Dyke Road Cycle and Pedestrian Improvements **14/02/2014**

Reference number 102470

PEDESTRIAN CROSSING AND GUARDRAILING ASSESSMENT

SYSTRA

DYKE ROAD CYCLE AND PEDESTRIAN IMPROVEMENTS

PEDESTRIAN CROSSING AND GUARDRAILING ASSESSMENT

IDENTIFICATION TABLE	
Client/Project owner	Brighton and Hove City Council
Project	Dyke Road Cycle and Pedestrian Improvements
Study	Pedestrian Crossing and Guardrailing Assessment
Type of document	Report
Date	14/02/2014
File name	20140214_Pedestrian_Crossing_Assessment
Reference number	102470
Number of pages	36

APPROVAL					
Version	**Name**		**Position**	**Date**	**Modifications**
1	Author	Alexis Fuller	Analyst	21/02/2014	
	Checked by	Martin Hempell	Senior Consultant	21/02/2014	
	Approved by	Glenn Higgs	Managing Consultant	21/02/2014	
2					

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1.1.1 SYSTRA was commissioned by Brighton and Hove City Council (BHCC) to provide an assessment of the effectiveness of the two Pelican pedestrian crossings on the stretch of Dyke Road between the Old Shoreham Road and Highcroft Villas Junctions. This crossing review ties in with the wider proposals being developed for Dyke Road by SYSTRA.

1.1.2 The operation of the existing crossings is evaluated as well as potential options for their improvement, including their location and type. An analysis of the necessity for the guardrailing which currently exists at each location is also undertaken. The report draws conclusions about the nature of the existing crossing provision and provides recommendations for the optimum pedestrian crossing arrangement within the study area.

1.1.3 This report is set out as follows:

- Background character assessment of the Dyke Road area and the existing pedestrian crossings as well as traffic flows;
- Analysis of the operation of the existing crossings;
- Assessment of the optimum number, location, type and design of pedestrian crossings within the study area;
- Evaluation of the existing guardrailing at each crossing;
- Conclusions on pedestrian crossing arrangements; and
- Recommendations for pedestrian crossing layout on Dyke Road.

2. DYKE ROAD CHARACTER

2.1 Area Context

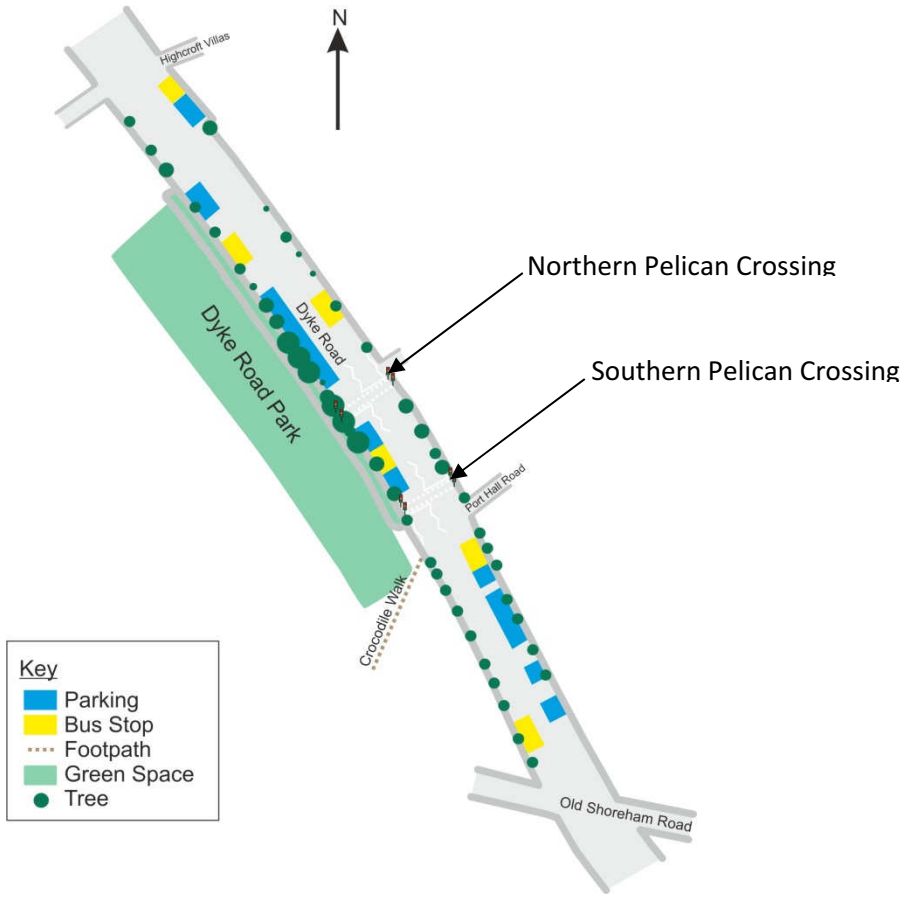
2.1.1 Dyke Road forms part of the A2010, acting as a local distributor road from the centre of Brighton north-west through the city to the South Downs National Park.

2.1.2 The road provides a mix of land use within the study area. Dyke Road Park runs along its western side for much of this stretch. South of the park Brighton Hove and Sussex Sixth From College occupies the space between the edge of the park and the junction with Old Shoreham Road. The eastern side of the road is mostly residential, but does also include the entrance to Windlesham Primary School.

2.1.3 The road is lined with mature trees to either side, mostly sited on the footway, which is around 3m in width throughout its length. A second pedestrian footway runs along the border of Dyke Road Park, set back from the carriageway. A pedestrian footpath, Crocodile Walk, emerges on Dyke Road between the park and sixth form college which provides a link south to Old Shoreham Road.

2.1.4 **Figure 1** shows the section of Dyke Road on which this report is focussed.

Figure 1. Dyke Road Study Area



2.2 Existing Pedestrian Crossings

2.2.1 There are currently two formal pedestrian crossings within the study area. One is located adjacent to the end of Crocodile Walk, close to the junction with Port Hall Road, referred to as the southern crossing in this report. The second crossing is located directly opposite the park café, close to the entrance to Windlesham School and is referred to as the northern crossing herein.

2.2.2 Both pedestrian crossings are Pelican crossings. The southern crossing has a single long length of guardrailing extending down the western footway for around 20m south of the crossing. The northern crossing has two very short sections of guardrailing, one immediately to the south outside the entrance to Windlesham School and one just to the north adjacent to the entrance to a housing estate; both sections are on the eastern footway.

2.2.3 **Figures 2 and 3** show the northern and southern crossings respectively, looking north in each instance.

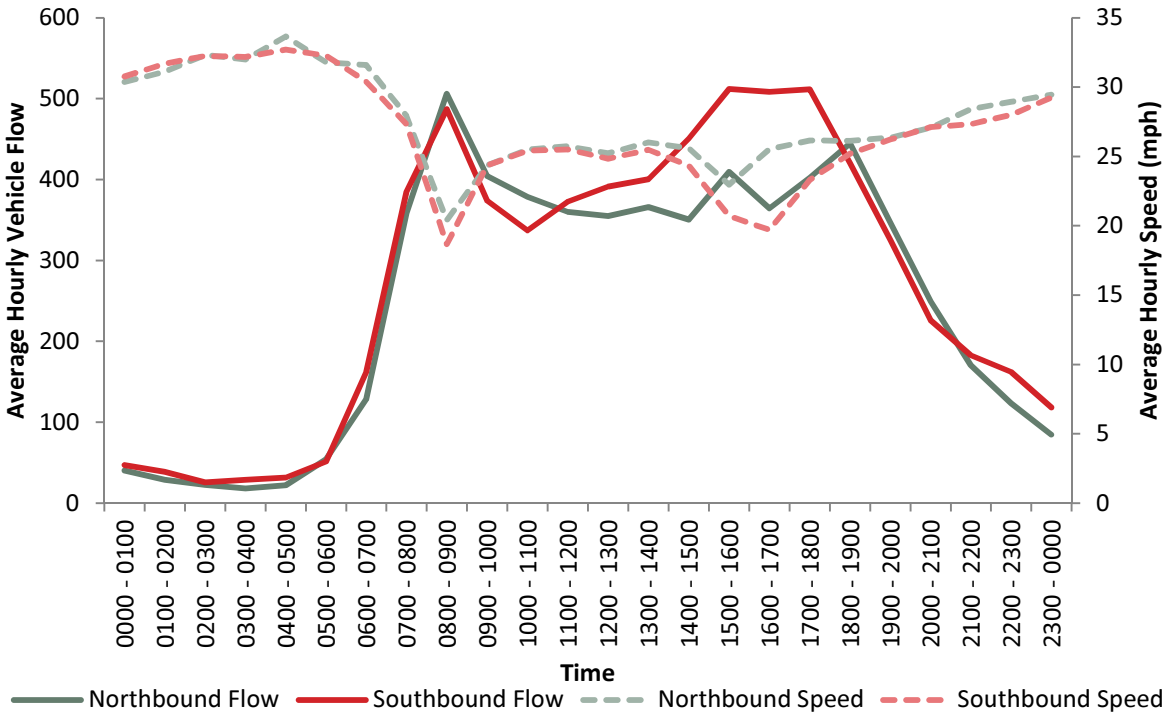
Figure 2. Northern Pedestrian Crossing

Figure 3. Southern Pedestrian Crossing

2.3 Traffic Characteristics

2.3.1 Dyke Road has a single lane of traffic in either direction along the length of the study area. **Figure 4** shows average weekday traffic flows and average vehicle speeds recorded by automatic traffic counts.

