View of Standing Red Man from Up platform exit

Figure 15 Down Platform Exit – north west side

Figure 16 View of Standing Red Man from Down platform exit

2.4 Road approaches

Road approach to the crossing from the east

A 30mph speed limit applies on the road approach from the east from 50m southeast of the crossing, prior to that the limit is 40mph. During the 9-day census the 85th percentile speed of approach was 28.6mph.

The key features of the approach are:

1. The road is straight on the approach.
2. There is a station car park on the left, 90m east of the crossing (*Figure 22*).
3. There is a gate on the right 50m east of the crossing (*Figure 23*).
4. Vehicles park on the left, 40m east of the crossing (*Figure 20*).
5. There are bus stops on both sides of the road 15m east of the crossing.
6. There is a Network Rail depot on the left, 14m east of the crossing (Figure 24). This has Keep Clear road markings.
7. There is a rail access gate on the right, by the line of the crossing (*Figure 26)*.
8. The near side RTL is visible from beyond 150m on the approach. Trees obscure the view of the offside RTL until 80m east of the crossing.
9. The level crossing signage had good conspicuity at the time of the site visit.

The distant, intermediate and close road approaches from the east are shown in *Figure 18* to *Figure 21*. It can be seen in *Figure 18* that the crossing is visible from the distant signage.

A plan of the key features is shown in *Figure 17;* the numbers in the figure refer to the above numbered list of features.

Figure 17 Key features on the eastern approach to the crossing

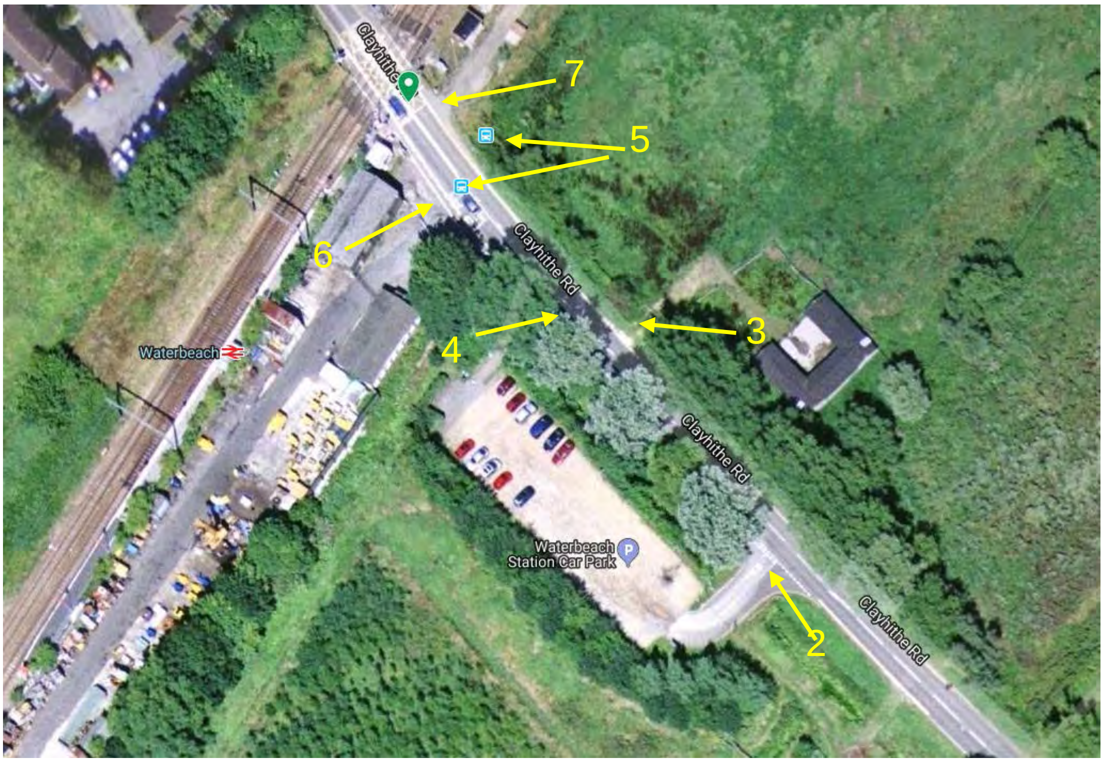


Figure 18 View approaching crossing from the east - distant

Figure 19 **View approaching crossing from the east - intermediate**

Figure 20 **View approaching crossing from the east - intermediate**

Figure 21 View approaching crossing from the east - near

Figure 22 Car park on left

Figure 23 Gate on right

Figure 24 Network Rail depot on left

Figure 25 Keep Clear

Figure 26 Gate on right

Road approach to the crossing from the west

A 30mph speed limit applies on the road approach from the west. During the 9-day census the 85th percentile speed of approach was 34.2mph. The key features of the approach are:

1. The road has a bend to the right on the approach, 85m west of the crossing.

2. There is a junction with Lode Avenue on the left, 93m west of the crossing (*Figure 32*).

3. There is a bus stop on the left, 80m west of the crossing (*Figure 29*).

4. There is a junction with Whitmore Way on the right, 32m west of the crossing (*Figure 34*).

5. The nearside RTL is visible from 125m on the approach, but due to the bend the offside RTL is not visible at this point. At 86m the offside RTL becomes partially visible, however it is partially obscured by vegetation until around 75m west of the crossing.

6. The level crossing signage was partially obscured by vegetation growth at the time of the site visit (*Figure 29*).

7. The crossing has a skew of 65^{0}.

The distant, intermediate and close road approaches from the northwest are shown in *Figure 28* to *Figure 31*.

A plan of the key features is shown in *Figure 27;* the numbers in the figure refer to the above numbered list of features.

Figure 27 Key features on the western approach to the crossing

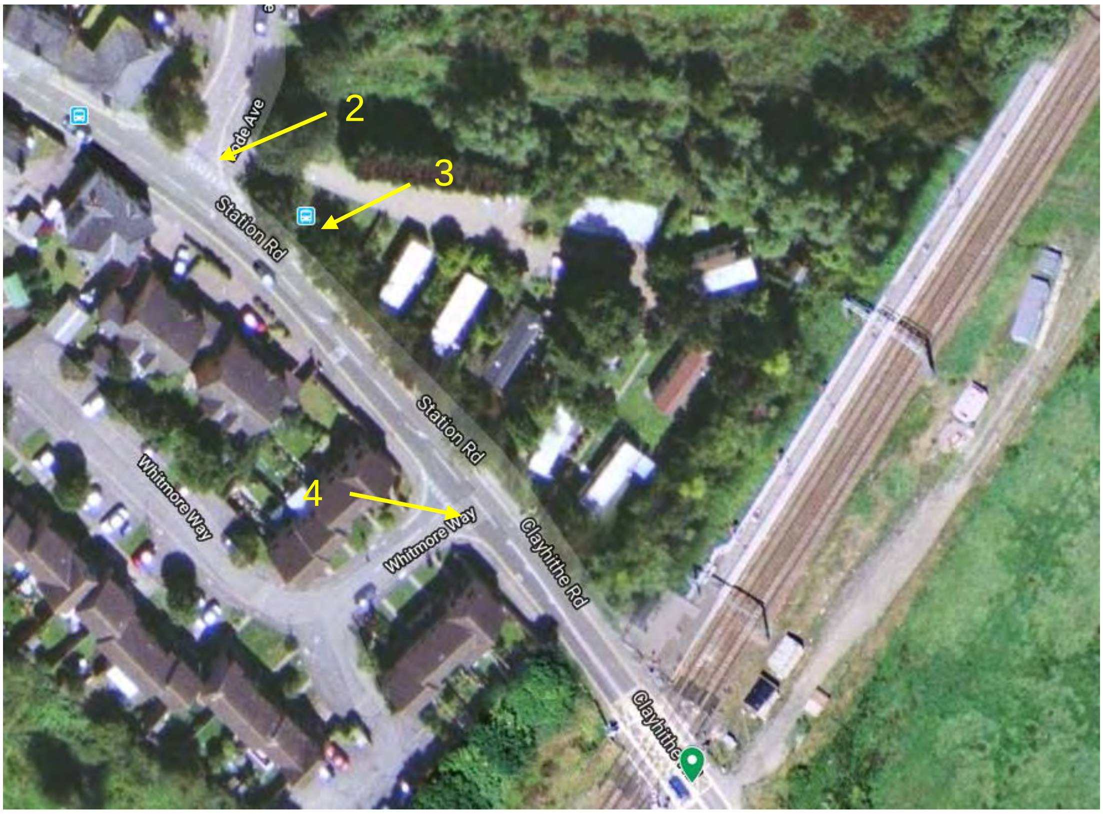


Figure 28 View approaching crossing from the west - distant

Figure 29 **View approaching crossing from the west - intermediate**

Figure 30 **View approaching crossing from the west - intermediate**

Figure 31 **View approaching crossing from the west - near**

Figure 32 **Lode Avenue on left**

Figure 33 Driveway on right

Figure 34 Whitmore Way on right

Figure 35 Crossing surface

Figure 36 Crossing skew 65^0

2.5 Impact of low sun on the crossing

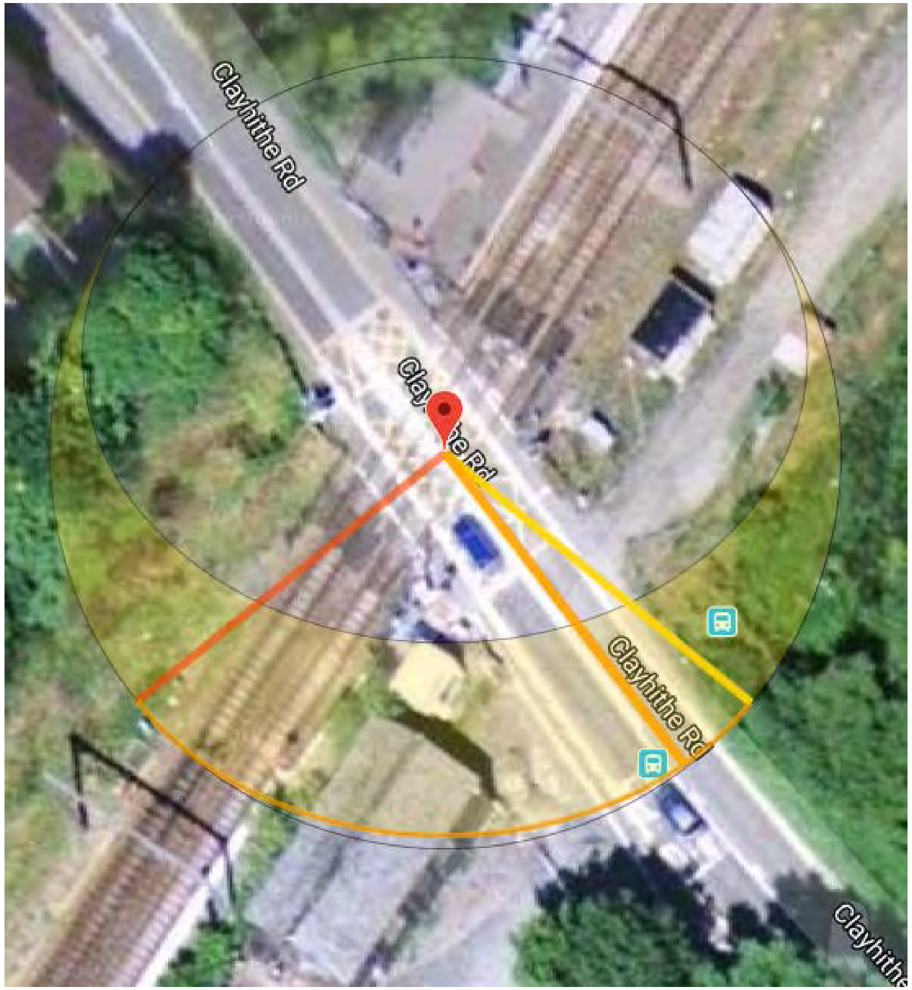
Waterbeach level crossing is a northwest-southeast facing crossing (for the road), therefore road users are potentially affected by sun glare.

Below, is the output from the SunCalc application, which has been used to identify the line of the sun at sunrise and sunset at times of year when low sun would align with the road approaches. The shortest and longest day are shown in *Figure 37*.

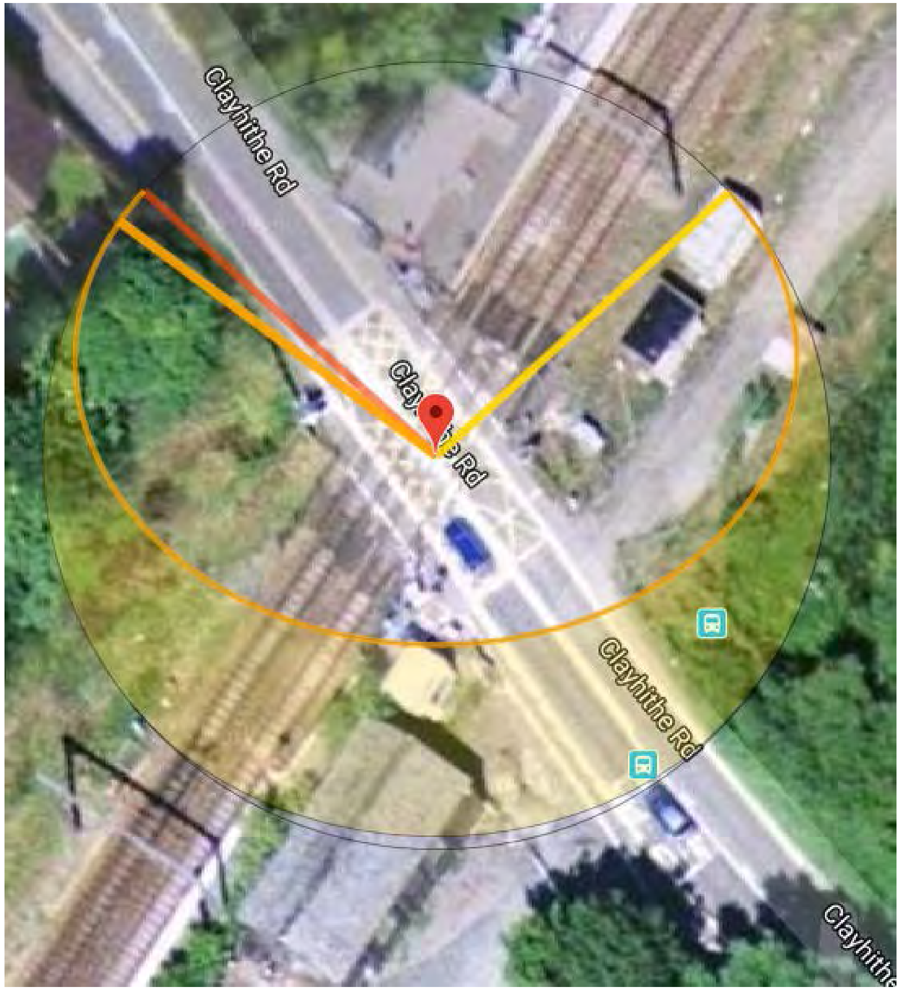
The thin orange curve is the current sun trajectory, and the yellow area around is the variation of sun trajectories during the year. The closer a point is to the centre, the higher is the sun above the horizon.