Figure 4. Weekday Vehicle Flows and Speeds

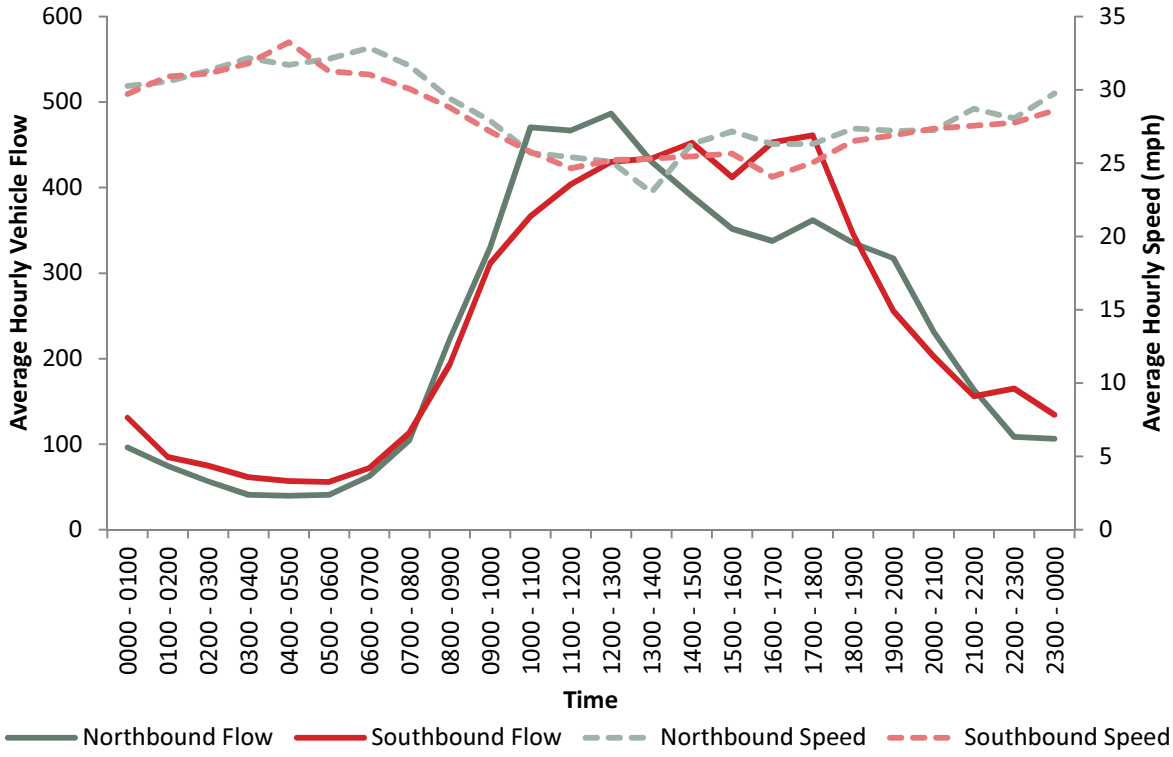


2.3.2 Average weekday hourly vehicle flows were from 350 to just over 500 in each direction during daytime hours of 07:00-20:00, and significantly lower between 20:00 – 07:00. Northbound peaks were recorded between 08:00 – 09:00 and 18:00 – 19:00, at averages of 506 and 444 vehicles per hour respectively. Southbound peaks occurred at 08:00 – 09:00 at an average of 487 vehicles per hour and an elongated PM peak between 15:00 – 18:00 averaging 510 vehicles per hour.

2.3.3 Vehicle speed is generally inversely proportional to flows, rising and falling according to the levels of traffic. The speed limit along this section of Dyke Road is 30mph. Northbound weekday speeds average around 25mph between 08:00 – 20:00 with exceptions during the peaks where speeds are lower; the lowest average hourly northbound speed recorded was 20.4mph during the morning peak. Speeds outside of the daytime are considerably higher. Southbound speeds between 08:00 – 20:00 fluctuate more than northbound, with the lowest daytime average speed 18.7mph and the highest 26.2mph. Again, speeds outside these hours are considerably higher.

2.3.4 **Figure 5** shows average weekend vehicle flows and speeds.

Figure 5. Weekend Vehicle Flows and Speeds



2.3.5 Weekend traffic showed a pattern of peaking during the middle of the day with a gradual increase across the morning and subsequent decrease in the afternoon. The northbound peak occurred between 10:00 – 14:00, with averages of over 430 vehicles per hour. The southbound peak was longer and later, with average vehicle flows above 400 vehicles per hour from 11:00 – 18:00.

2.3.6 Weekend speeds are higher across the course of the day than weekday with lowest hourly averages of 23.0mph northbound and 24.1mph southbound. Average speeds rise outside the elongated daytime peaks.

3. EXISTING CROSSING BEHAVIOUR

3.1 PV^2 Criteria

3.1.1 PV^2 is a nationally accepted impartial measure for the need for a pedestrian facility at any site, given pedestrian and vehicle flows in the area. The PV^2 value was calculated for both existing pedestrian crossings on Dyke Road. The two criteria used in the evaluation are:

- P = the pedestrian flow (pedestrians/hour) across a 100m length of road centred on the proposed crossing site; and
- V = the number of vehicles in both directions (vehicles/hour).

3.1.2 The PV^2 value uses the average over the four busiest hours of the day. In the case of both of the existing crossings on Dyke Road these were 08:00-10:00 and 15:00-17:00. The PV^2 value for the north crossing is:

144 x 890^2 = 114,062,400

3.1.3 The PV^2 value for the south crossing is:

172 x 890^2 = 136,241,200

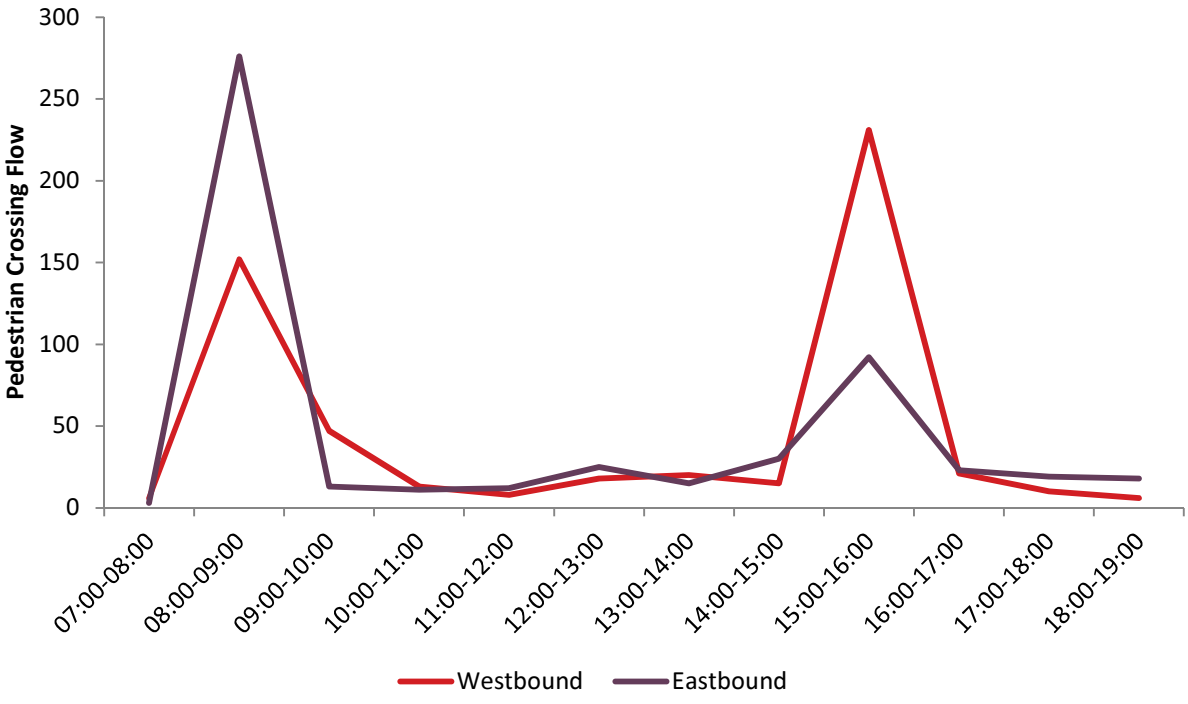
3.1.4 In both cases the PV^2 value exceeds $1x10^8$. For a continuous crossing with no break or stagger on a traffic island scores that exceed $1x10^8$ are considered justification for a pedestrian crossing facility.

3.2 Pedestrian Behaviour

Crossing Flows

3.2.1 **Figure 6** shows the weekday crossing flow in each direction at the northern crossing

Figure 6. Weekday Pedestrian Crossing Flow, Northern Crossing



3.2.2 **Figure 6** reveals two very distinct peaks in pedestrian crossing flow at the crossing, between 08:00-09:00 and 15:00-16:00. These peaks correspond with Windlesham School opening and closing times, between 08:10-08:50 and 15:15-15:50 respectively. The crossing flows show a clear tidal pattern; the eastbound flow is higher in the

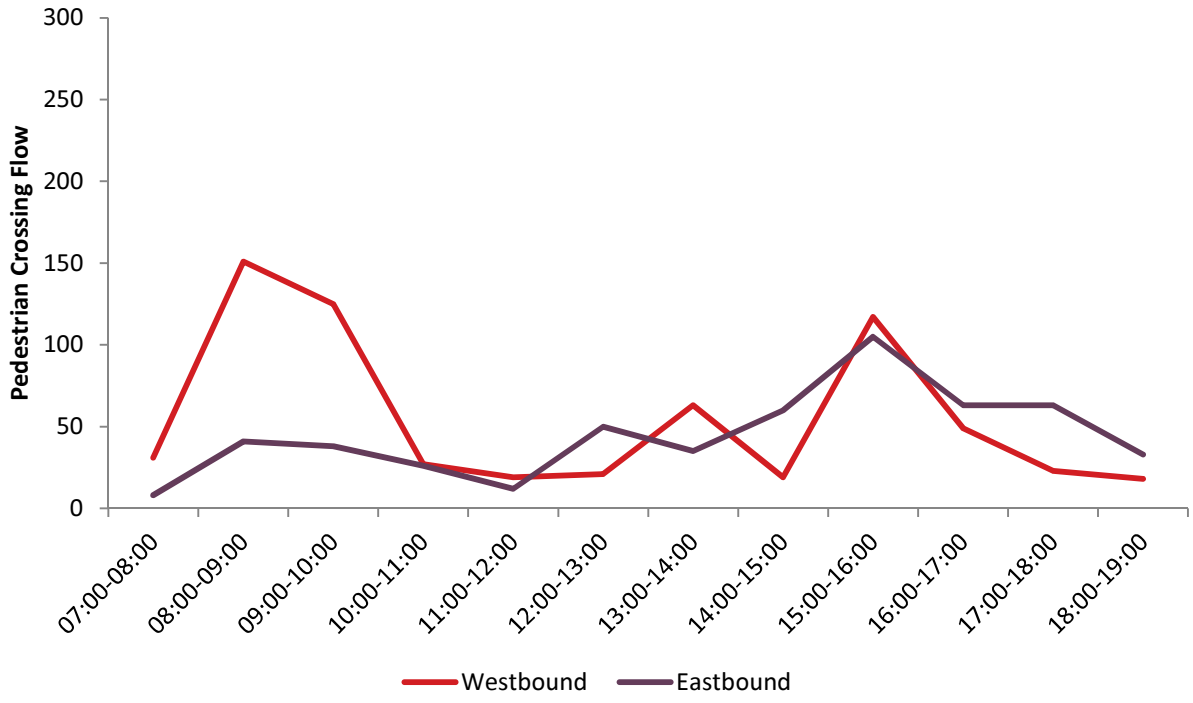
morning peak, with the westbound flow higher in the afternoon peak. This pattern of pedestrian flows reflects parents arriving with children in the morning and crossing Dyke Road before dropping the children off at school and then returning across the road. The reverse behaviour occurs in the afternoon.

3.2.3 Outside of the peaks crossing flows are low, with a two way flow of less than 50 pedestrians per hour for most of the day.

3.2.4 Weekend crossing flows at this crossing are low, peaking in the afternoon period between 15:00-16:00 when the total two-way flow was 39 pedestrians.

3.2.5 **Figure 7** displays weekday pedestrian crossing flows at the southern crossing.

Figure 7. Weekday Pedestrian Crossing Flow, Southern Crossing



3.2.6 **Figure 7** shows that total flows are very similar to the northern crossing, but with less abrupt peaks. Westbound flows peak at just over 150 pedestrians per hour in the morning between 08:00-09:00 and again at a little above 100 pedestrians per hour in the afternoon between 15:00-16:00. Eastbound flows do not have a clear morning peak, but rise steadily across the afternoon, also peaking at just over 100 pedestrians per hour. These peaks coincide with school opening and closing times, pupils crossing the road westbound to reach the sixth form college in the morning and returning eastbound in the afternoon. The higher peak in the morning could be explained by commuters travelling via Crocodile Walk, whose return journeys are more spread out in the afternoon.

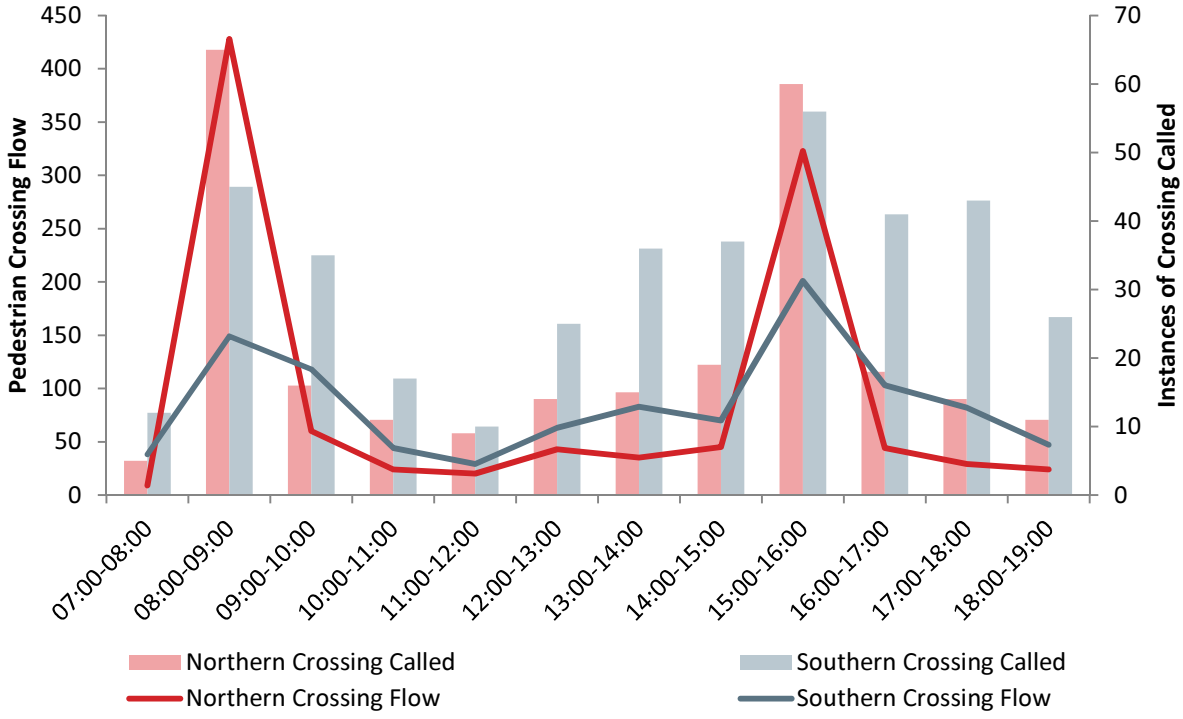
3.2.7 Outside of the peaks the two-way flow varies, but is generally around 100 pedestrians per hour.

3.2.8 Weekend crossing flows on the southern crossing are higher than those at the northern crossing, but are still low. The peak hourly two-way crossing flow is 79 pedestrians, between 12:00-13:00. There is no clear pattern across the course of the day.

Crossing Calling

3.2.9 **Figure 8** illustrates the total two-way crossing flow and the number of times the pedestrian crossing was called per hour.

Figure 8. Pedestrian Crossing Flow and Instance of Pedestrian Crossing Called



3.2.10 **Figure 8** shows that as would be expected there is a clear correlation between the flow and the number of times the crossing is called. In the two peak periods, the northern crossing was called over 60 times, that is more often than once a minute. During the busiest part of this period the crossing effectively reaches saturation, as it could not be called more frequently due to the built in break whilst the signal is green for traffic. The high volume of pedestrians means that this equates to between five or six pedestrians crossing per instance of the crossing being called. The lower peaks on the southern crossing are reflected in lower occurrences of the crossing being called during peak periods, 45 in the morning peak and 56 in the afternoon peak. This has a higher ratio of the crossing being called to total pedestrian flow though, amounting to three pedestrians for each instance of the crossing being called.

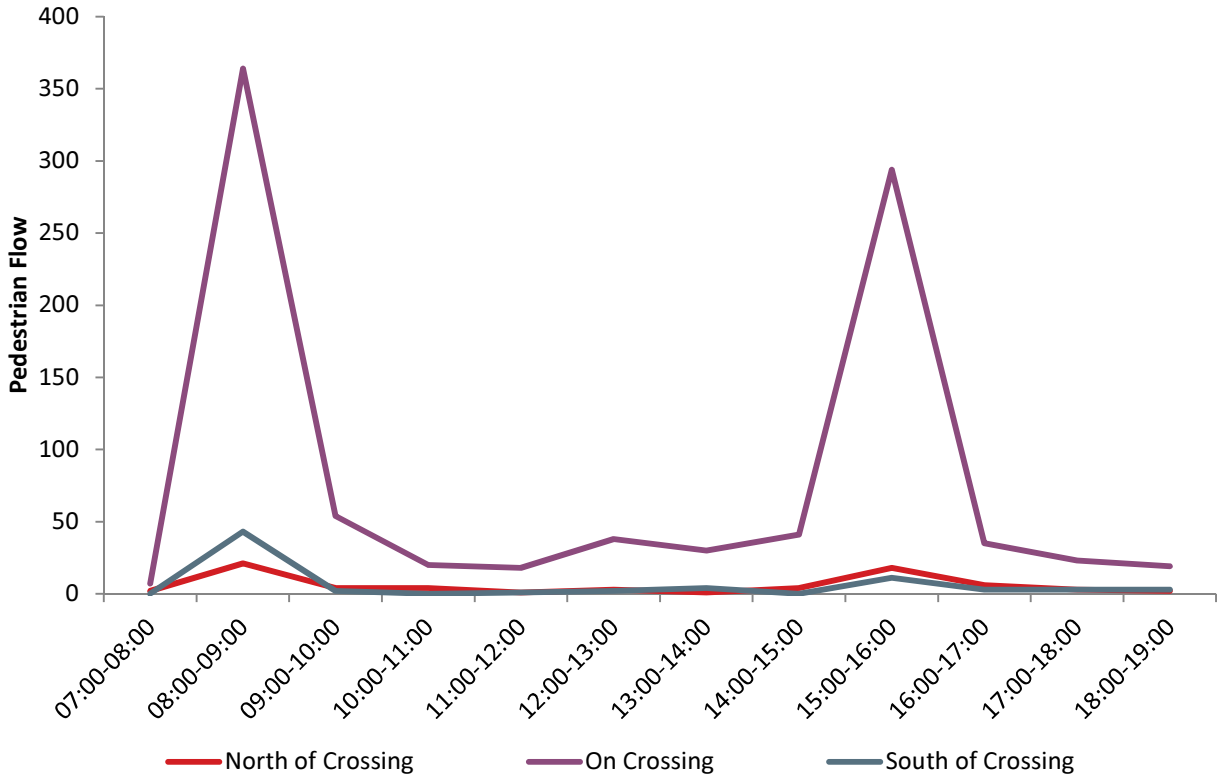
3.2.11 Outside of the peak period the northern crossing is called much less frequently, generally between 10-20 times per hour. During these periods this means around two to three pedestrians crossing the road for each time the crossing is called. The southern crossing however still experiences fairly regular use throughout the day. In the period 09:00-10:00 and for most of the afternoon the crossing is called over 35 times per hour,

averaging only two pedestrians crossing the road for each instance of the crossing being called.