The yellow line shows the direction of sunrise; the dark orange line the direction of sunset and the mid orange line the direction at a selected time of day (shown by the orange circle above the satellite image).

Figure 37 Suncalc diagrams



Shortest Day



Longest Day

Northwestbound approach

There are two potential issues with low sun when approaching the crossing northwestbound:

1. In the winter the rising sun would shine towards the RTLs, potentially washing them out. The impact of this is reduced by the trees to the south of the crossing.
2. In the summer the setting sun would be almost straight behind the crossing, potentially causing glare. The impact of this is reduced by the buildings and trees to the north of the crossing which would provide background screening and the fact that the sun would never be quite behind the crossing.

Southeastbound approach

There is one potential issue with low sun when approaching the crossing south-eastbound:

1. In the winter the rising sun would be straight behind the crossing, potentially causing glare. The impact of this is reduced by the trees to the south of the crossing which would provide background screening.

The crossing is currently provided with LED type RTLs to mitigate the impact of the low sun.

3 CROSSING USAGE

This section of the risk assessment discusses the current usage of the crossing and its history of accidents and incidents. It then considers proposed and potential future changes to the usage and assesses the safety impact.

3.1 Traffic census

A nine-day, 24-hour traffic census by continuous recording was carried out at the crossing between 2nd and 10th June 2018. The following provides a summary of the results obtained of this census.

Train frequency	**Weekday**	183
	Saturday	140
	Sunday	79
Road closure (min:secs)	**Average**	00:51
	Maximum	02:26
Road vehicle frequency	**Busiest day**	5,753
	Average weekday	5,515
Blocking Back Observations		None
85th percentile speed (free flowing cars only)	**Eastbound**	34.2
	Westbound	28.6
Pedestrian and cyclist frequency	**Busiest day**	939
	Average week day	881
Train Pedestrian Value (TPV)		189
Pedestrian Category		B

The observed train, vehicle and pedestrian usage is presented in *Table 2* and a detailed breakdown for pedestrians is shown in *Table 3*; the nine-day average hourly distribution of usage is shown graphically in *Figure 38*.

The notable observations recorded in the report were:

- No Blocking back was observed.
- No red light misuse was observed.

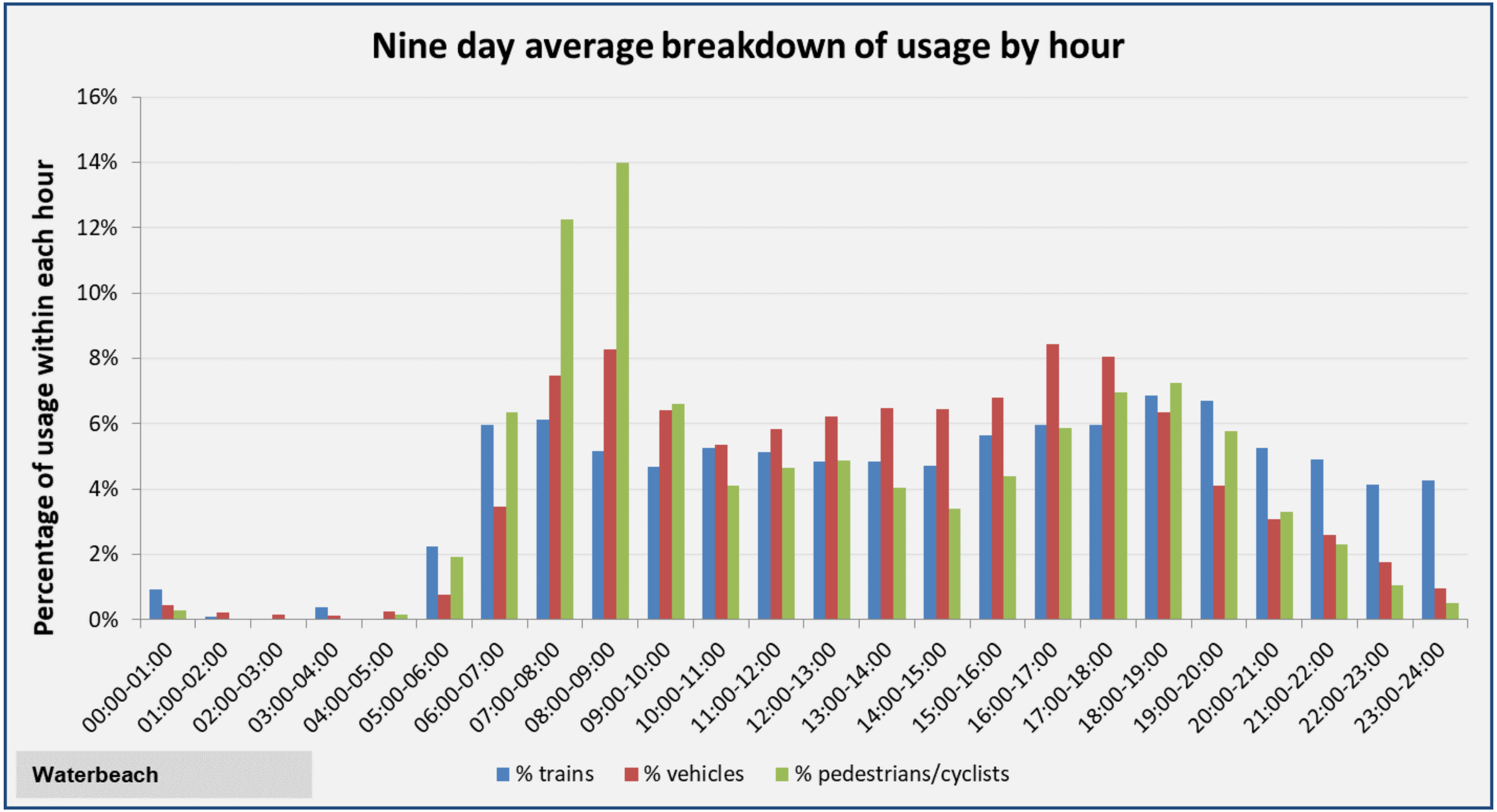
Table 2 Traffic survey observed usage

Census Site 27 - Waterbeach			Totals per day										
			Vehicles							Pedal cyclists and pedestrians			
Day		No. trains per day	Cars	Vans / small lorries	HGVs	Buses	Tractors	Motor cycles	Total	Pedal cycles	Herded animals and horses	Pedestrians	Total
Saturday	02-Jun-18	140	3,337	237	20	0	0	39	3,633	213	0	492	705
Sunday	03-Jun-18	79	3,001	154	11	0	3	61	3,230	257	0	498	755
Monday	04-Jun-18	178	4,370	552	58	11	2	57	5,050	175	0	608	783
Tuesday	05-Jun-18	183	4,681	629	65	9	7	64	5,455	359	0	557	916
Wednesday	06-Jun-18	174	4,952	613	58	6	5	60	5,694	356	0	583	939
Thursday	07-Jun-18	162	5,007	597	73	13	14	49	5,753	267	0	580	847
Friday	08-Jun-18	177	4,917	572	54	9	10	61	5,623	276	0	646	922
Saturday	09-Jun-18	139	3,475	229	18	0	3	39	3,764	196	0	473	669
Sunday	10-Jun-18	78	3,115	141	7	0	0	46	3,309	251	0	490	741
Highest		183	5,007	629	73	13	14	64	5,753	359	0	646	939
7 day average		156	4,342	478	48	7	6	55	4,935	270	0	564	835
Weekday average		175	4,785	593	62	10	8	58	5,515	287	0	595	881

Table 3 Observed pedestrian usage

Pedestrian census		Totals per day									
Site 27 - Waterbeach											
Day		Adult	Accompanied Child	Unaccompanied Child	Elderly	Impaired	Wheelchair	Pushchair / Pram	Scooter	Railway Personnel	Total
Saturday	02-Jun-18	474	11	0	0	0	0	7	0	0	492
Sunday	03-Jun-18	479	11	0	0	1	0	7	0	0	498
Monday	04-Jun-18	590	15	0	0	0	0	3	0	0	608
Tuesday	05-Jun-18	546	5	0	0	0	0	6	0	0	557
Wednesday	06-Jun-18	566	5	0	0	0	0	12	0	0	583
Thursday	07-Jun-18	568	4	0	0	0	0	8	0	0	580
Friday	08-Jun-18	628	8	2	0	0	0	8	0	0	646
Saturday	09-Jun-18	443	14	0	1	2	0	13	0	0	473
Sunday	10-Jun-18	461	12	0	0	0	0	17	0	0	490
Highest		628	15	2	1	2	0	17	0	0	646
7 day average		547	9	0	0	0	0	8	0	0	564
Weekday average		580	7	0	0	0	0	7	0	0	595

Figure 38 Nine Day Average Breakdown of Usage by Hour



3.2 Rail approach and usage

The crossing is located between Bishops Stortford and Ely North Junction. There are two tracks at the crossing, and it is electrified by overhead line. It is a moderately utilised stretch of line with a weekday average of 178 trains. There are approximately 176 passenger trains in each direction and the remainder are freight trains. The line speed is 75mph along this stretch of track.

The rail approach to the crossing from the south

Trains travelling north are travelling in the Down direction towards Ely. The view from the crossing looking south is shown in *Figure 39*. The track is straight on this approach.

For trains travelling in the Up direction, in the unlikely event of a derailment following hitting a vehicle on the crossing, the OHL stanchions and station platform may exacerbate the potential derailment consequences.

Figure 39 View of Down rail approach (looking towards Cambridge)

The rail approach to the crossing from the north

Trains travelling south are travelling in the Up direction towards Cambridge.

The view from the crossing looking north is shown in *Figure 40*. The track is straight on this approach.

For trains travelling in the Down direction, in the unlikely event of a derailment following hitting a vehicle on the crossing, the OHL stanchions and station platform may exacerbate the potential derailment consequences.

Figure 40 View of Up rail approach (looking towards Ely)

3.3 Incident/near miss history

Ten years of Incident data have been analysed for the crossing, which was provided by RSSB (the data period ends in August 2016). A summary by incident type is listed in *Table 4*.

The crossing has a much greater than average number of near miss/misuse incidents for the crossing type.

It is recognised that not all incidents are reported into RSSB's SMIS database.

Table 4 Summary of Incidents

SMIS classification	Incidents in data set	Average for LC type	Ratio to average for LC type
Train - striking road vehicle or gate at LC	0	0.10	0.00
Train - striking or being struck	0	0.15	0.00
Non-rail vehicles (incl. vehicle on line)	1	1.55	0.65
Person - personal accident	0	0.28	0.00
Level Crossing/LC equipment - misuse/near misses	31	5.36	5.78
Near miss - train with person (not at LC)	0	0.01	0.00
Train - striking animal	0	0.07	0.00
Animals - on the line	0	0.11	0.00
Person - trespass	0	0.12	0.00
Person - vandalism	0	0.25	0.00
Irregular working (pre 25/11/2006)	0	0.05	0.00
Irregular Working	0	0.24	0.00
Level crossing - equipment failure	3	9.38	0.32
Signalling system - failure	0	0.11	0.00
Permanent way or works - failure	0	0.03	0.00
All incidents	35	18.10	**1.93**

Note, the data in this table is not normalised, therefore a crossing with high use would generally be expected to have higher ratios.

The following incidents are noteworthy at the crossing:

- A person was hit by train and fatally injured outside of the above data period in April 2018, this was considered to be non-suspicious.
- A '*near miss*' with a vehicle reported

- Two '*near misses*' with cyclists reported
- Nine '*near misses*' with pedestrians reported
- Fourteen other incidents of misuse by pedestrians reported
- One incident of a lorry stuck on crossing after hitting barrier reported
- One incident of blocking back due to traffic build-up after a road accident

More recent SMIS data, for one year to 13th March 2019, shows an incident of a collision between train and vehicle on the crossing in March 2018 causing minor injuries; a '*near miss*' with two pedestrians and misuse by a cyclist.

3.4 Future demand and use of the level crossing

Any decision to install a level crossing needs to account for both the current use and any reasonably foreseeable increase in future demand that may affect the risk to passengers and the public.

Key factors that can affect the future use are:

- Planned increases to train services or train speeds;
- Local developments (e.g. opening schools, retail outlets, factories);
- Closure of adjacent level crossings, meaning that the road and pedestrian traffic of any closed crossings now use the one subject to assessment.

Under the South Cambridgeshire Local Plan (5) (Adopted Sept 2018), Waterbeach is identified as Strategic site. A new town of approximately 8,000 to 9,000 dwellings and associated uses is proposed on the former Waterbeach Barracks and land to the east and north of Waterbeach. It aims to deliver high quality public transport links to Cambridge, including a relocated railway station to enable a high modal share of travel by means other than the car. Five schools, two secondary schools, a sixth-form college and shops are also included in the local plan. An overview of the development is shown in *Figure 41* to *Figure 46.*

Relocation of the station further north, close to the new developments is also proposed. This would potentially reduce the pedestrian usage at Waterbeach crossing significantly. The increase in population may increase the usage for a period before the relocation and vehicle usage could be increased overall as the crossing provides a through road to the A14.