Crossing Paths

3.2.12 **Figure 9** shows the numbers of pedestrians crossing directly on the northern crossing, that is between the studs, and in zones extending as far as the crossing zig-zags immediately to the north or south of the crossing.

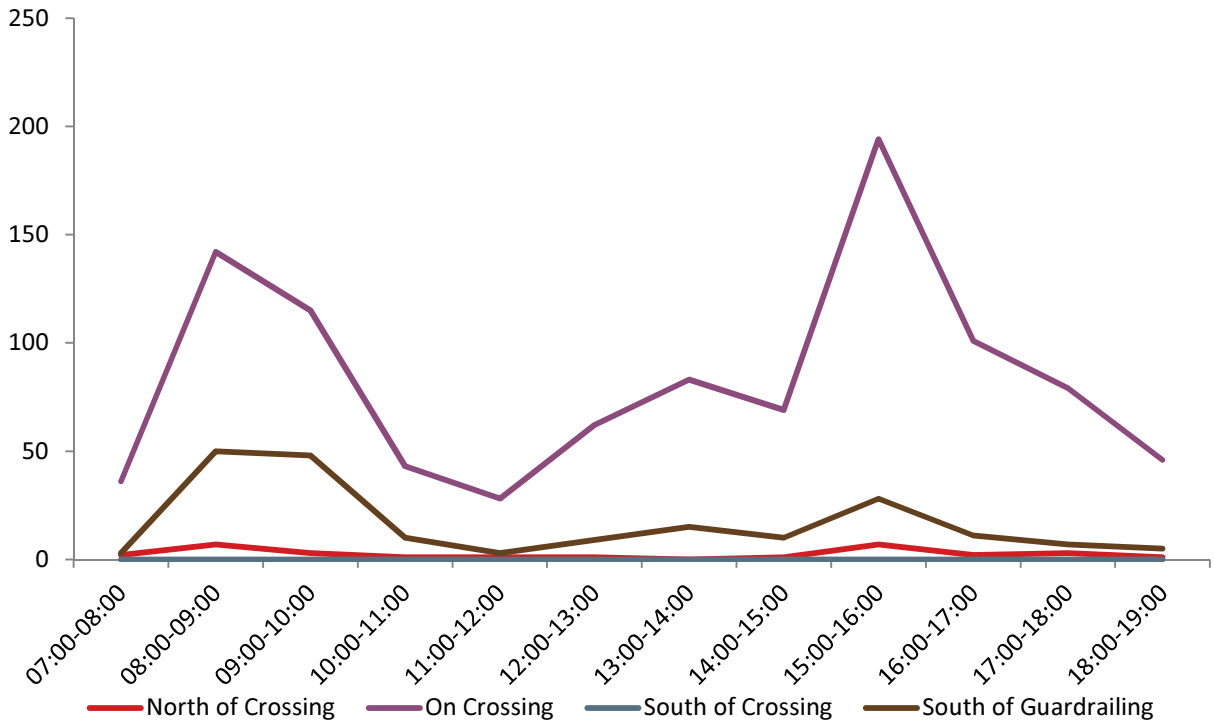
Figure 9. Pedestrian Crossing Paths, North Crossing



3.2.13 **Figure 9** illustrates that the vast majority, nearly 90%, of pedestrians are crossing directly on the crossing (between the studs), with very few crossing to either side. The numbers crossing either north or south of the crossing are similar, at around 6% of pedestrians crossing on either side.

3.2.14 **Figure 10** displays the numbers of pedestrians crossing directly on the southern crossing (between the studs), in the zone covered by the crossing zig-zags to the north, in the zone corresponding with the guardrailing to the south, and in the 25m south of the guardrailing.

Figure 10. Pedestrian Crossing Paths, South Crossing

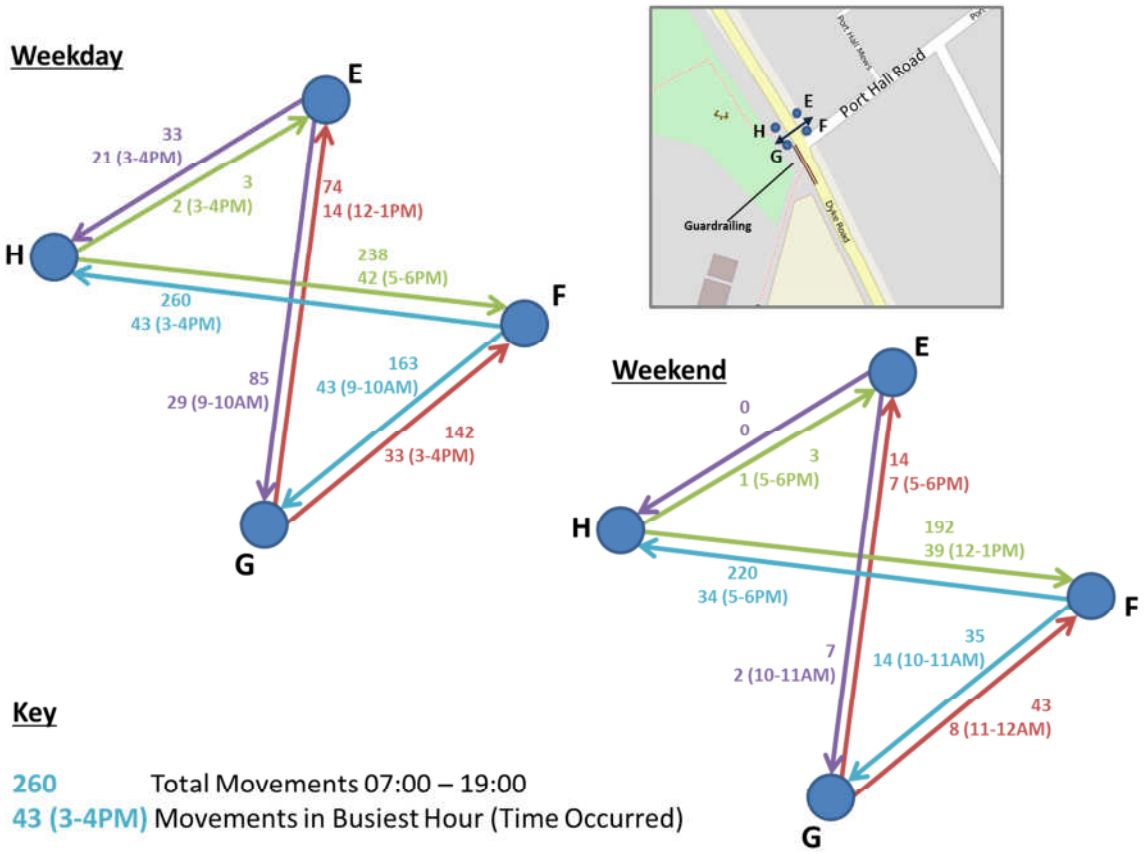


3.2.15 **Figure 10** shows that just over 80% of pedestrian crossing movements are made directly on the pedestrian crossing. No crossing takes place in the zone with guardrailing to one side, whilst very limited crossing takes place to the north of the crossing. More significant numbers cross to the south of the guardrailing, especially in the morning peak, this makes up 16% of total crossing movements at this site.

Origin/Destination of Pedestrians Crossing

3.2.16 **Figure 11** shows the origin and destination of pedestrians using the southern crossing.

Figure 11. Origin/Destinations of Pedestrians, Southern Crossing

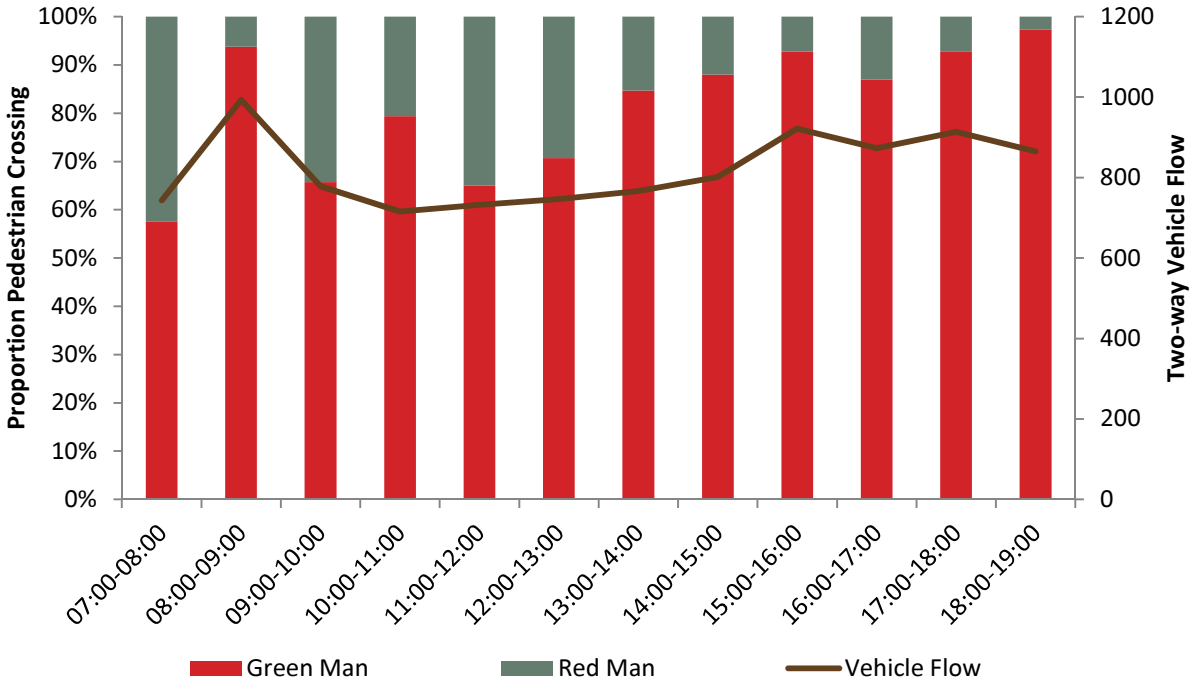


3.2.17 **Figure 11** illustrates that the majority of crossing movement are from the south-east to north-west and vice versa, this movement makes up almost exactly 50% of total movements at the crossing. The second most popular movement is south-west to south-east, at around 30% of total movements.

Use of Green Man

3.2.18 **Figure 12** shows the proportion of pedestrians crossing on either the green or red man phases across the course of the weekday on the northern crossing along with the two-way vehicle flow.

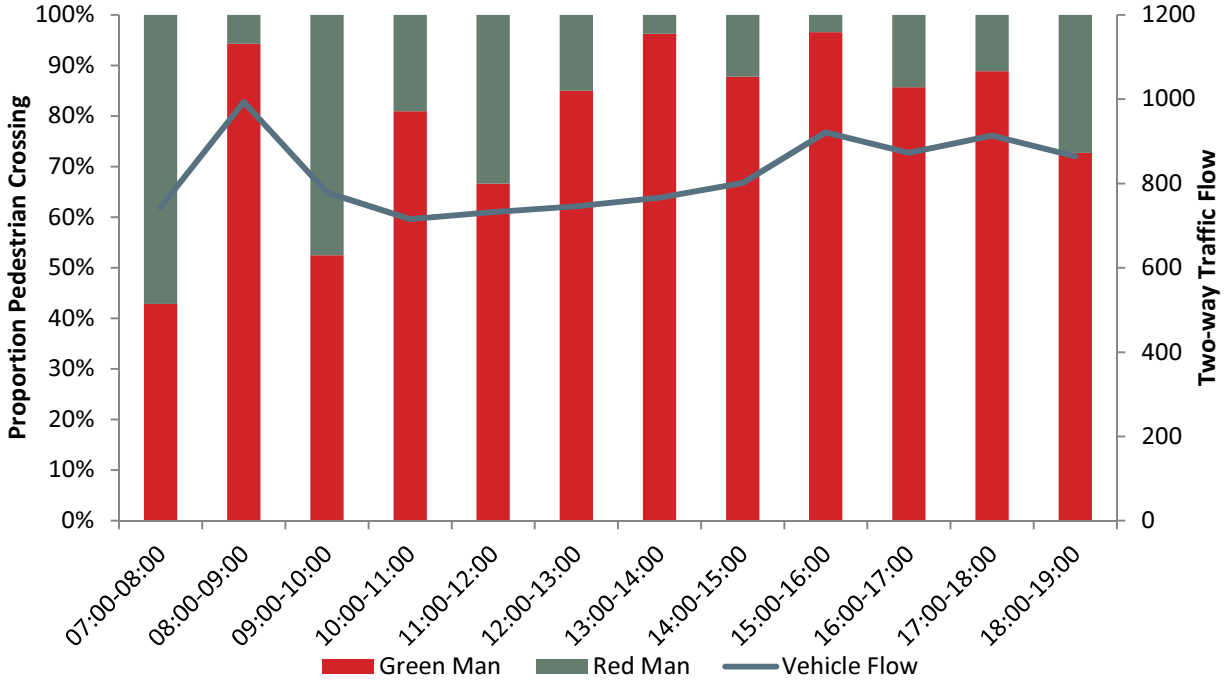
Figure 12. Pedestrians Crossing on Green Man and Traffic Flow, North Crossing



3.2.19 **Figure 12** illustrates that, with exception of the early morning time period where total numbers of pedestrians crossing was very small, the majority of pedestrians waited for the green man phase of the crossing to cross the road. Crossing on the green man correlates with overall traffic flow and this was particularly true during the two peaks when at least 94% of pedestrian crossings were made whilst the crossing had been called.

3.2.20 **Figure 13** displays the proportion of pedestrians crossing on either the green or red man phases across the course of the weekday on the southern crossing along with the two-way vehicle flow.

Figure 13. Pedestrian Crossing on Green Man and Traffic Flow, South Crossing



3.2.21 **Figure 13** shows that similar to the northern crossing, the majority of pedestrians on the southern crossing wait for the green man phase before crossing the road. As at the northern crossing the proportion crossing on the green man correlates with the vehicle flows and is particularly high during the 08:00-09:00 and 15:00-16:00 peaks.

3.2.22 These overall proportions from both crossings suggest that the volume of traffic flow is such that, in general, pedestrians do not feel comfortable crossing the road without the assistance of the pedestrian crossing, especially during the peak period for traffic.

Pedestrian Waiting Volumes

3.2.23 During the peak periods the maximum number of pedestrians recorded waiting to cross on one side of the road at either crossing was fifteen. This level occurred during the morning peak at the northern crossing. However for the vast majority of the time the number of pedestrians waiting to cross was much lower than this with only one or two pedestrians waiting to cross.

Red Light Violations

3.2.24 Over the course of the two survey days two vehicles and eight pedal cyclists passed through the crossing during a red light phase. Given this is a very small proportion of total traffic this suggests that the signals are have a high level of compliance. There was a single conflict observed where a vehicle braked late and had to alter its course slightly to avoid a pedestrian crossing during a flashing amber phase.

4. CROSSING REQUIREMENT AND LOCATION

4.1.1 This section discusses whether crossings are required and whether the current crossings are in the optimal location.

4.2 Crossing Requirement

4.2.1 The consideration of the requirement for a crossing has been informed by the following data:

- Traffic flow;
- Pedestrian flow; and
- Whether pedestrians are crossing on the red or green man phases of the existing crossings.

4.2.2 The PV^2 analysis suggests that pedestrian flows are high enough with regard to the volume of traffic and nature of Dyke Road that there is justification for a crossing at both locations. The low proportion of pedestrians crossing the road during the red man phases of the existing crossings or outside of the demarcated crossing areas supports the need for a formal crossing as it suggests that the road is difficult to cross without the assistance of a pedestrian crossing.

Conclusion: There is justification for a pedestrian crossing at both locations.

4.3 Crossing Location

4.3.1 The PV^2 analysis confirms that there is justification for both pedestrian crossings in their existing location. Although their current location can be justified it does not necessarily follow that both crossings are in the optimum location, therefore a further review of available evidence is required.

4.3.2 The optimum location for the pedestrian crossings is identified by considering:

- Pedestrian crossing flows;
- The proportions of pedestrians crossing directly on each crossing rather to either side; and
- Origin/Destination paths of pedestrians using the crossings.

Northern Crossing

4.3.3 It was shown in **Chapter 3.2** that the vast majority of pedestrians adhere to the pedestrian crossing within the studs when crossing Dyke Road at this point. This suggests that the crossing is in an appropriate location. Although it should be remembered that a section of guardrailing to the south of the crossing on the eastern footway may limit the extent to which pedestrians can cross to the south, but the impact of this on the crossing desire line is likely to be minimal.

4.3.4 The temporal distribution of pedestrians crossing the road shows two very clear peaks connected to accessing Windlesham Primary School. Given the current proximity of the

crossing to the school entrance it would not seem to be beneficial to move the crossing further from the entrance. Children coming to or from the school are likely to approach from both the north and the south as well as via Dyke Road Park, or from parents using the available parking on the west side of the road. Furthermore there is a relative gap in the trees that line the footway to either side of Dyke Road at this point. All of these factors suggest that the crossing location at present cannot be improved upon.

Southern Crossing

4.3.5 As with the northern crossing, the majority of pedestrians using the southern crossing cross the road within the marked area of the crossing and not to either side. However guardrailing to the south does hinder potential demand to cross immediately to the south of the crossing. There is some evidence that pedestrians are crossing to the south of the guardrailing, but this is only a notable proportion during the morning peak. At all other times the proportion of pedestrians crossing on the crossing suggest that the crossing is well located at present.

4.3.6 Origin/Destination observations at this crossing showed that both during the week and weekend the most common movement is from south-east to north-west and vice versa. This endorses the current location of the crossing. If the crossing were too far south or north it would be expected that south-east to south-west or north-east to north-west movements would be the most common, with pedestrians forced off their desire line to reach the crossing.

4.3.7 The proximity of the crossing both to the entrance to Crocodile Walk and the end of Port Hall Road is advantageous at present as it serves any pedestrians who emerge from either of these access points to Dyke Road who then wish to cross the road. The crossing is also close enough to the bus stops both to the north and south to assist pedestrians travelling to or from these stops without having to deviate significantly from desire lines. All of these factors suggest that the current location of the southern crossing is satisfactory at present.

Replacement with a Single Crossing

4.3.8 Given the advantages of both locations in serving desire lines and linking up with local trip attractors, there seems little benefit for pedestrians in the creation of a single larger crossing. Furthermore the distinct pedestrian peaks at either crossing mean that this single crossing would need a very high capacity to deal with highest volumes of pedestrian flow.

Conclusion: Both pedestrian crossings are in their optimum location, there is no justification for moving either or combining into a single pedestrian crossing.

5. CROSSING TYPE ANALYSIS

5.1.1 This section discusses whether the current type of crossings are appropriate. Consideration is made of whether the crossings should be signalised or Zebra crossings, and if signalised which type of signalised crossing, as well whether either or both crossings should be raised.