Figure 41 New Town Development Area

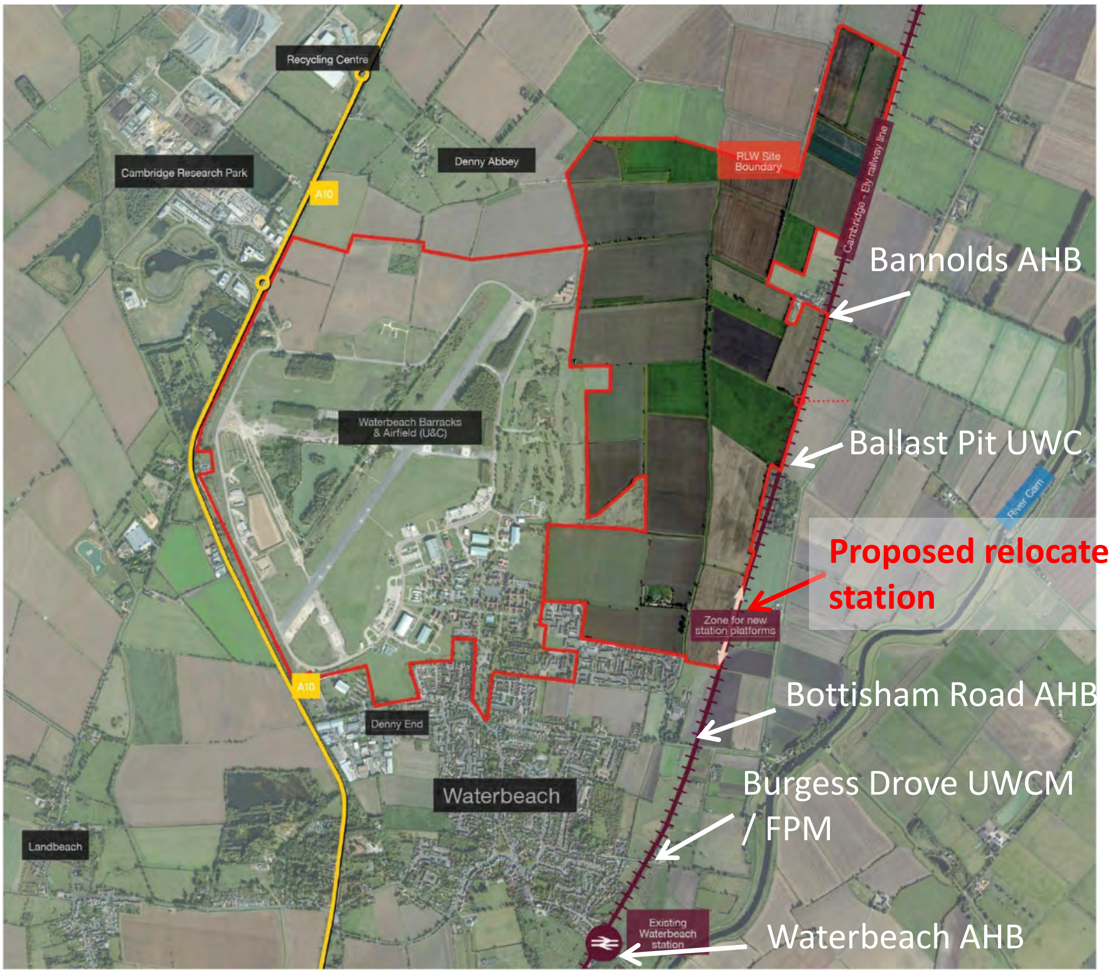


Figure 42 RLW Development Key

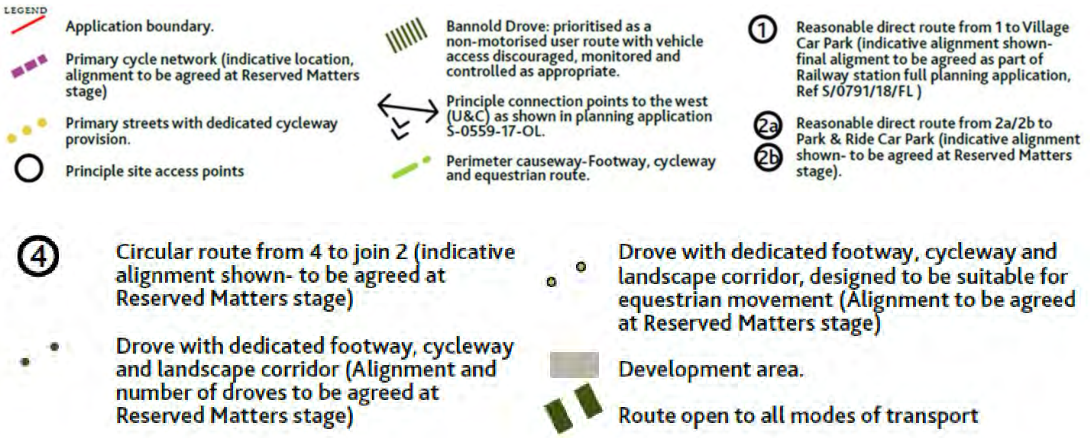


Figure 43 Access and movement – southern part of RLW development

Figure 44 Access and movement – northern part of RLW development

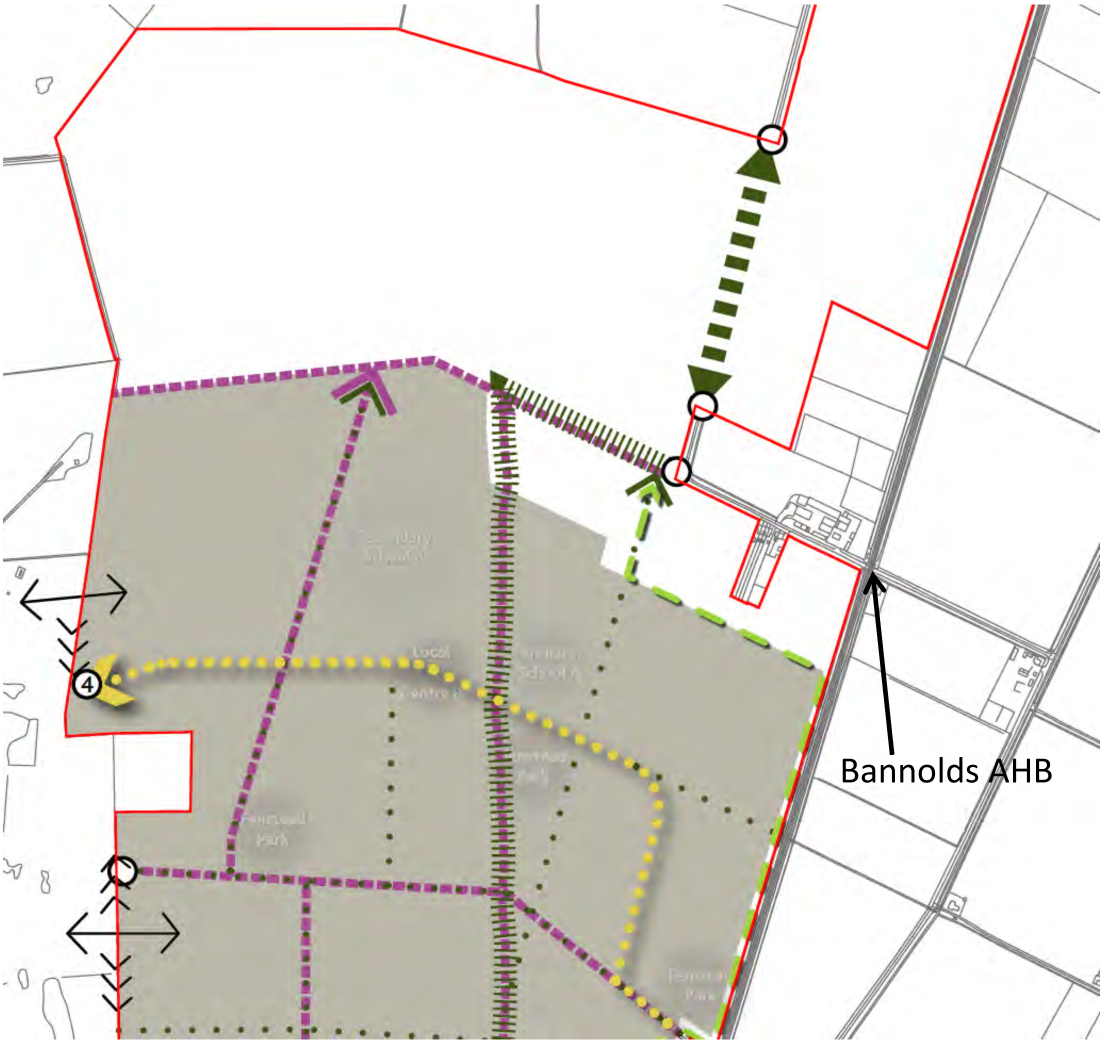


Figure 45 Access and movement – southern part of RLW development

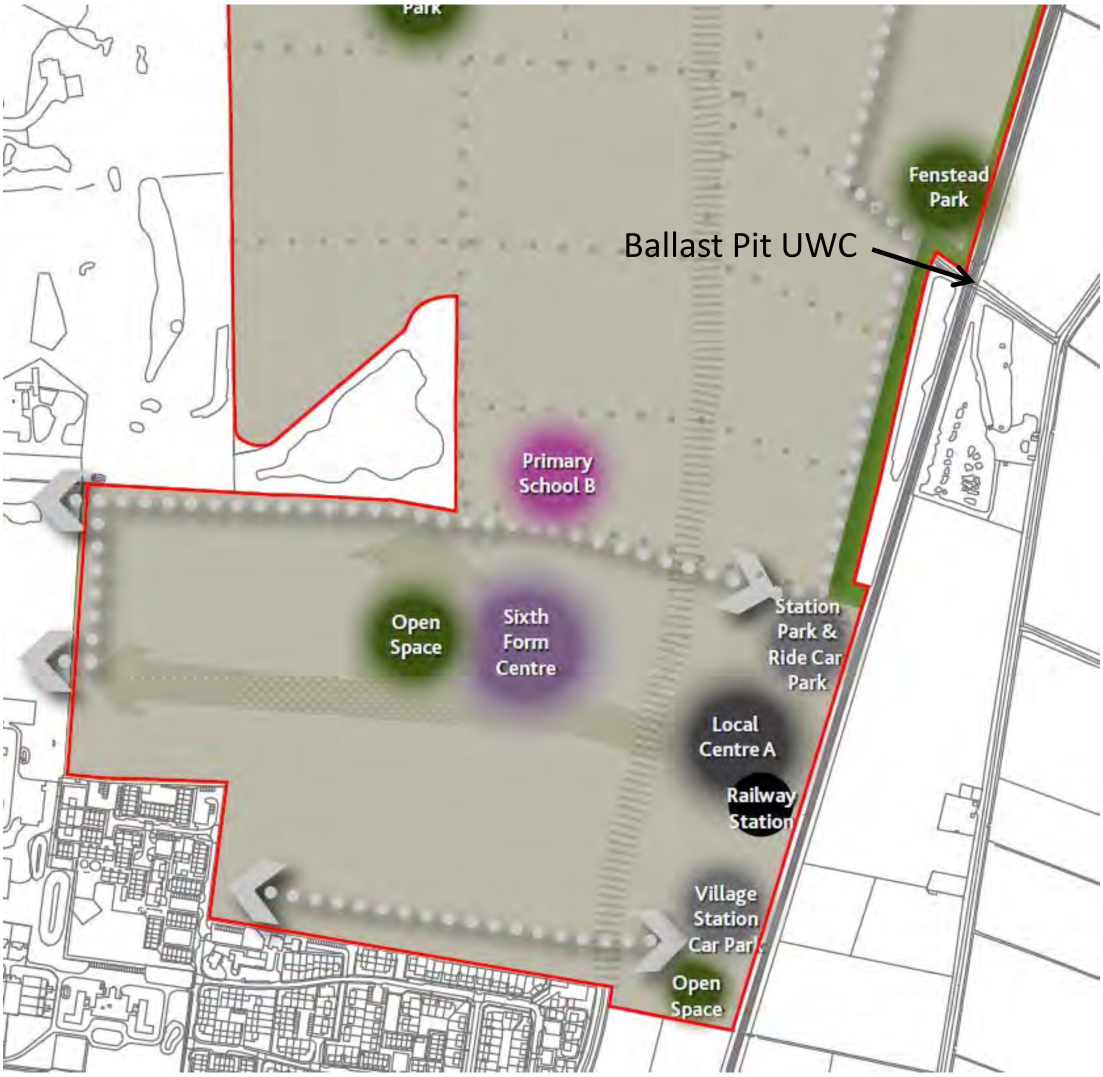
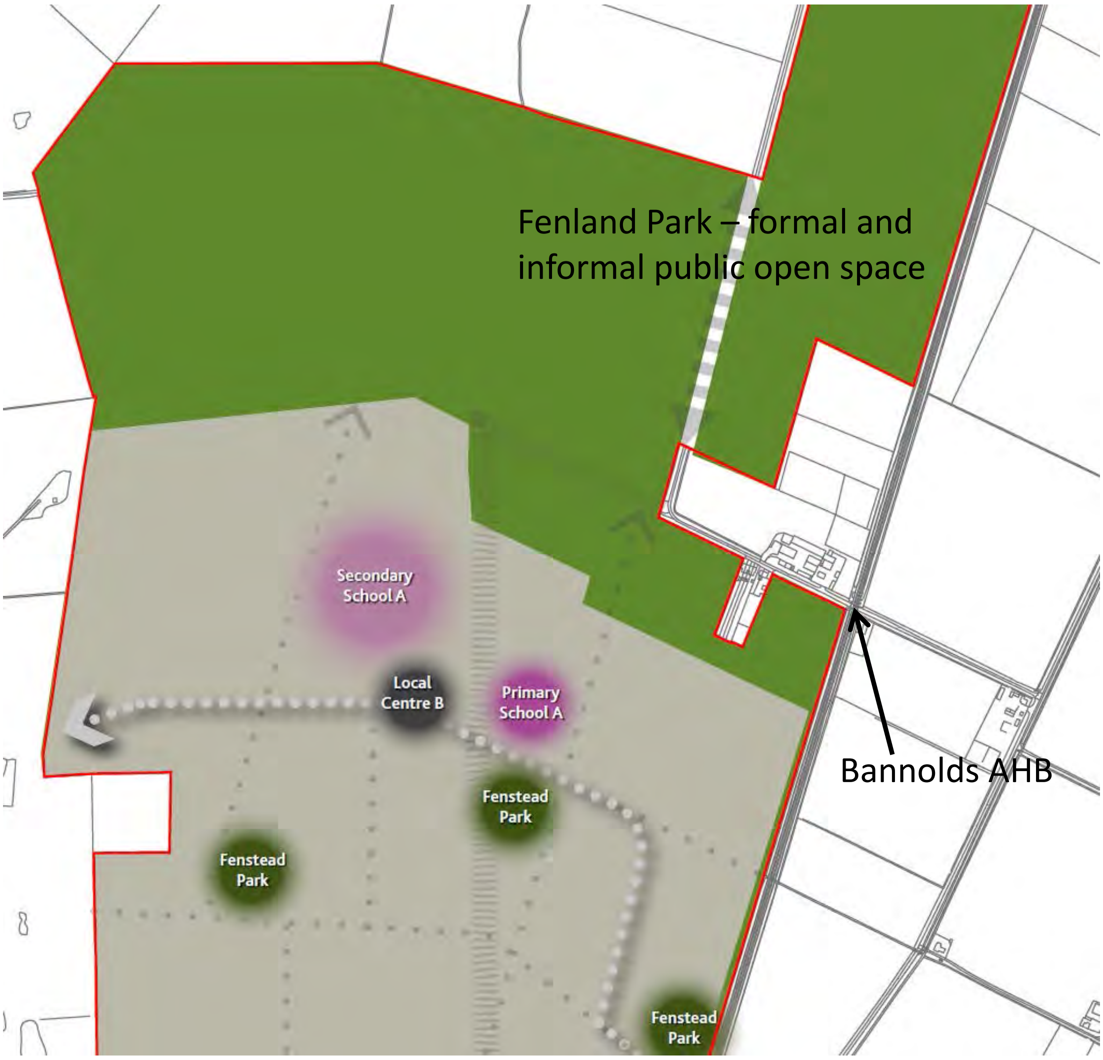


Figure 46 Access and movement – northern part of RLW development



It is important, as for all level crossings, that Network Rail ensures it is consulted about any change of use for the businesses and area adjoining the crossing and seeks compensation for further upgrade should anything be proposed which would significantly increase the usage of the crossing.

There are no proposals for increasing the line speed. Whilst not a resignalling project as such in this area, proposed renewals as full-barrier MCB type crossings will require islands of resignalling to provide appropriate protecting signals and signal spacing.

A separate project, the Ely Area Capacity Enhancement (EACE) project, is considering significant enhancement to the train frequency in the long term. If such an increase were to occur, it would significantly increase the risk at the crossing, or in the event of renewal as a full-barrier MCB type crossing, would result in much higher road closure times.

Road closure time predictions

Road closure time is an important parameter that impacts level crossing risk as well as utility. This is because a high road closure time can cause aggravation and frustration for users which can lead to increased misuse.

Sotera has used a fairly simple model to estimate the potential impact of any upgrade to an MCB-type fall barrier crossing (MCB-OD or MCB-CCTV). For Waterbeach, this suggests that the busiest hour road closure time would increase from about 16% now to about 51%; this would be further increased should any train frequency increases occur (e.g. due to the EACE project) as shown in *Figure 47*. The average daytime road closure time is shown in *Figure 48*.

Figure 47 Road closure time in the busiest hour

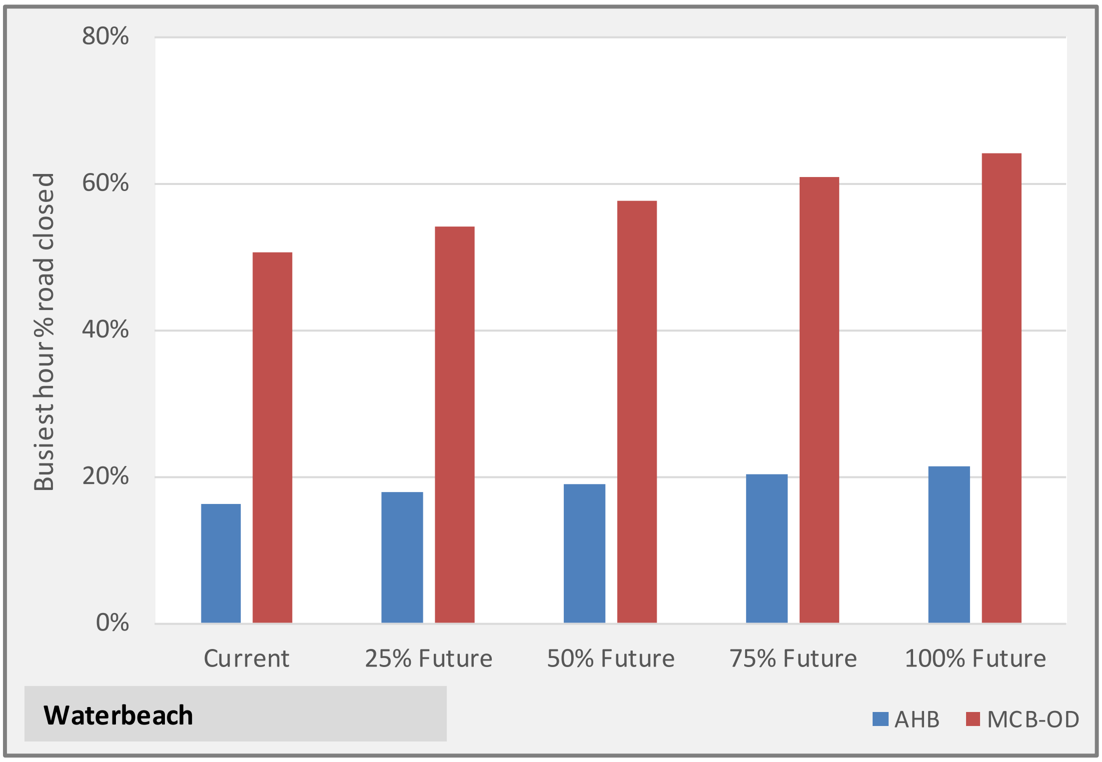
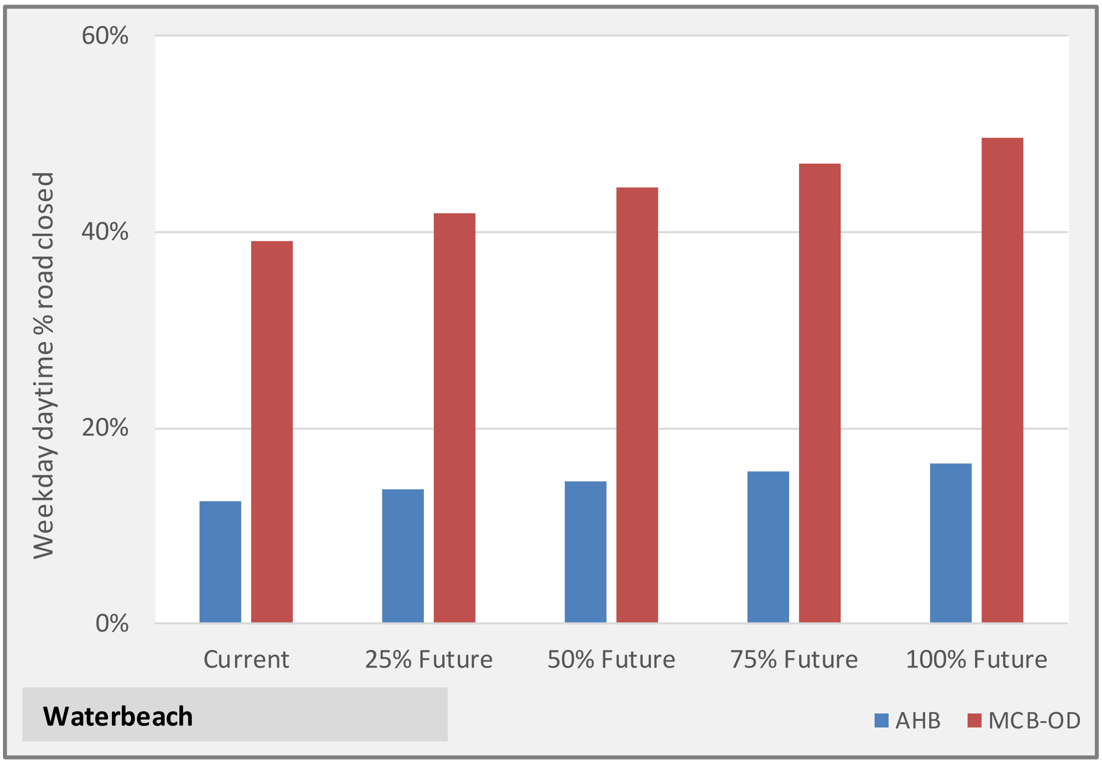


Figure 48 Average daytime road closure time



4 OPTIONS ASSESSMENT

Sotera carried out an initial assessment of options for the crossing, which was then reviewed and updated in workshops with Network Rail staff. The results of the assessment are described in this section.

4.1 Options assessment workshops

The attendees of the initial workshop at One Stratford Place on 3rd April 2019 were as follows.

Present	Role
David Swift	Project Engineer Signalling
Bode Asabi	Project Manager
Ray Spence	Senior Delivery Manager
John Prest	Route Level Crossing Manager
Sam Longhurst	Senior Asset Engineer, Signalling
Nathan Garratt	DPE
Brendan Lister	LCM
James Taylor	Programme Manager, Level Crossing Development Team
Chris Chapman	Sotera, Workshop Chair
David Harris	Sotera, Workshop Secretary

Following this initial workshop, The Safety Review Panel commented that a more robust consideration should be made of a new type of full barrier level crossing (AHB+), which is being developed by Network Rail. The basic premise of this type of level crossing is envisaged to be an adaptation of the existing AHB crossing type, adding exit barriers whilst retaining the AHB's train approach initiated method of operation. Road closure times would be comparable with those of existing AHB level crossings. The lowering function of the exit barriers would be controlled by obstacle detection technology.

As such two further workshops were held:

i) To understand better the functionality of AHB+ level crossings and the progress of the AHB+ development project;

ii) To assess the potential benefits of AHB+ at crossings at the specific crossings that were proposed for upgrade as part of the Cambridge resignalling and recontrol project.

The attendees at the first AHB+ workshop on 9th September 2019 were:

Present	Role

Present	Role
Bode Asabi	Project Manager
Nathan Garratt	DPE
Brendan Lister	LCM
Chris Chapman	Sotera, Workshop Chair
Ben Chipman	Level Crossing Designer
Gavin Scott	RAM Signals Anglia
Sam Rose	Graduate
Paul Fletcher	Signaller / Project Operations Interface Specialist
Paige Skinner	Scheme Project Manager
Darren Witts	STE Principal Engineer
Will Cavill	Principal Designer

The attendees at the second AHB+ workshop on 25th October 2019 were:

Present	Role
Bode Asabi	Project Manager
Nathan Garratt	DPE
Brendan Lister	LCM
Chris Chapman	Sotera, Workshop Chair
Ben Chipman	Level Crossing Designer
Gavin Scott	RAM Signals Anglia
Sam Rose	Graduate Engineer
Paul Fletcher	Signaller / Project Operations Interface Specialist
Paige Skinner	Scheme Project Manager
Darren Witts	STE Principal Engineer
John Prest	Route Level Crossing Manager
Charles Muriu	Asset Engineer
Gabrielle Hodlaun	Delivery Manager
Harry Newgas	Graduate Engineer
Isaac Dozen-Anane	Assistant Project Engineer
Rebecca Wiecigroch	Asset Engineer - Signalling

4.2 Assessment of AHB+

Overall risk benefit

Currently the All Level Crossing Risk Model (ALCRM) does not include an assessment of AHB+ and does not include a breakdown of AHB hazards to enable such an assessment to be made. In order to make an assessment of potential benefits of AHB+, RSSB's Safety Risk Model (SRM) v8.5.0.2 (15) can be used. The risk at an AHB level crossing is broken down into 66 contributory events in *Table B1* of the SRM. The most significant contributors to risk at an AHB crossing are shown in *Table 6*. It can be seen that not all risk contributors are expected to be affected by fitment of AHB+ e.g. '*RV struck by train - on AHB - RV stranded/failed on LC*' is not expected to be affected by the fitment of the additional barrier as there are no protecting signals with which to stop a train. One of the highest contributors to risk at an AHB level crossing is, however, '*MOP (non-trespasser) pedestrian or cyclist struck/crushed by train on AHB - ignores lights/barriers*' and it is reasonable to assume that an AHB+ type crossing, which would have an offside barrier lowering as the same time as the entrance barrier, would provide a greater deterrent to level crossing users who might use the open off side to traverse the railway with the lights on and barriers down. In this instance, a 75% reduction in risk from this source is estimated.

Of the 66 AHB contributors identified in the SRM, the following change in risk was estimated for AHB+:

- 10 were considered to be reduce
- 3 were considered to increase (additional barriers likely to result in more strikes on people)
- 53 were considered to be similar (no change in risk estimated).

The risk contributors for which change is predicted is shown in *Table 7*. It was noted in the first workshop that if the off-side barrier was not fully lowered, the train driver would report it as a '*failure*'. As such, it is expected that AHB+ level crossings will only be installed in locations where the off-side OD controlled barriers very rarely fail to lower i.e. AHB+ will only be fitted to crossings that do not have high peak pedestrian/cyclist use, not at a busy station or where there is pedestrians are not going to be able to traverse the crossing in time due to a long traverse distance or slow/vulnerable users. As such, the benefits of AHB+ is assessed on this basis.

Generally, the following factors are taken into account:

- The '*second train coming*' benefits are taken to be greater than for first train as the likelihood that the off-side barriers have lowered is greater;
- Whilst an AHB+ is not considered suitable for a busy station environment, the benefits at a station would be considered lower

as there is an incentive to cross to catch a train on the opposite platform;

- Road vehicles generally get a higher level of benefit than pedestrians/cyclists as it will be more of a violation to drive through a barrier than to duck under or climb the barrier;
- A minor benefit is taken for users that have failed to observe the level crossing, which is likely to be associated with those that approach from the off side; and
- A disbenefit is predicted for users being potentially struck by barriers.

It should be noted that existing AHB precursors from the SRM have been modified; there may be new error mechanisms such as users going onto the crossing while the barriers are held up incorrectly believing that the crossing is safe. Such potential precursors have not been assessed.