5.1.2 A range of different types of pedestrian crossings exist, which vary in suitability depending on context and provide differing advantages and disadvantages for both pedestrians and vehicles. The key differences for pedestrians will be the length of delay before being able to cross and the safety and perception of safety of the crossing. The length of delay created by pedestrians crossing will be the biggest factor for vehicles.

5.1.3 Key factors to consider in determining the type of crossing are;

- Vehicle and pedestrian delays at the crossing;
- Vehicle flows and speeds;
- Safety;
- The character of the area and context of the road; and
- The volume and make-up (if high proportions of elderly, children, disabled etc.) of pedestrian flow.

5.1.4 Data collected that will inform the crossing type analysis includes:

- Pedestrian flows;
- Vehicles flows and speeds;
- Use of crossing by cyclists;
- Red light violations of traffic signals by pedestrians and vehicles;
- Frequency with which existing signalised crossings are called; and
- Secondary research on the impact of crossing type on safety.

5.2 Vehicle and Pedestrian Delay

Vehicle Delays - Methodology

5.2.1 The differences in the way in which Zebra crossings and signalised crossings operate means that the extent to which they cause delays for vehicles and pedestrians will vary according to traffic and pedestrian flow. Combining the ATC vehicle flow data with the pedestrian crossing flow data and the record of the number of times the signalised crossings were called by pedestrians allows an estimate of the total delay currently caused to both vehicles and pedestrians by the signalised crossings and the potential delay caused if these crossings were replaced by Zebra crossings.

5.2.2 The current delay to vehicles caused by the signalised crossing can be established by considering the number of times the pedestrian crossing is called and the vehicle flow. From video review it can be seen that each time the pedestrian crossing is called the subsequent red light phase is ten seconds.

5.2.3 It will be assumed that vehicles are always able to move off immediately on the commencement of the flashing amber phase. The vehicle flow data can allow an estimation of how many vehicles will be delayed by a red signal. For simplicity it is assumed that vehicles are spread at even intervals, so if the vehicle flow was six vehicles per minute, these would be spread evenly every ten seconds. It is also assumed that a vehicle is only delayed if it arrives at the crossing whilst the signal is red, slowing for lights that subsequently change is not considered.

5.2.4 The method of establishing vehicle delay was applied in 15 minute periods across the day as follows:

1. The number of times the crossing was called was multiplied by 10 seconds. This provides the amount time for which vehicles were stopped within the 15 minute period.
2. The total vehicle flow in each direction for the 15 minute period was used to establish the interval between vehicles were they evenly distributed. Dividing the vehicle flow by 900, the number of seconds in 15 minutes, provides the vehicle interval.
3. The total stopping time calculated in (1) was divided by the interval in (2) to determine the number of vehicles caused to stop by the crossing in each direction.
4. Given that vehicles could arrive at any point during the red light phases, it was assumed that the average delay would be 5 seconds. Multiplying the number of vehicles affected by 5 seconds provides the total vehicle delay caused by the signalised crossing.

5.2.5 An illustration of the vehicle delay calculation for one fifteen minute period is provided below:

Instances Crossing Called x 10 = Total Time of Red Light Phase: **14 x 10 = 140 sec**

Northbound Vehicle Flow ÷ 900 = Northbound Vehicle Interval: **122 ÷ 900 = 7.4 sec**

Southbound Vehicle Flow ÷ 900 = Southbound Vehicle Interval **102 ÷ 900 = 8.8 sec**

Total Time of Red Light Phase ÷ Vehicle Interval = Number of Vehicles Delayed:

Northbound**: 140 ÷ 7.4 = 19.0 vehs** Southbound: **140 ÷ 8.8 = 15.8 vehs**

Number of Vehicles Delayed x 5 = Total Vehicle Delay: **(19.0 + 15.8) x 5 = 173.8 sec**

5.2.6 To estimate the likely vehicle delays caused by a Zebra crossing, the ATC vehicle flow and the pedestrian crossing flows can be used using a similar method to that for the signalised crossings. For a Zebra crossing there is no fixed length of delay, however video observations suggest that it takes 6 seconds on average for a pedestrian to cross Dyke Road. Therefore each crossing of the road will cause 6 seconds of delay to vehicles. However some pedestrians will cross in groups and pedestrians from opposite sides of Dyke Road may cross at the same time. Without precise data to quantify these movements it has been assumed that only 75% of pedestrians crossing will be a unique crossing and therefore cause a delay. Closer inspection of the crossing data reveals that there are fifteen minute periods where almost every pedestrian crossing caused the existing signalised crossing to be called, suggesting these were all unique crossing movements. Therefore if the 75% figure amounts to less than the number of times the existing signalised crossing was called in a fifteen minute period then all pedestrian crossings have been treated as unique crossing movements. Once the total delay is established, the same method can be followed as for the signalised crossings.

5.2.7 Therefore the method for establishing the vehicle delay for a Zebra crossing is as follows:

1. The number of pedestrian crossing movements was multiplied by 75%. This was compared to the number of times the signalised crossing was called, if the latter was higher then the total number of pedestrian crossing movements was used, otherwise the 75% figure was carried forward.
2. The pedestrian crossing number from (1) was multiplied by 6 to provide the total amount of time vehicles will be stopped.
3. The total vehicle flow in each direction for the 15 minute period was used to establish the interval between vehicles were they evenly distributed.
4. The total stopping time calculated in (2) was divided by the interval in (3) to determine the number of vehicles caused to stop by the crossing in each direction.
5. Given the vehicles could arrive at any point during a pedestrian crossing, it was assumed that the average delay would be 3 seconds. Multiplying the number of vehicles affected by 3 seconds provides the total vehicle delay caused by the signalised crossing.

5.2.8 An illustration of the vehicle delay calculation for a Zebra crossing for the same fifteen minute period used above is illustrated below:

Number of pedestrians crossing x 75%: **72 x 75% = 54**

Comparison of 75% figure against instances of signalised crossing being called: **54 > 14**

75% of Pedestrians Crossing x 6: **54 x 6 = 324**

Northbound Vehicle Flow ÷ 900 = Northbound Vehicle Interval: **122 ÷ 900 = 7.4 sec**

Southbound Vehicle Flow ÷ 900 = Southbound Vehicle Interval **102 ÷ 900 = 8.8 sec**

Total Time of Crossing Delay ÷ Vehicle Interval = Number of Vehicles Delayed:

Northbound**: 324 ÷ 7.4 = 43.8 vehs** Southbound: **324 ÷ 8.8 = 36.6 vehs**

Number of Vehicles Delayed x 3 = Total Vehicle Delay: **(43.8 + 36.6) x 3 = 241.3 sec**

5.2.9 In this example it can be seen that the total vehicle delay would be much higher for a Zebra crossing than a signalised crossing. This is due to a high volume of pedestrians causing a large amount of delay, whereas when pedestrian numbers are lower the balance would tip more in favour of the Zebra crossing. It should be noted that the delay caused by pedestrians reaches a saturation point on a signalised crossing where the crossing cannot be called any more frequently, whereas the delay on a Zebra crossing could theoretically continue to increase until there was no vehicle flow at all.

Pedestrian Delays - Methodology

5.2.10 The total pedestrian delays for each type of crossing can be established by considering the total number of pedestrian crossing movements and the average length of delay each pedestrian is likely to face.

5.2.11 Given a Zebra crossing allows pedestrians to cross almost immediately on arrival, it has conservatively been estimated that the average pedestrian waits for two seconds to be able to cross the road. Multiplying the total number of pedestrians crossing by two gives the total pedestrian delay in seconds.

5.2.12 For the signalised crossing the delay is more difficult to establish given the wait for a green man after calling the crossing can vary significantly. The average wait has therefore been taken as 5 seconds. Pedestrians who arrive during the green man phase will also benefit from no wait at all; the proportion of pedestrians for whom this applies is difficult to quantify, but it is unlikely to be greater than 20%. Therefore each pedestrian crossing movement is multiplied by 5 to get a total delay, but only 80% of this figure is used to accommodate those pedestrians who benefit from arriving during the green man phase.

Assumption Limitations

5.2.13 Whilst considering the delay analysis the following limitations born out of the assumptions made should be kept in mind:

- Treating all traffic as at equal intervals ignores any bunching effect that may occur, which could in turn exacerbate queues and increase delays. This is likely to be more true during the longer delay caused by a signalised crossing;
- Basing vehicle delays on the interval between vehicles assumes that there will be gaps in between pedestrians using a Zebra crossing through which unaffected vehicles may pass, but a constant flow of pedestrians may prevent this and hence a greater build-up of traffic and subsequent delay may occur;
- Vehicle delays on a signalised crossing may be longer than ten seconds as vehicles will have to remain stationary if pedestrians continue to cross during the flashing amber phases;
- Vehicle delays on a Zebra crossing may be shorter than 6 seconds as many pedestrians will cross in less than this time and vehicles will often pass over the crossing before pedestrians have completed crossing the road entirely; and
- Pedestrian delays on a Zebra crossing may average less than two seconds as this does not consider the case where pedestrians do not have to wait at all as a lack of traffic or already slowing traffic allows instantaneous crossing.

5.2.14 Despite the limitations this method can be considered reasonably robust given the data available and many of the assumptions are likely to balance out overall or have limited total impact on the results.

Crossing Delay Comparison by Location

5.2.15 The total vehicle and pedestrian delays for each type of crossing at each location is shown in **Table 1**. How this works out over the course of the day is shown in **Figures 10 and 11**.