Taking these benefits into consideration, the risk at all current AHB level crossings and total benefit if all these crossings were upgraded to AHB+ is shown in *Table 5*. It can be seen that overall, upgrade to AHB+ is expected to approximately halve the risk compared to an AHB.

Table 5 Overall risk benefit if all AHB level crossings were upgraded to AHB+.

Parameter	SRMv8.5 Risk (FWI/yr)
AHB	1.62
AHB+	0.84
AHB+ Benefit	0.78
% AHB+ Benefit	48%

Table 6 Most significant contributors to risk at an AHB level crossing

Hazardous Event Code	Precursor code	Cause precursor description	Risk cont. (FWI/year)	% of Total	Assessment of AHB reduction in risk	Comment
HEM-27E	KAHB-WALKH	MOP (non-trespasser) pedestrian or cyclist struck/crushed by train on AHB - ignores lights/barriers	0.627	39%	75%	AHB+ barriers will be down in vast majority of instances such that a pedestrian would have to climb over or under barrier, rather than walk around the barrier.
HET-10E	VAHB-DELTH	RV struck by train - on AHB - zigzags barriers	0.245	15%	85%	AHB+ barriers would be lowered in vast majority of instances to prevent a zig zagging car being struck by the approaching train. There may be some unreliability of OD and small objects may prevent barrier lowering. Note that there is no 'fail safe' for OD system – if there is an OD system failure, the exit barrier will not lower.
HET-10E	VAHB-STRTE	RV struck by train - on AHB - RV stranded/failed on LC	0.090	6%		
HET-10E	VAHB-EBLTE	RV struck by train - on AHB - RV incorrectly on LC due to environmental factors/driver error: user brakes too late	0.068	4%		
HEM-27E	KAHB-2TRAH	MOP (non-trespasser) pedestrian or cyclist struck/crushed by train on AHB - second train coming	0.063	4%	85%	AHB+ barrier will be down in vast majority of instances by the time a second train arrives so pedestrian would have to climb over or under a barrier.
HET-10E	VAHB-ASETH	RV struck by train - on AHB - fails to observe level crossing	0.050	3%	2%	Additional barrier would give a small increase in visibility if approaching from the off-side
HET-10E	VAHB-VANTE	RV struck by train - on AHB - RV deliberately placed on level crossing	0.043	3%		
HET-10E	VAHB-ESNTE	RV struck by train - on AHB - RV incorrectly on LC due to environmental factors: sunlight obscures crossing/lights	0.043	3%		
HET-10E	VAHBRTA-TE	RV struck by train - on AHB - RV incorrectly on LC due to RTA	0.036	2%		
HEM-27E	KAHB-SLOWH	MOP (non-trespasser) pedestrian or cyclist struck/crushed by train on AHB - slow moving/short warning	0.035	2%		

Table 7 Changes in Risk with AHB +

Hazardous Event Code	Precursor code	Cause precursor description	Risk cont. (FWI/year)	% of Total	Assessment of AHB+ reduction in risk	Comment
HET-10E	VAHB-ASTTH	RV struck by passenger train - on AHB - second train coming	1.15E-03	0.1%	90%	AHB+ barrier will be down in vast majority of instances by the time a second train arrives so vehicle would have to drive through barrier. There may be some unreliability of OD and small objects may prevent barrier lowering.
HET-11E	VAHB-ASTTH	RV struck by freight train - on AHB - second train coming	1.36E-04	0.0%	90%	AHB+ barrier will be down in vast majority of instances by the time a second train arrives so vehicle would have to drive through barrier. There may be some unreliability of OD and small objects may prevent barrier lowering.
HEM-27E	KAHB-2TRAH	MOP (non-trespasser) pedestrian or cyclist struck/crushed by train on AHB - second train coming	0.063	3.9%	85%	AHB+ barrier will be down in vast majority of instances by the time a second train arrives so pedestrian would have to climb over or under a barrier.
HET-10E	VAHB-DELTH	RV struck by passenger train - on AHB - zigzags barriers	0.245	15.1%	85%	AHB+ barrier will be down in vast majority of instances by the time a zig zagging car that would be hit by a train arrives. Unreliability of OD and small object being detected. There may be some unreliability of OD and small objects may prevent barrier lowering. Note that there is no 'fail safe' for OD system – if there is an OD system failure, the exit barrier will not lower.
HET-11E	VAHB-DELTH	RV struck by freight train - on AHB - zigzags barriers	0.029	1.8%	85%	AHB+ barriers would be lowered in vast majority of instances to prevent a zig zagging car being struck by the approaching train.
HEM-11E	PAHB-2TRAH	Passenger struck/crushed by train on AHB adjacent to station - second train coming	0.030	1.9%	75%	AHB+ barrier will be down in vast majority of instances by the time a second train arrives so pedestrian would have to climb over or under a barrier. There is an Incentive to cross at a station to join the arriving train.

Hazardous Event Code	Precursor code	Cause precursor description	Risk cont. (FWI/year)	% of Total	Assessment of AHB+ reduction in risk	Comment
HEM-27E	KAHB-WALKH	MOP (non-trespasser) pedestrian or cyclist struck/crushed by train on AHB - ignores lights/barriers	0.627	38.7%	75%	AHB+ barriers will be down in vast majority of instances such that a pedestrian would have to climb over or under barrier, rather than walk around the barrier.
HEM-11E	PAHB-WALKH	Passenger struck/crushed by train on AHB adjacent to station - ignores lights/barriers	5.41E-03	0.3%	50%	AHB+ barriers will be down in vast majority of instances such that a pedestrian would have to climb over or under barrier, rather than walk around the barrier. There is an incentive to cross at a station as the passenger may attempt to join the arriving train.
HET-10E	VAHB-ASETH	RV struck by train - on AHB - fails to observe level crossing	0.050	3.1%	2%	Additional barrier would give a small increase in visibility if approaching from the off side
HET-11E	VAHB-ASETH	RV struck by train - on AHB - fails to observe level crossing	5.90E-03	0.4%	2%	Additional barrier would give a small increase in visibility if approaching from the off side
HEN-44E	KEQUAHB-1H	MOP (non-trespasser) pedestrian or cyclist/motorcyclist struck/trapped by level crossing equipment on AHB - user error	9.38E-04	0.1%	-50%	Assumed that near side barriers are a threat to those entering of leaving the crossing while the off side barriers are a threat only to those entering the crossing
HEN-44E	KEQUAHB-3H	MOP (non-trespasser) pedestrian or cyclist/motorcyclist struck/trapped by level crossing equipment on AHB - other	9.38E-04	0.1%	-50%	
HEN-44E	KEQUAHB-2H	MOP (non-trespasser) pedestrian or cyclist/motorcyclist struck/trapped by level crossing equipment on AHB - incorrect use	4.69E-04	0.0%	-50%	

Level crossing specific risk benefit

The risk reduction at a particular crossing will be dependent at the risk contributors at that crossing. The following scaling factors were taken to apply:

Pedestrian/cyclist hazards were taken to scale with:

- The number of pedestrian/cyclists relative to the average at AHB level crossings;
- The number of trains relative to the average at AHB level crossings.

Vehicular hazards were taken to scale with:

- The number of pedestrian/cyclists relative to the average at AHB level crossings;
- The number of trains relative to the average at AHB level crossings.

Second train coming hazards were taken to scale with the square of the number of trains relative to the average at AHB level crossings unless there was a single track, in which case, the factor was set to zero.

Road approach speed was used to generate the scaling factors for the *brakes too late* hazard. The methodology used is summarised in *Table 8*. The value for each level crossing is the average of the factors for the two approaching directions.

Table 8 Road approach speed factor

85% tile Speed (mph)	Road approach speed factor
<20	0.1
20-30	0.2
30-40	0.5
40-50	2
50-60	6
>60	10
>60 long straight	15

The level crossing usage from the 2018 census and scaling factors for the Cambridge level crossings are shown in *Table 9*. The risk benefit from upgrading to AHB+ can then be calculated and the benefit to cost ratio for renewing as an AHB+ level crossing as compared with renewing as an AHB can also be calculated assuming the renewal costs are as follows:

- AHB renewal cost £1.46m
- AHB+ renewal cost £2.007m

These costs are based on the CP6 unit rates for level crossings and, in particular, the AHB+ cost was based on the cost of an MCB-OD level crossing without lower LIDAR.

A benefit to cost ratio greater than 1 in *Table 10* does not indicate that AHB+ is the preferred upgrade. Indeed, at very high risk level crossings, it is likely that the preference will be to upgrade to a protected full barrier crossing (MCB-OD or MCB-CCTV), as this will give a higher level of safety benefit. The risk for each crossing as an AHB, AHB+ and as an MCB-OD is shown in *Figure 49*.

The cost benefit analysis for upgrading to an MCB-OD type crossing relative to upgrading to an AHB+ type level crossing is shown in *Table 11*. The second to last column in this table compares the safety benefits and costs for upgrading to an MCB-OD type with upgrading to AHB+. A higher value indicates that and MCB-OD type crossing is justified from a safety perspective and a value less than 1 indicates that investing in and MCB-OD is disproportionate to the safety benefit. However, whether cost is grossly disproportionate also needs to be considered, and as such, other factors such as a road closure time and modifying signal locations are likely to be factors.

From *Table 11,* it can be seen that the very high levels of risk at Waterbeach mean that the upgrade to MCB-OD is justified despite the costs of the additional signalling. An AHB+ solution at Waterbeach would not be considered to be a suitable upgrade at a busy station where there is an incentive to cross to the opposite platform. If the plans to move Waterbeach station came to fruition decreasing the usage of the crossing, AHB+ would become a potential upgrade path.

Table 9 Scaling factors for individual AHB level crossings

Level crossing	Daily usage 2018			Factors 2018					
	Vehicles	Pedestrians/ cyclists	Trains	Vehicles	Pedestrians/ cyclists	Trains	Trains[2] (Second train coming)	Station	Road approach speed
Milton Fen	77	366	178	0.05	4.0	2.4	5.5	0	0.1
Waterbeach	4,880	889	178	3.0	9.7	2.4	5.5	Yes	0.4
Dimmocks Cote	6,330	133	178	3.8	1.4	2.4	5.5	0	6.0
Six Mile Bottom	7,826	99	35	4.7	1.1	0.5	0.0	0	3.3
Brinkley Road	1,626	60	35	1.0	0.6	0.5	0.0	0	4.0
Black Bank	1,378	59	127	0.8	0.6	1.7	2.8	0	4.0
Croxton	4,466	15	67	2.7	0.2	0.9	0.8	0	10.5
Meldreth Road	1,455	124	194	0.9	1.4	2.6	6.6	0	1.3

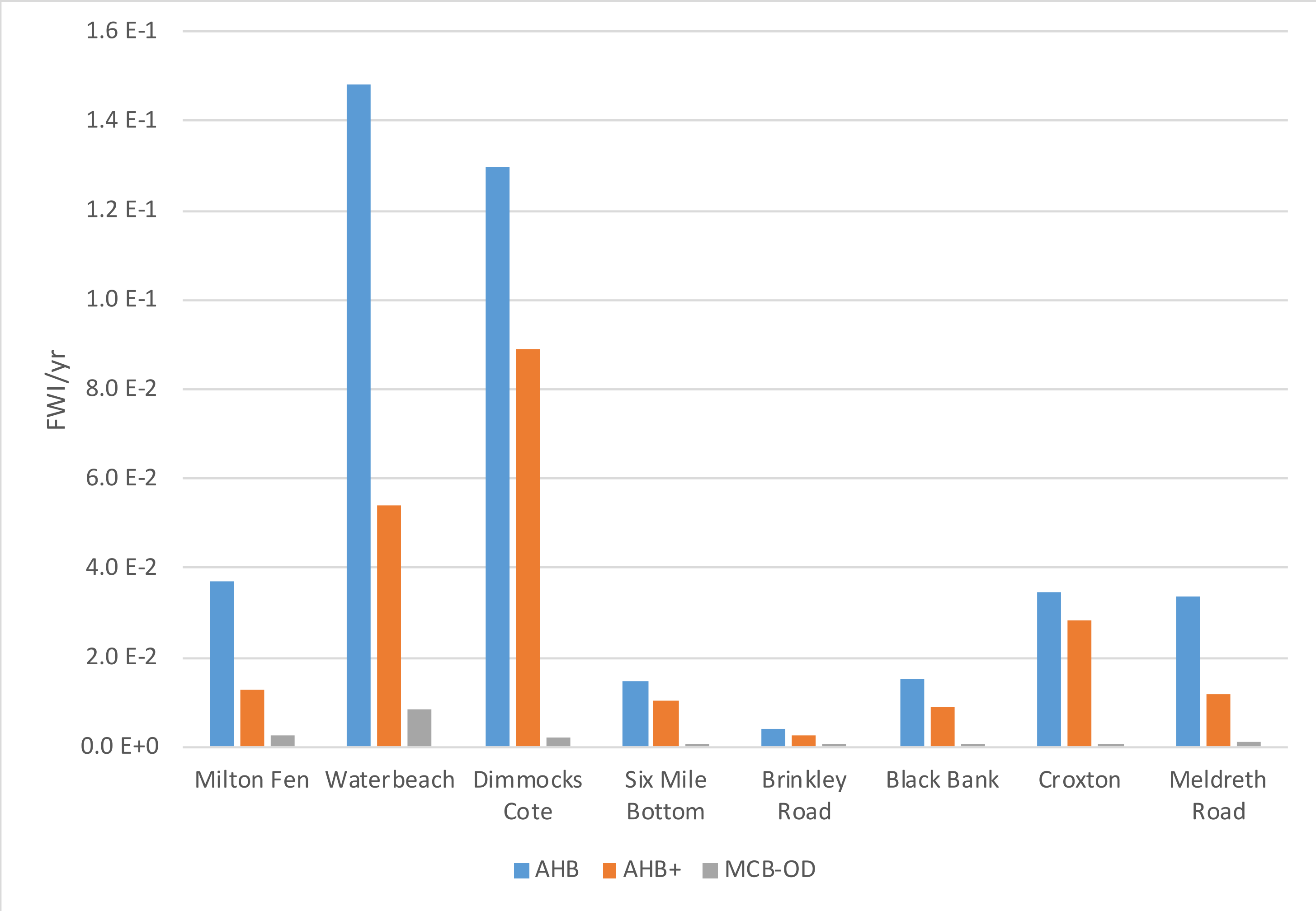
Table 10 Risk benefit and cost benefit analysis for renewing as AHB+ relative to AHB

Level crossing	ALCRM Risk as AHB	%Risk Benefit for AHB+ from SRM	Comments	Risk as AHB+	AHB+ Risk Benefit	NPV of safety benefit over 30 years (AHB+)	Benefit to cost ratio for renewing as AHB+ relative to AHB)
Milton Fen	3.7 E-2	65%	High pedestrian and rail use	1.3 E-2	2.4 E-2	£1,145,935	2.09
Waterbeach	1.5 E-1	64%	High level of benefit for AHB+ but currently at a station and so probably would not be suitable for fitment as AHB+	5.4 E-2	9.4 E-2	£4,466,196	8.16
Dimmocks Cote	1.3 E-1	31%	Does not address late braking	8.9 E-2	4.1 E-2	£1,929,555	3.53
Six Mile Bottom	1.5 E-2	31%	No second train coming benefit (single track)	1.0 E-2	4.6 E-3	£217,390	0.40
Brinkley Road	4.0 E-3	36%	No second train coming benefit (single track)	2.6 E-3	1.5 E-3	£68,963	0.13
Black Bank	1.5 E-2	40%	Does not address late braking e.g. southwest bound traffic. Vehicles do slow down for crossing.	9.0 E-3	6.1 E-3	£288,859	0.53
Croxton	3.4 E-2	17%	Does not address late braking etc.	2.8 E-2	6.0 E-3	£285,008	0.52
Meldreth Road	3.4 E-2	65%	Addresses second train coming; relatively high pedestrian use	1.2 E-2	2.2 E-2	£1,047,676	1.91

Table 11 Cost benefit analysis for renewing as AHB+ relative to renewing as MCB-OD

Level crossing	NPV of safety benefit over 30 years (MCB-OD)	%Risk Benefit (AHB to MCB-OD)	Cost of providing MCB-OD or MCB-CCTV	MCB-OD Cost justification	Benefit to cost ratio (AHB to MCB-OD)	Benefit to cost ratio (Difference between upgrading MCB-OD and AHB+)	Comments
Milton Fen	£1,627,290	93%	£2,482,532	1 SEU	0.66	1.01	Some concern about vulnerable users with AHB+ (4 uses by wheelchair user and 1 scooter in 9 days)
Waterbeach	£6,610,690	94%	£2,932,532	2 SEUs	2.25	2.32	AHB + at a station not likely to be preferred. May be suitable if station is moved
Dimmocks Cote	£6,059,183	98%	£4,732,532	Six additional signals 6 SEUs	1.28	1.52	Much higher benefit for full barrier level crossing
Six Mile Bottom	£691,693	98%	£3,832,532	4 SEUs	0.18	0.26	To be considered in conjunction with Brinkley Road
Brinkley Road	£184,971	97%	£2,032,532	0SEUs - assume signals already in place for Six Mile Bottom	0.09	4.58	Brinkley Road would not cost significantly more to renew as MCB-OD if the signals have already been put in place for Six Mile Bottom. Mix of crossing types for protecting signal if not upgraded.
Black Bank	£694,912	97%	£3,157,532	2 new signals and 2 signal re-heads (2.5 SEUs)	0.22	0.35	If signals installed at Black Bank, a train stopped at the signal would stand over adjacent AHB level crossings introducing a new hazard at those AHB level crossings
Croxton	£1,617,385	99%	£3,832,532	4 SEUs	0.42	0.73	Only a full barrier crossing with signal protection addresses the main hazards at Croxton level crossing and facilitates the removal of the TSR. Skew crossing and so any pedestrians may hold up exit barrier.
Meldreth Road	£1,543,040	96%	£2,032,532	0SEUs	0.76	19.54	The only benefit of AHB+ relative to a full barrier crossing is the shorter road closure time

Figure 49 Chart showing risk as AHB, AHB+ and MCB-OD



4.3 Options for closure or alternate level crossing designs

Options Assessment

The following options were considered:

- Crossing closure (via diversions);
- Crossing closure with a pedestrian bridge only provided;
- Crossing closure with an underpass for road vehicles and pedestrians;
- Crossing closure with a full road bridge provided;
- Crossing closure via a bypass and bridging scheme to also close Bottisham Road and Burgess Drove crossings;
- Retain '*As-Is*' as AHB type;
- Renew as ABCL;
- Renew as an automatic full barrier (AHB+);
- Upgrade to an MCB-CCTV or MCB-OD, which provide the highest level of protection as a level crossing.

Table 12 provides a summary of the results of the workshop. The main arguments are then discussed below. Rows showing the total risk for the three Waterbeach crossings (Waterbeach AHB, Burgess Drove UWCM, Bottisham Road AHB) are also included as any decision for Waterbeach needs to consider the other two crossings.

In the table, the residual safety risk of each option has been converted into monetised safety cost in Net Present Value (NPV) terms over the life of the crossing. This is based on the VpF for 2018 published by RSSB and a safety discount rate of 1.5%. It represents the total financial value of safety for accidents at the crossing over a life of 30 years should that option be pursued. It includes minor (injury) accidents such as slips, trips and falls as well as more serious accidents involving vehicles or pedestrians being struck by trains.

The impact on the crossing usage and risk from nearby housing developments and the potential station relocation is not known at this stage.

Table 12 Closure / level crossing type assessment

Option/ Crossing type	ALCRM			Feasibility	Cost		Justification for cost estimate
	2019 usage						
	FWI	Score	NPV (30)		Capital	Annual	
Current crossing type (AHB)	1.48E-01	D1	£7,021,884	Feasible but very high level of existing risk means upgrade or closure will be required; it is contrary to NR policy to renew such a high risk crossing as AHB. SICA renewal date is 2021. This is a problematic crossing for misuse: only one stopping train per hour per direction increases possibility of misuse. Increased usage will increase risk further. Proposals to move station to the north as part of a major new town development. Relocation of the station would reduce the risk at the crossing, but through road usage could be high when additional 11,000 dwellings are built - especially when there are problems on the A10 as this route provides an alternative route to the A14 and Cambridge. Possibility of platform extension work taking place prior to the station move. RLSE proposed to installation within the next few weeks. Diversionary route when problems on A10. Normally send MOM to site when this in place to monitor crossing	£1,460,010	£16,933	Standard cost, if renewal is required. SICA Renewal date: 2021
All 3 Waterbeach crossings	1.94E-01	-	£10,567,908	Significant additional risk at Burgess Drove UWCM and Bottisham Road AHB crossings.			
Closure	0		£0	Well utilised road between Waterbeach and Clayhithe/Horningsea and even some parts of Cambridge. Closure impossible.			
Closure + pedestrian bridge	0		£0	As above			
Closure + road bridge	0		£0	Unlikely to be feasible whilst station is retained in its current location. May be feasible as part of station relocation and wider scheme, but			

Option/ Crossing type	ALCRM 2019 usage			Feasibility	Cost		Justification for cost estimate
	FWI	Score	NPV (30)		Capital	Annual	
				there are issues with access to some properties. A ramped foot/cycle bridge provides a more attractive closure option, combined with new access from the north.			
Closure + underpass	0		£0	As above, costs likely to be greater and more of a flood risk.			
Closure with bypass (Waterbeach, Burgess Drove, Bottisham Road - Option A)	0		£0	Scheme to close with Burgess Drove and Bottisham Road - Waterbeach Option A. This option would need to avoid severing the flood defence embankment. Scheme requires cycle/footbridges at Waterbeach & Burgess Drove + new road bridge to south of Bottisham Road + about 1.3km link road	£16,900,000		Assume: Road bridge £7m Cycle bridges 2 x £3m Link road 1.3km at £2.5k per m assumed as some of length new, some upgraded. Plus land purchase
ABCL	-	-	-	Not a viable option due to the restriction in linespeed that would be necessitated and would be very high risk	£1,336,708	£16,933	
AHB+	5.4 E-2	-	£2,555,687	The very high levels of risk at Waterbeach mean that the upgrade to MCB-OD is justified despite the costs of the additional signalling. An AHB+ solution at Waterbeach would not be considered to be a suitable upgrade at a busy station where there is an incentive to cross to the opposite platform. If the plans to move Waterbeach station came to fruition decreasing the usage of the crossing, AHB+ would become a potential upgrade path.	£2,007,185	£20,154	CP6 standard renewal costs for MCB-OD without lower LIDAR and no signalling costs
MCB-CCTV	8.7 E-3	G3	£411,194	Feasible. There are protecting signals currently at 1255m and 1430m from the crossing. These may be adequately positioned to provide distant signals, but additional protecting signals would be required, necessitating 2 SEUs. Protecting signal placement would need to consider the potential for trains to stand over Burgess Drove LC which	£2,764,316	£54,265	CP6 standard renewal costs, 2 x SEUs

Option/ Crossing type	ALCRM			Feasibility	Cost		Justification for cost estimate
	2019 usage						
	FWI	Score	NPV (30)		Capital	Annual	
				is 385m from Waterbeach or Bottisham Road. Likely to involve shared protecting signals, increasing the road closure time. Risk remains high, but likely less so on station closure as pedestrian use would be expected to reduce (although road use may increase). A footbridge might offer an additional risk reduction option should the station move not go ahead. Ergonomics assessment recommended Preferred if station move does not occur or is delayed			
MCB-OD	8.67E-03	G3	£411,194	Feasible as above. Within 20km Cambridge radio telescope planning zone. Mk2 MCB-OD provides more directional Radar so may be easier to design for this. Risk remains high, but likely less so on station closure as pedestrian use would be expected to reduce (although road use may increase). A footbridge might offer an additional risk reduction option should the station move not go ahead. There are protecting signals currently at 1255m and 1430m from the crossing. These may be adequately positioned to provide distant signals, but additional protecting signals would be required, necessitating 2 SEUs. Protecting signal placement would need to consider the potential for trains to stand over Burgess Drove LC which is 385m from Waterbeach or Bottisham Road. Likely to involve shared protecting signals, increasing the road closure time. MCB-OD not preferred should station remain due to high pedestrian use and misuse, coupled with high road closure time which could increase the misuse. Could frequently result in 'failures'.	£2,932,532	£20,154	CP6 standard renewal costs, 2 x SEUs

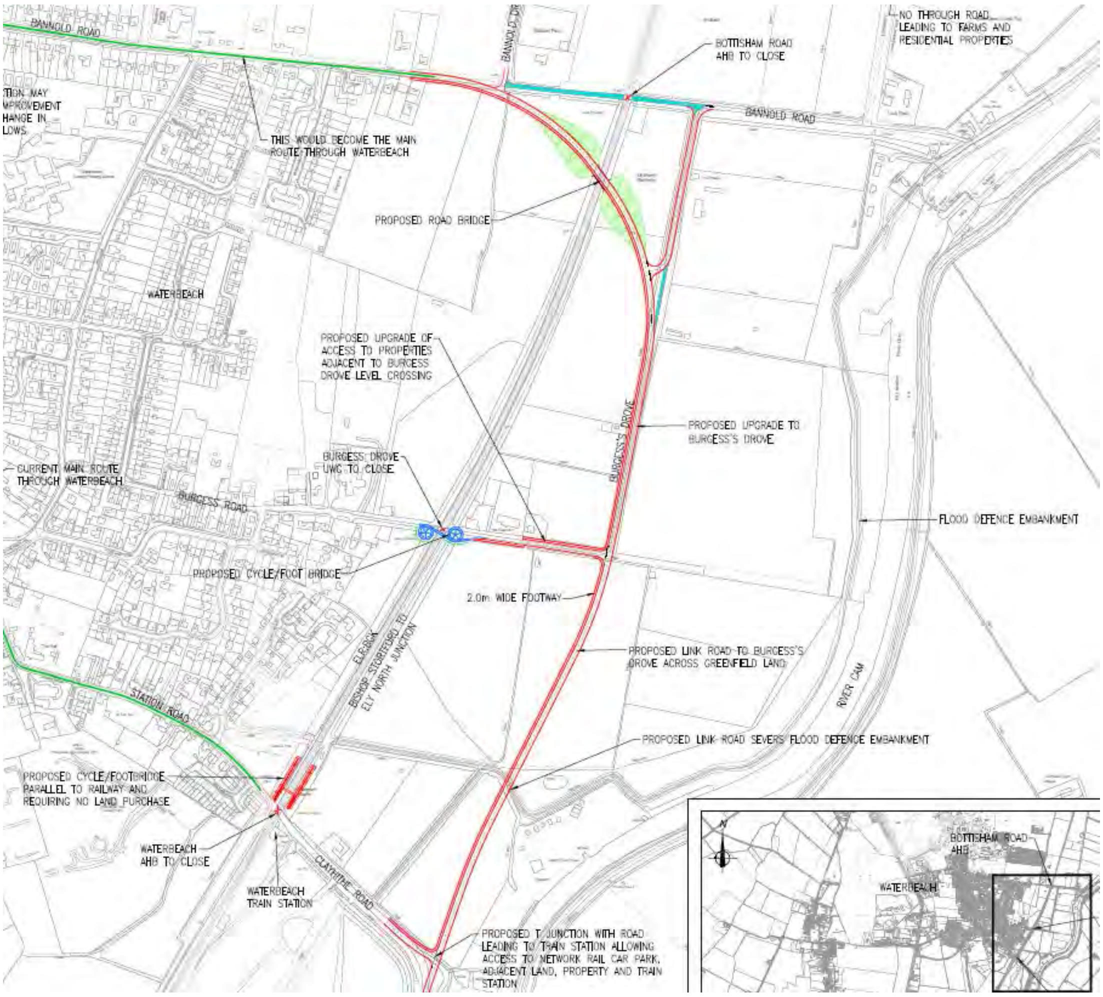
Option/ Crossing type	ALCRM			Feasibility	Cost		Justification for cost estimate
	2019 usage						
	FWI	Score	NPV (30)		Capital	Annual	
MCB-OD and/or MCB-CCTV at all 3 Waterbeach crossings	1.06E-02	-	£565,139	Significant residual risk if all 3 Waterbeach crossings are retained, even if they are upgraded to MCB-OD/CCTV. Consideration would need to be given to protecting signal placement with three crossings within 1km. Likely to involve shared protecting signals, increasing the road closure time.	£8,797,596	£60,462	

4.4 Conclusions regarding closure of the crossing

The first priority should be to close the crossing where possible. The only option identified that could be feasible is a major road and bridge scheme to close the three crossings in Waterbeach (Waterbeach AHB, Burgess Drove UWCM and Bottisham Road AHB) all of which are high risk crossings. The feasibility of this option is being assessed in more detail by the EACE project.