Table 1. Crossing Delay Comparison

LOCATION	CROSSING TYPE	PEDESTRIAN DELAY	VEHICLE DELAY	TOTAL DELAY TO ROAD USERS
North Crossing	Signalised	1hr 34mins	52mins	**2hrs 26mins**
	Zebra	35mins	1hr 22mins	**1hr 57mins**
Difference in Delay:		**-59mins**	**+30mins**	**-29mins**
South Crossing	Signalised	1hr 7mins	1hr 15mins	**2hrs 22mins**
	Zebra	33mins	54mins	**1hr 27mins**
Difference in Delay:		**-34mins**	**-21mins**	**-55mins**

Figure 14. Pedestrian and Vehicle Delays and Flows, North Crossing

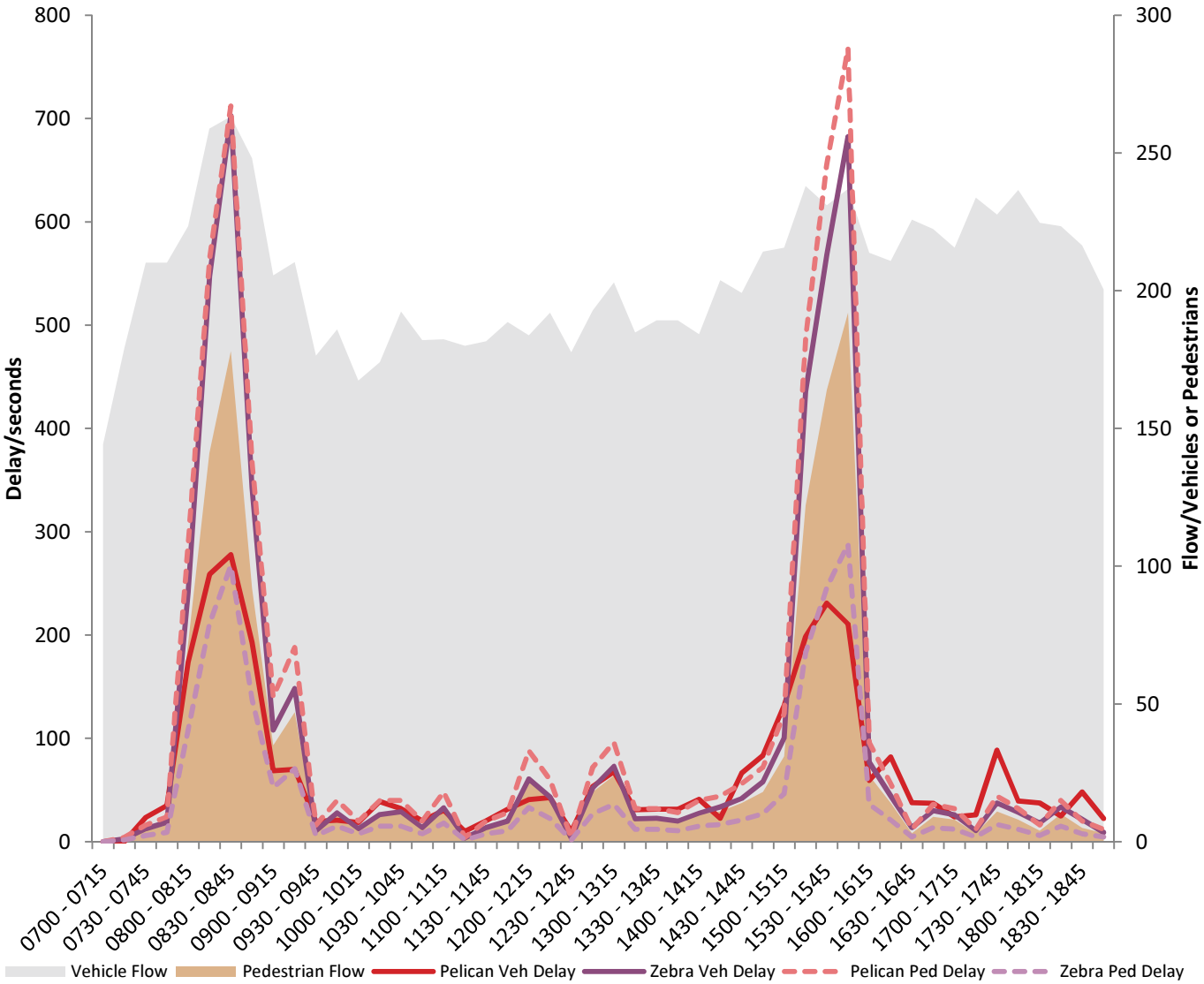
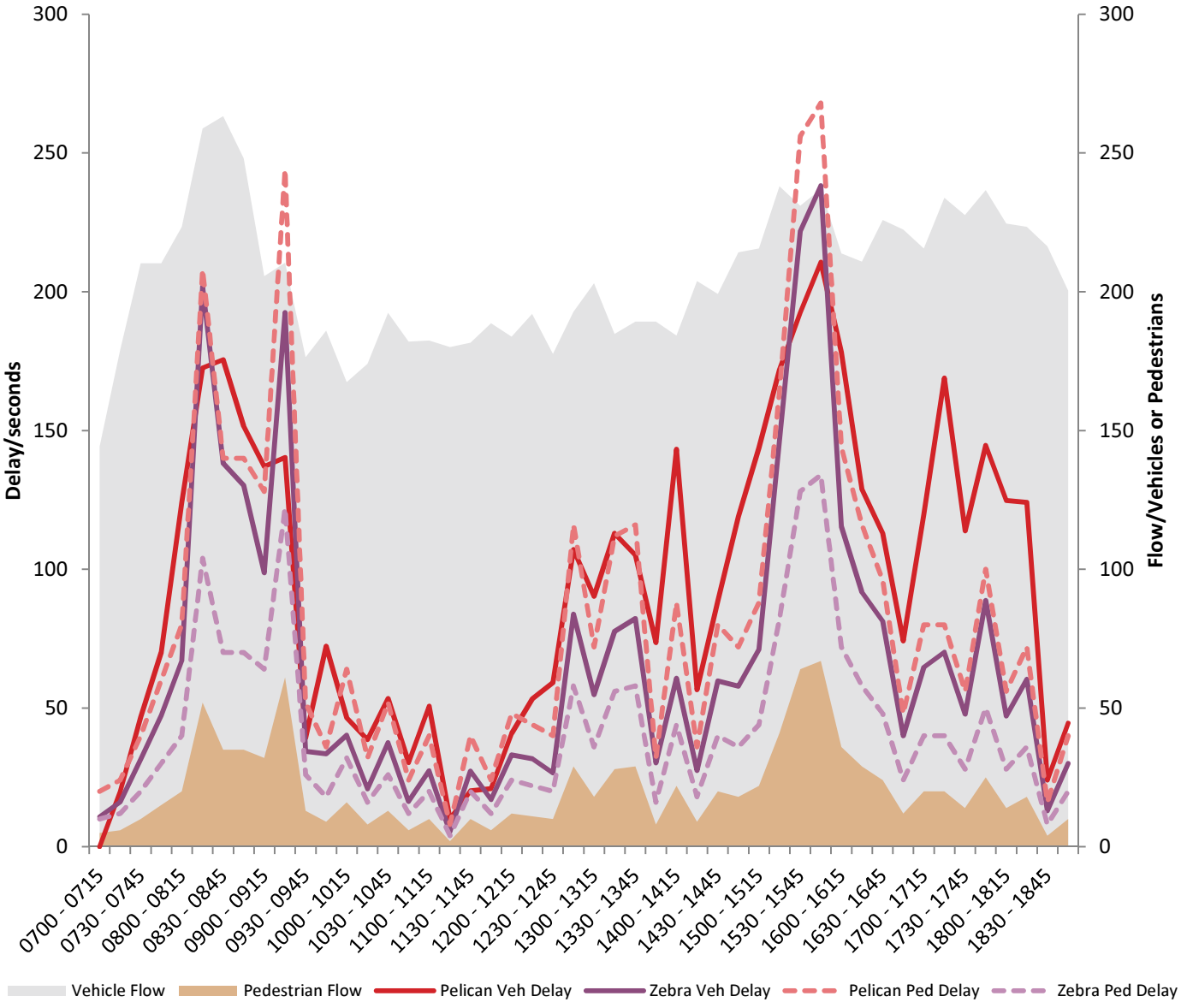


Figure 15. Pedestrian and Vehicle Delays and Flows, South Crossing



Pedestrian and Vehicle Delay Summary - North Crossing

5.2.16 The analysis shows that in terms of both vehicle and pedestrian delay that over the course of the whole day less delay will be experienced if a Zebra crossing is in place rather than a signalised crossing.

5.2.17 However during the two peaks, a Zebra crossing will cause a greater level of vehicle delay than a signalised crossing. Conversely though, pedestrians will benefit most from a Zebra crossing in terms of reduced delay at this point since when a signalised crossing is being constantly called there is a limit to how short a red light phase can be, but a Zebra crossing permits an almost continuous flow of pedestrians.

5.2.18 Outside of the peaks a Zebra crossing would cause less delay for both pedestrians and vehicles at almost all points.

5.2.19 In terms of delay this would suggest that a Zebra crossing would be the better option rather than a signalised crossing at this location. However by assuming that vehicles will always be spread at even intervals and that pedestrians will simply cause delay evenly spread across any given time frame does not take into account the nuances of behaviour at the crossing. In the peak periods where the pedestrian flow averages at level of a pedestrian crossing the road more often than every six seconds, there is a risk that a continuous flow will cause a lengthy delay to vehicles which are unable to progress due to pedestrians being on the Zebra crossing.

Pedestrian and Vehicle Delay Summary - South Crossing

5.2.20 The analysis shows that in terms of both vehicle and pedestrian delay that over the course of the whole day less delay will be experienced if a Zebra crossing is in place rather than a signalised crossing.

5.2.21 Pedestrians will benefit from a reduced delay across the course of the day, and there are only brief periods during each peak where the frequency of pedestrians crossing will mean delays caused by a Zebra crossing would exceed those caused by a signalised crossing.