This scheme is shown in *Figure 50* and would likely require a road bridge south of Bottisham Road, cycle/footbridges at Waterbeach & Burgess Drove, about 1.3km link road and some means of raising the road over the flood defences east of Waterbeach.

Figure 50 Potential road and bridge scheme to close all three Waterbeach Crossings



Whilst this scheme would likely cost £16m or more, it would deliver the maximum safety benefit without the high road closure time implications of an MCB-CCTV or MCB-OD type crossing and would eliminate the risk at all three crossings, all of which present a high risk currently as can be seen in *Table 13*.

Table 13 ALCRM Risks at the three Waterbeach crossings

		Current type			MCB-CCTV or MCB-OD		
Crossing	Type	FWI	Score	NPV_{30}	FWI	Score	NPV_{30}
Waterbeach	AHB	1.5 E-1	D1	£7,021,884	8.7 E-3	G3	£411,194
Bottisham Road	AHB	2.0 E-2	C2	£1,542,378	1.1 E-3	F4	£84,409
Burgess Drove	UWCM	2.6 E-2	B2	£2,003,646	8.9 E-4	E5	£69,536
Total		1.9 E-1		£10,567,908	1.1 E-2		£565,139

The closure scheme would be the most future proof option considering the major housing developments taking place in Waterbeach and the possibility of significant train frequency increases in the future. Should the train frequency increases under consideration by the EACE project occur then a future road closure time of about 64% in the busiest hour for any MCB-CCTV or MCB-OD type crossings in this area would be hard to sustain, particularly should the station move not take place.

It is therefore concluded that closure of the crossing could be feasible and should be explored with the EACE project which is considering the feasibility of this in more detail.

4.5 Conclusion about crossing type

An AHB crossing would not be a viable renewal option as it presents a very high level of risk and a past history of accidents and misuse. Renewal of a crossing with an ALCRM score of D1 as an AHB would also be contrary to Network Rail's strategy of upgrading higher risk AHB level crossings.

The very high levels of risk at Waterbeach mean that the upgrade to MCB-OD is justified despite the costs of the additional signalling. An AHB+ solution at Waterbeach would not be considered to be a suitable upgrade at a busy station where there is an incentive to cross to the opposite platform. If the plans to move Waterbeach station came to fruition decreasing the usage of the crossing, AHB+ would become a potential upgrade path.

The preferred renewal option is therefore MCB-CCTV or MCB-OD; both of these crossing types would offer significant risk reduction compared with AHB from 0.15 to 8.67 x 10^{-3} FWI per year. Despite this the residual risk would still be quite significant. How this would be affected by future changes is hard to predict, given that there is some uncertainty about the station move and future train service growth. The vehicle usage of the crossing may increase even if the station move takes place due to the housing development taking place in Waterbeach.

Normally MCB-OD would be preferred over MCB-CCTV for workload reasons. The crossing is within the 20km Cambridge MERLIN radio telescope planning zone so precautions against interfering with this would need to be taken should MCB-OD Mk. 1 be provided; the Mk. 2 MCB-OD units is understood to be less problematic in this respect should they be available and have type approval in time for this project.

Both MCB-CCTV and MCB-OD types would lead to similarly high road closure times which would be problematic on such a busy road, particularly one providing station access, and even more so should train frequency increases occur in the future. Liaison with the Highway Authority about the likely build-up of traffic through the village once a full barrier crossing has been provided is recommended.

Without the station move, or if the station move occurs after crossing renewal, then the high level of misuse suggests that MCB-CCTV might be preferred over MCB-OD in order to reduce the likelihood of barrier strikes on pedestrians or other crossing users and crossing failures caused by crossing misuse.

The possibility of introducing a footbridge to provide cross platform access should also be considered should the station move not occur.

If the station move occurs before crossing renewal, then AHB+ or MCB-OD might be preferred.

Given the high risk of the crossing in its current form, renewal should be considered even if the closure scheme were to take place as it is likely that the closure scheme would take longer to deliver.

4.6 Options for additional controls

The key level crossing hazards at the crossing have been considered to determine what additional controls should be provided upon renewal (see *Table 14*).

The additional controls identified for consideration include:

- RLSE cameras to help mitigate the risk from misuse, especially by road vehicles. The crossing has a relatively high level of misuse and this might be increased by renewal to an MCB-CCTV or MCB-OD due to the road closure time.
- Pedestrian misuse associated with a high road closure time could be somewhat mitigated by provision of a footbridge to provide crossing platform access. This option is only likely to be justifiable if the station move does not take place.
- Blocking back does occur at this crossing, although it was not observed in the nine-day census. The likelihood of this would be increased by the high road closure time associated with an MCB-CCTV or MCB-OD type crossing. BPM should, therefore, be considered.
- If the station is not moved prior to crossing renewal, then the pedestrian approach to the crossing from the platform exits would need to be considered. There are currently standing red man indications are the two offside corners, i.e. the non-platform exit sides, providing these at all four corners would provide a better interface for the large number of pedestrians approaching from the platform exits. Additionally, only one of the two platform exits has a barrier to prevent a surge of pedestrians into the road; this may be worthy of consideration at the other exit also.

- The current footway widths are not sufficient to meet ORR guidance, especially in areas where they narrow towards the ends. Consideration should be given to provision of two 1.8m wide footways to meet the guidance. Narrower footways, likely of 1.5m width, may be appropriate should the station move precede the crossing renewal.

Table 14 Assessment of additional controls

Hazard	Comment	Standard/existing controls	Potential additional controls	Feasibility	Cost (£)	Recommend	Justification for cost estimate
High road closure time - misuse by vehicles and pedestrians	Exacerbated as a station crossing, but staggered platforms should reduce the impact slightly High recorded misuse	Obstacle detection system to ensure crossing is clear	RLSE cameras	Yes	£150k	Yes	Typical per site cost (from information provided at EACE workshops)
			Footbridge for pedestrians	Yes	£1.1m (stepped) to £2.1m (ramped)	Consider Unclear if would need to be DDA compliant given the level crossing provides level access	Average Anglia costs
Blocking back	None was observed in the 2018 census, however there are factors that could occasionally cause blocking back: i) Frequent vehicle movements turning right into the Network Rail Depot 14m east of the crossing ii) Bus stops on both sides on the east side of the crossing, but buses quite infrequent iii) The station car park entrance, 90m east of the crossing, is a right	Yellow box markings on crossing Obstacle detection system to ensure crossing is clear	BPM	Yes	Low upon renewal	Yes; it is understood that blocking back does occur and vehicle usage could increase LCM: Blocking back is observed, in both directions - cars parking, drop-offs as well. Previously school bus caused problems, now has been resolved	

Hazard	Comment	Standard/existing controls	Potential additional controls	Feasibility	Cost (£)	Recommend	Justification for cost estimate
	turn after coming over the crossing, so there is potential for blocking back at busy times of the day						
Skew	Skew is 65° to the rail. Concrete panels and significantly cyclist use.		Velostrail deck	Yes - maximum speed is 120km/h / 75mph		No - skew of 65° is insufficient to justify this	
			Eliminate skew	No - nearby station prevents this. Any alleviation would also introduce bends.		No	
View of RTLs from platform exits	Crossing has standing red men on non-barrier sides only, not visible from platform exists which have poor visibility of RTLs as they are close to the RTLs	RTLs oriented for the road Audible alarms	Standing red men for all 4 corners	Yes	Minimal upon renewal	Yes if station is not moved before renewal	
Up platform exit	The Up platform exit is open with no gate or barrier to prevent pedestrians stepping into the road	Barrier for Down platform exit	Barrier for Up platform exit	Yes	Minimal	Yes	

Hazard	Comment	Standard/existing controls	Potential additional controls	Feasibility	Cost (£)	Recommend	Justification for cost estimate
Narrow footways	Footway widths are not sufficient to meet ORR guidance, especially in areas where they narrow towards the ends. Road width is 6m.		New footways that meet ORR guidance width along entire length (1.8m)	Yes	Low upon renewal	Yes	

4.7 Assessment of the costs and benefits of Lower LIDAR

Network Rail has developed an assessment tool to calculate the benefits of the provision of Lower LIDAR at MCB-OD level crossings [11]. The rationale for undertaking the assessment is that the Lower LIDAR, whilst providing some additional safety benefit, reduces the overall reliability of the crossing with a knock-on impact for delaying trains. The system also has associated capital and maintenance costs. The capital cost can be very high for some crossings due to the stringent demands it places on the flatness of the road profile.

The project currently anticipates that it will use the Mk. 2 version of MCB-OD, although this currently does not have type approval. It is expected that the Mk. 2 system will not require LIDAR as the RADAR would be configured to provide equivalent functionality. An assessment of lower LIDAR is however made in case the Mk. 2 system is not available or does not obviate the need for LIDAR.

The Costs of Lower LIDAR

Based upon accepted Network Rail HQ costs and adjustments [10], the costs for providing Lower LIDAR are taken to be as shown in *Table 15*.

Table 15 Assumed Lower LIDAR costs

Type of cost	Costs	
	Low Level LIDAR Child vulnerable user group (175mm beam height)	**Low Level LIDAR Adult (elderly) vulnerable user group (280m m beam height)**
Materials	£17,141	£17,141
Installation and set up	£8,206	£8,206
Civils work	£site specific, may be zero	£site specific, may be zero
Maintenance costs - attending failure (over 30 year asset life)	£17,987	£17,987
Faulting / local control over (30 years asset life)	£17,987	£8,993
Total cost associated with Lower LIDAR	£61,321 + Civils work	£52,327 + Civils work

No civil engineering or train delay cost estimate for Lower LIDAR is available currently; therefore, in order to provide an onerous assessment case these have been assumed to be zero.

The benefits of Lower LIDAR

The key inputs to and outputs from the numerical assessment are as follows:

Inputs		
Recommended height setting		Child
Train frequency per day		178
Pedestrians per day		564
Cycles per day		270
Motorcycles per day		55
Other road vehicles per day		4,880
Crossing is at a station		Y
If at a station, the number of stopping trains per day		61
Is line speed at the crossing 20mph or less?		N
Outputs		
Safety benefit	**FWI per year**	0.00195
	NPV_{30}	£78,206
Cost	**NPV_{30}**	£61,321
Safety benefit to cost ratio over 30 years		1.28

From these inputs, the current safety benefit of the Lower LIDAR is 1.95 x 10^{-3} FWI per year. This is equivalent to a monetised benefit over 30 years of £78,206.

Lower LIDAR – comparing costs and benefits

The estimated cost of Lower LIDAR at this crossing is at least £61,321 over the life of the asset. The nine-day traffic census recorded some, albeit low, usage by unaccompanied children (two in the nine-day census) however it is considered that with its current proximity to the station this could be much greater. The lower height setting is therefore a consideration at this crossing and has been assumed in this calculation. The safety benefit is approximately £78,206. The benefit to cost ratio for providing Lower LIDAR is 1.28, subject to there not being significant civils cost, which suggests that the cost of providing Lower LIDAR is not grossly disproportionate to the safety benefit according to the guidance [10] that *"If above 0.5 Lower LIDAR should be considered. Lower LIDAR may be considered if below 0.5 where there are significant hazards unmitigated"*.

Lower LIDAR risk factors

The tool [11] for the assessment of the benefits to pedestrian slip, trip or fall risk from Lower LIDAR identifies a range of potential local hazards related to the causation of users slipping, tripping or falling on the crossing. This set of hazards has been reviewed and supplemented by Sotera and is considered to represent a fairly comprehensive set of pedestrian slip, trip or fall hazards (some however appear to have only limited relevance to pedestrian slip, trip or fall) but one, relating to equestrian use has been added. Each hazard has been considered in relation to the crossing based upon the site visit and traffic census to determine the potential significance of each hazard based upon the crossing features; it was then discussed in the risk workshop and additional controls considered. Each hazard has been rated as to its significance based upon the tool's three-point rating scale of 'Major', 'Minor' or 'No'.

In assessing whether additional control measures are required, both the rating and the overall level of risk have been considered. Where mitigation is suggested, the post-mitigation risk rating is also provided.

The full list of hazards, ratings and crossing specific comments are presented in *Table 16*. This assumes that the crossing is maintained in good condition over its full life.

Table 16 Lower LIDAR Hazards

Ref:	Topic	Hazards	Site comments	Possible additional controls	Rating pre-mitigation	Rating post-mitigation
Topographic/physical features						
1	Surface	Slippery surface	No specific objects likely to cause slip hazard		No	No
2	Surface	Uneven surface, differential height of slabs, gaps between panels, holes in asphalt, subsided surface	Minor trip hazards at edge of sill beams (ZN corner)	Alleviate minor trip hazards at deck edge	Minor	No
3	Surface - loose material	Mud in rural areas, gravel	Vegetation encroachment at ends of footways, some gravel	Improved maintenance to remove vegetation from footway ends	Minor	Minor
4	Surface – drainage	Pooling of water following rain	Crossing slightly humped so major pooling unlikely and no specific issues identified		No	No
5	Surface - flange gap	Degradation of flange gap - bicycle wheels trapped, trip hazard for pedestrians	To standards		No	No
6	Layout – bend	Level crossing on bend	Crossing is on an almost straight road		No	No
7	Layout - skew	Direction of users traverse not orthogonal to tracks. Increased traverse time where skew is significant.	Minor skew (65°)		Minor	Minor
8	Layout / environment / conspicuity	Extraneous light and noise sources, short approach, no audible alarm (or hard to	Crossing is conspicuous on fairly straight approach, audible warnings are of sufficient volume for the small crossing area. Distractions are likely at		Minor	Minor

Ref:	Topic	Hazards	Site comments	Possible additional controls	Rating pre-mitigation	Rating post-mitigation
		hear), poor conspicuity	this busy station location which is busy for pedestrians and drop-offs.			
9	Gradient / profile	Crossing on a raised profile (gradient up or down to crossing). Crossing itself on a gradient	Minor hump at the crossing		Minor	Minor
10	Footpath width and road width	Narrow footpath, or narrow roadway meaning less space for pedestrians	Footway widths are not sufficient to meet ORR guidance, especially in areas where they narrow towards the ends. Station crossing means could be subject to peak pedestrian flows. Road width is 6m.	New footways that meet ORR guidance width along entire length (1.8m)	Major	No
11	Pedestrian walkway - edging	Poor marking of edge of crossing / railway	Footways well marked.		No	No
12	Pedestrian walkway - obstacles	Posts, fencing, etc protrudes into walkway	No specific obstructions		No	No
13	Lighting	Low levels of lighting in hours of darkness	There is station lighting and some street lighting to the north		No	No
Pedestrian vulnerability factors						
14	Vulnerable - elderly	Used by large numbers of elderly people	The census identified very low levels of use by this group. There are no specific environs that would encourage a particular user group, but a greater usage than observed in the census would be expected.		Minor	Minor

Ref:	Topic	Hazards	Site comments	Possible additional controls	Rating pre-mitigation	Rating post-mitigation
15	Encumbered – push chairs, luggage / baggage	Used by large numbers of adults with push chairs, and/ or lots of travellers	The census identified some use by this group.		Minor	Minor
16	Encumbered - dogs	Used by high proportion of dog walkers	Some dog walkers would be expected to access nearby footpaths towards the river, but this will be a minority of the overall usage		Minor	Minor
17	Vulnerable – cognitive impairment	Large proportion of users with reduced cognitive capability	There are no specific environs that would encourage a particular user group.		No	No
18	Vulnerable – other mobility impaired	Large proportion of users with impaired mobility including wheelchair users	The census identified a low level of use by this group and no specific sources of major use are identified		Minor	Minor
19	Vulnerable – unaccompanied children	Used by large numbers of school children who are not accompanied by adults	The census identified a low level of use by this group and it is considered that some such usage would be expected given the proximity to station platforms		Minor	Minor
20	Impaired users	Users under the influence of alcohol	There are pubs further to the north in the centre of the village, so some use is possible		Minor	Minor
N/A	Equestrian use	Person thrown from horse	The census identified no use by this group.		No	No
Operational factors						

Ref:	Topic	Hazards	Site comments	Possible additional controls	Rating pre-mitigation	Rating post-mitigation
21	Event hazard	Local event promotes high temporary use of the crossing	High use possible when the station is particularly busy		Minor	Minor
22	Seasonal hazard	Weather - icy road	Rural location likely subject to occasional icing. On a priority gritting route.		Minor	Minor

The following additional controls are recommended for consideration:

- Alleviation of minor trip hazards at the deck edge (ZN corner).
- Improved maintenance to remove vegetation from footway ends.
- New footways that meet ORR guidance width along entire length (1.8m).

Table 17 summarises the number of hazards afforded each rating before and after the proposed additional controls.

Table 17 Number of Pedestrian slip, trip or fall hazards

Hazard rating	Number of hazards afforded stated rating	
	Number before additional mitigation	Number after proposed additional mitigation
Major	1	0
Minor	13	12

Conclusion about Lower LIDAR

Lower LIDAR is likely to be required at this crossing should an MCB-OD crossing be provided whilst the station is in its current location as the safety benefit to cost ratio is more than 1.0. Consideration should be given to setting it at a height suitable to detect a fallen child.

Should an MCB-OD crossing be provided after the station has moved then these conclusions would need to be reviewed, with a new census to inform the decision.

4.8 MCB-OD Configuration factors

There are a number of design parameters for the MCB-OD system that can be modified to help manage particular hazards at a crossing. Sotera has considered these and they were further assessed in the workshop. This process is documented in *Table 18*. Although MCB-OD is not recommended in the event that the station is retained in its current location, the assessment accounts for the current layout for completeness as well as considering the impact if the station is moved.

No firm recommendations are made as the designer would prefer flexibility to make the design decisions to manage the hazards in the most appropriate way, however key considerations for this crossing are listed as follows:

- *Minimum Road Open time (MROT).* In its current form the crossing is likely to be used by large groups of pedestrians, suggesting that increasing the MROT to allow these to cross before the crossing closes should be a consideration. The downside of this would be increased road closure time and, considering that the crossing would have a particularly high road closure time even without this, changing this parameter is not likely to be preferred.

- *Blocking back.* Blocking back does occur at this crossing, although it was not observed in the nine-day census. The likelihood of this would be increased by the congestion associated with the high road closure time associated with an MCB-CCTV or MCB-OD type crossing. BPM is therefore worthy of consideration. It is not clear whether or not it would be required if the station were to move prior to commissioning.

- *Lower LIDAR.* See *Section 4.7*.

- *Provide audible warning at all four wig-wags.* The crossing is not likely to have a large area, and the audible warning is not currently set quite low. There is however background noise from the station so providing audible warnings at all four corners might be beneficial should the crossing be commissioned prior to the station moving.

- *Standing red man indications.* If the station is not moved prior to crossing renewal, then the pedestrian approach to the crossing from the platform exits would need to be considered. There are currently standing red man indications in the two offside corners, i.e. the non-platform exit sides, providing these at all four corners would provide a better interface for the large number of pedestrians approaching from the platform exits.

- *Response time and number of available attendants for CCU operation should it be necessary.* A crossing attendant is likely to approach from Cambridge depot. It would be preferred to locate the CCU on the Up side due to the available car parking.

Table 18 Review of MCB-OD configuration factors

MCB-OD configuration factor	Hazards	Consideration at level crossing	Recommended	
			If station retained	If station moved
Minimum Road Open time (MROT) Default of 10 seconds from when the barriers are fully raised until the amber light coming on for a new closure	**Lower MROT**: May cause entrapment - large queues of pedestrians not having time to cross, e.g. at a station. **Higher MROT**: Increasing closure time, higher chance of second train coming - may lead to frustration and misuse.	Likely to be used by large groups of pedestrians therefore consider if renewal before station move Would increase road closure time which is undesirably high, could impact on train service CCTV would have push and hold facility so MROT less of an issue	Consider in design however concern about impact on road closure time	N
Fitting of BPM at exit barriers or at the exit and entrance barriers. Default is fitment but can be removed based on blocking back survey and assessment of likely hazards to the barrier.	**Provision of BPM:** Manages blocking back risk	None was observed in the 2018 census, however there are factors that could occasionally cause blocking back: i) Frequent vehicle movements turning right into the Network Rail Depot 14m east of the crossing ii) Bus stops on both sides on the east side of the crossing, but buses quite infrequent iii) The station car park entrance, 90m east of the crossing, is a right turn after coming over the crossing, so there is potential for blocking back at busy times of the day Believe blocking back does occur and vehicle usage could increase LCM: Blocking back is observed, in both directions - cars parking, drop-offs as well. Prefer	Y	Consider - may not be required

MCB-OD configuration factor	Hazards	Consideration at level crossing	Recommended	
			If station retained	If station moved
		BPM but may not require should station be moved.		
Default time at which time barriers lower (30 secs). Exit barriers at 4 barrier crossing.	Blocking back for extended durations	Shorter duration blocking back so not required	N	N
Fitting of lower LIDAR. Default is fitment but can be removed based on risk assessment. LIDAR height – adult or child	Person (pedestrian, cyclist, motorcyclist) incapacitated on crossing.	See separate lower LIDAR risk assessment	Y	N
Minimise distance between barriers	Long traverse at skew crossing giving rise to entrapment risk.	There is a moderate skew however the distance between the barriers at the existing AHB crossing is not high (13m) so no further action needs to be taken.	N	N
Anti-trapping delay in lowering and pausing of the exit barriers (default is up to 10 seconds)	Long traverse distance Slow, encumbered or vulnerable users	Not a long traverse length and not a high number of slow, encumbered or vulnerable users recorded in the census so not recommended.	N	N
Enhanced OD Control of Barriers Lowering. There is an option to also require the OD system (i.e. POD and COD) to be clear in order to allow the lowering of any barrier pair (similar to BPM).	Long traverse distance (> 39m, or where BPM also provided) Entrapment	There is no specific entrapment risk at this location that is not well managed with the standard configuration.	N	N
Hurry call systems integrating with highway traffic lights	Traffic congestion caused by nearby highway traffic lights.	Not recommended, there are no nearby highway traffic lights.	N	N

MCB-OD configuration factor	Hazards	Consideration at level crossing	Recommended	
			If station retained	If station moved
Lengthen the amber phase. Default is 3 seconds	Amber sequence provides inadequate warning - high road approach speeds, difficulty braking, high use by large vehicles.	Use by HGVs but the 85th percentile road vehicle speeds are below 30mph and there is good RTL visibility. Not recommended.	N	N
Sacrificial RADAR reflectors	Road vehicles accidentally driven down the railway, e.g. high skew or Sat. Nav. errors with nearby junctions.	Not a high risk location for vehicles turning down the railway, skew is moderate, junctions are some distance from the crossing and station platforms with lighting provide a good visual cue not to do so.	N	N
Provide audible warning at all four wig-wags	Large crossing area, local background noise or high likelihood that would be set to low volume due to nearby properties meaning that audible warning cannot be heard.	Moderate crossing area and audible warning level is not set low If retain station that recommend this due to background station noise	Y	N
Standing red man indication	High pedestrian use Poorly sited RTLs for pedestrians	Crossing has standing red men on non-barrier sides only, not visible from platform exists which have poor visibility of RTLs as they are close to the RTLs. Recommend for all sides.	Y	N
Response time and number of available attendants for CCU operation should it be necessary	Crossing spends a long duration in a failed state, delaying trains.	Cambridge depot, can approach either side but preferable to approach on Up side as has car parking - LCU therefore preferred on Up side	Y	Y

5 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are made from the analysis:

Strategic options

1. Waterbeach is undergoing major development with 9,000 additional dwellings proposed on the north side of the current village and there is a possibility that the station will move nearer to the new development. These changes will have a profound impact on Waterbeach level crossing.

2. Closure of the crossing, together with nearby Burgess Drove UWCM and Bottisham Road, could be feasible and should be explored with the EACE project, which is considering the feasibility of this in more detail. This scheme would likely require a road bridge south of Bottisham Road, cycle/footbridges at Waterbeach & Burgess Drove, about 1.3km link road and some means of raising over the flood defences east of Waterbeach.

3. Whilst this scheme would likely cost £16m or more, it would deliver the maximum safety benefit without the high road closure time implications of an MCB-CCTV or MCB-OD type crossing and would eliminate the risk at all three crossings, all of which present a high risk currently.

4. An AHB crossing would not be a viable renewal option as it presents a very high level of risk and a past history of accidents and misuse.

5. An AHB+ solution at Waterbeach would not be considered to be a suitable upgrade at a busy station where there is an incentive to cross to the opposite platform. If the plans to move Waterbeach station came to fruition decreasing the usage of the crossing, AHB+ would become a potential upgrade path.

6. Despite the high road closure time implications, the preferred renewal option is, therefore, MCB-CCTV or MCB-OD; both of these crossing types would offer significant risk reduction.

7. Without the station move, or if the station move occurs after crossing renewal, then the high level of misuse suggests that MCB-CCTV might be preferred over MCB-OD in order to reduce the likelihood of barrier strikes on pedestrians or other crossing users and crossing failures caused by crossing misuse.

8. The possibility of introducing a footbridge to provide cross platform access should also be considered should the station move not occur.

9. If the station move occurs before crossing renewal, then AHB+ or MCB-OD may be preferred to minimise signaller workload.

10. Given the high risk of the crossing in its current form, renewal should be considered even if the closure scheme were to take place as it is likely that the closure scheme would take longer to deliver.

Consideration of local hazards and MCB-OD configuration parameters

11. The additional controls identified for consideration include:

- RLSE cameras to help mitigate the risk from misuse, especially by road vehicles. The crossing has a relatively high level of misuse and this might be increased by renewal to an MCB-CCTV or MCB-OD due to the road closure time.

- Pedestrian misuse associated with a high road closure time could be somewhat mitigated by provision of a footbridge to provide crossing platform access. This option is only likely to be justifiable if the station move does not take place.

- Blocking back does occur at this crossing, although it was not observed in the nine-day census. The likelihood of this would be increased by the high road closure time associated with an MCB-CCTV or MCB-OD type crossing. BPM should, therefore, be considered.

- If the station is not moved prior to crossing renewal then the pedestrian approach to the crossing from the platform exits would need to be considered. There are currently standing red man indications are the two offside corners, i.e. the non-platform exit sides, providing these at all four corners would provide a better interface for the large number of pedestrians approaching from the platform exits. Additionally, only one of the two platform exits has a barrier to prevent a surge of pedestrians into the road; this may be worthy of consideration at the other exit also.

- The current footway widths are not sufficient to meet ORR guidance, especially in areas where they narrow towards the ends. Consideration should be given to provision of two 1.8m wide footways to meet the guidance. Narrower footways, likely of 1.5m width, may be appropriate should the station move precede the crossing renewal.

12. Lower LIDAR is likely to be required at this crossing should an Mk 1 MCB-OD crossing be provided whilst the station is in its current location as the safety benefit to cost ratio is more than 1.0. Consideration should be given to setting it at a height suitable to detect a fallen child. Should an MCB-OD crossing be provided after the station has moved then this conclusion would need to be reviewed, with a new census to inform the decision.

13. MCB-OD design parameters that should be considered to manage the risk for this crossing are listed as follows:

- *Minimum Road Open time (MROT).* In its current form the crossing is likely to be used by large groups of pedestrians, suggesting that increasing the MROT to allow these to cross before the crossing closes should be a consideration. The downside of this would be increased road closure time and, considering that the crossing would have a particularly high road closure time even without this, changing this parameter is not likely to be preferred.

- *Blocking back.* Blocking back does occur at this crossing, although it was not observed in the nine-day census. The likelihood of this would be increased by the congestion associated with the high road closure time associated with an MCB-CCTV or MCB-OD type crossing. BPM is therefore worthy of consideration. It is not clear whether or not it would be required if the station were to move prior to commissioning.

- *Lower LIDAR.* See above.

- *Provide audible warning at all four wig-wags.* The crossing is not likely to have a large area, and the audible warning is not currently set quite low. There is however background noise from the station so providing audible warnings at all four corners might be beneficial should the crossing be commissioned prior to the station moving.

- *Standing red man indications.* If the station is not moved prior to crossing renewal, then the pedestrian approach to the crossing from the platform exits would need to be considered. There are currently standing red man indications in the two offside corners, i.e. the non-platform exit sides, providing these at all four corners would provide a better interface for the large number of pedestrians approaching from the platform exits.

- *Response time and number of available attendants for CCU operation should it be necessary.* A crossing attendant is likely to come from Cambridge depot. It would be preferred to locate the CCU on the Up side due to the available car parking.