5.2.22 The frequency with which the existing crossing is called by pedestrians outside of the peak, but only a single pedestrian crosses the road means the delay caused to vehicles is higher than might be expected across the course of the day for a signalised crossing. It is during these periods that a Zebra crossing would be particularly beneficial in terms of delay.

5.2.23 During the morning peak there are lengthy time periods where the queue from the Old Shoreham Road junction to the south backs up through the existing crossing. Given the slow moving nature of traffic during these periods a Zebra crossing is likely to work well and the suggested increased delay to vehicles caused by a Zebra crossing is of less importance given there is limited opportunity to progress once beyond the crossing.

5.2.24 Therefore this would suggest that in terms of delay a Zebra crossing would be more efficient for all road users at this site as opposed to a signalised crossing.

Cyclist Delay

5.2.25 Cyclists will always benefit in terms of a shorter delay in encountering a Zebra crossing rather than a signalised crossing. A Zebra crossing gives cyclists more potential to alter their speed on approach to let pedestrians cross but not have to stop themselves, whilst not causing any conflict with crossing pedestrians.

5.3 Demand for Facilitating Cycle Crossing Movements

5.3.1 The crossing data reveals that the number of cyclists using the existing crossings, either by riding across or pushing a bike is low. A total of 15 cyclists were recorded using the southern crossing on the weekday, and less at the weekend and the northern crossing. This does not suggest a significant demand for a Toucan crossing. Furthermore converting the southern crossing to a Toucan crossing would not hugely benefit cyclists turning right in or out of Port Hall Road as they would still have to dismount to traverse the northern footway with the current proposal if they wished to use the pedestrian crossing rather than cross the opposing traffic flow. Therefore it would seem that the existing Pelican crossing is the most suitable type of signalised crossing for the two locations. In the absence of a Toucan crossing, given the need to dismount to use a Pelican crossing, a Zebra crossing would be preferable for cyclists crossing given the shorter delay.

5.4 Requirement for Raised Crossings

5.4.1 Raised crossings provide a benefit by clearly defining an area that vehicles should not assume precedence due to the likely presence of pedestrians. They aid in calming traffic speeds and encouraging drivers to give way to pedestrians. Raised crossings would be beneficial at both locations were they to be converted to Zebra crossings given this impact on driver behaviour and they would help alleviate any concerns about vehicle speed in relation to the operation of the Zebra crossings, although this has not been proved to be a significant issue.

5.4.2 The benefit of a raised crossing may be less if combined with a signalised crossing since the traffic signals assert the precedence of pedestrians.. Howevera raised crossing at the southern crossing would also encompass a raised junction table and this would serve the dual purpose of calming traffic in proximity to the junction and indicating that this was the start of this character area of Dyke Road in which the park and primary school mean an increased pedestrian presence. Any improvement in driver behaviour as a result of a raised crossing at the southern crossing will also benefit cyclists turning in and out of Port Hall Road, further reducing the justification for a Toucan crossing at this location. Raising the northern crossing would be of benefit mainly for the purpose of consistency, whilst still providing some of the traffic calming benefits described above.

5.5 Road Safety

5.5.1 'LTN 1/95: The Assessment of Pedestrian Crossings' suggests that "*Zebra crossings should not be installed on roads with an 85 percentile speed of 35mph or above".* 85th percentile speeds are less than 30mph throughout the week and peak at 30.9mph on Sunday. For the majority of the daytime they are comfortably less than 30mph. From this evidence of vehicle speeds a Zebra crossing should not be considered unsafe for Dyke Road.

5.5.2 The same note states that "*there is little difference in the average rate of personal injury accidents at Zebra and signal-controlled types*". This would suggest that neither a Zebra nor signalised crossing should necessarily be considered the safer type of crossing. Emerging analysis performed by BHCC across the city suggests no major difference in safety when considering the number of accidents that occur at either signalised or Zebra crossings, with a slightly lower accident rate at Zebra crossings. Location specific characteristics will play a more important role in the safety of any given crossing.

5.5.3 Some of the key factors that influence safety and perception of safety at a signalised crossing are:

- Defined 'safe to cross' period for pedestrians;
- Signals remove need for pedestrians to assert precedence, which may be especially beneficial for elderly, disabled or children;
- Traffic signals provide clear warning to stop for vehicles that is visible from distance;
- Reduced responsibility for vehicles may lead to drivers approaching with greater speed or less care than at a Zebra crossing; and
- Delay in waiting for green man phase may cause impatient pedestrians to cross through flow of traffic.

5.5.4 Some of the key factors that influence safety and the perception of safety at a Zebra crossings are:

- Road markings and beacons makes presence of crossing clear;
- Pedestrian priority clearly established;
- Vehicles likely to take greater care on approach due to uncertainty of likelihood of pedestrians crossing;
- No defined 'safe to cross' period can lead to hesitancy or feeling of vulnerability for pedestrians; and
- In fast traffic with limited gaps between vehicles it can be difficult for pedestrians to assert precedence.

5.5.5 Pedestrians require a sufficient gap in traffic to assert precedence at a Zebra crossing. This will not occur if traffic volumes or speeds are too high. Given that traffic speeds on Dyke Road are generally low, and as traffic flows increase average speeds drop, pedestrians will are likely to be able to assert precedence safely at all times if a Zebra crossing were installed.

5.5.6 The high numbers of children using both crossings, the northern one in particular, puts some weight on the benefit of a signalised crossing due to the defined 'safe to cross' period that is easily understood. It may be the case that children find it harder to assert to precedence in crossing due to their lack of height making them less visible to vehicles, although there no clear evidence to back up this assertion.

5.5.7 The limited numbers of pedestrians crossing outside the crossing or during the red man phase suggests that the impatience of pedestrians crossing on the current crossing arrangement is not a huge issue.

5.5.8 Visibility at the northern crossing is good due to a break in the trees at this point, however pedestrians do congregate outside Windlesham School entrance at school opening and closing times. This may slightly reduce driver visibility of pedestrians, but given the school is slightly to the south of the crossing and the obstruction is to northbound traffic, pedestrians should become visible as or before they step into the road, giving northbound traffic plenty of time to react. There is a potential issue at the southern crossing due to the tree located on the eastern footway immediately to the north of the crossing may limit the visibility of approaching pedestrians on this side to southbound vehicles. This may be more a concern at a Zebra crossing, but the distance of the tree from the crossing means that pedestrians waiting to cross will be visible to oncoming vehicles in sufficient time to react before reaching the crossing. The proposed cycle lane moving traffic a minimum of 1.5m from the kerb will also enhance driver visibility of pedestrians.

5.5.9 Both crossings in their current state seem to be well observed by vehicle users and the record of vehicles not obeying the signals does not give an strong argument either way for which type of crossing would be more suitable.

5.5.10 Accident data shows that there has been one slight collision in the vicinity of each crossing in the last three year. This does not suggest a significant safety concern at either location.

5.5.11 Overall there are no over-riding safety reasons to determine whether a Zebra or signalised crossing would be more suitable for each location. Although there are slight concerns regarding visibility at each crossing, there is no strong evidence that this is sufficient to rule out either Zebra or signalised crossings.

Conclusions:

Both pedestrians and vehicles will experience less delays overall if both signalised crossing were replaced with Zebra crossings. There would be brief peak periods where vehicle delays would be increased by Zebra crossings.

There is little justification for facilitating cycle crossing at either location with signals.

There would be some benefit to raising both crossings, this benefit would be greater at the southern crossing.

There is no definitive safety argument in favour of either a Zebra or signalised crossing at each location, both crossing types would be sufficiently safe.

6. GUARDRAILING NECESSITY

6.1.1 This section considers whether there is a need for the guardrailing currently in place at the two crossings or whether it could be safely removed.

6.1.2 The key knowledge required in this discussion is:

- Whether pedestrians are crossing directly on the existing crossings or to either side;
- The origins and destinations of pedestrians using the crossings;
- Secondary research on the impact of guardrailing; and
- An understanding of the character of the area.

6.2 Background

6.2.1 'LTN 2/09: Pedestrian Guardrailng' suggests that guardrailing's primary purpose is to prevent pedestrians crossing at points that are considered unsafe. This would appear to be the motivation behind the guardrailing at both crossings on Dyke Road. At the northern crossing the guardrailing corresponds with the Windlesham School entrance and a presumed fear of children rushing straight from the school into the road. At the southern crossing the danger is related to the proximity of the crossing to the junction with Port Hall Road.

6.2.2 In both cases the guardrailing is unsightly and out of keeping with the attractive character, created by the tree lined footways and Dyke Road Park, of this section of Dyke Road. Furthermore it reduces the feeling of comfort for cyclists, as they are constrained between the guardrailing and flowing traffic. This means the existence of the guardrailing does not sit well with the proposed introduction of cycle lanes.

6.3 Analysis of Existing Guardrailing

Northern Crossing

6.3.1 The specific advantages of the guardrailing on the northern crossing are:

- Prevents children from Windlesham School going straight from the school entrance into the road;
- Ensures that parents congregating outside the school entrance do not spill over into the road; and
- Discourages pedestrians attempting to cross late in the green man phase, not within the crossing studs who may therefore be less visible to vehicles.

6.3.2 The specific disadvantages of the guardrailing on the northern crossing are:

- It reduces the effective width of the footway, a problem which is exacerbated by parents congregating outside the primary school entrance;
- Pedestrians attempting to avoid the congestion outside the school may walk round the outside of the guardrailing trapping themselves between the guardrailing and the traffic;
- Even where there is only a very small section of guardrailing to the north of the crossing, only 6% of pedestrians crossed in this area over the course of the weekday suggesting that pedestrians generally obey the crossing area whether guardrailing exists or not; and
- Guardrailing potentially obscures drivers' sight of pedestrians, particularly children, which is especially relevant given the location of the school.

6.3.3 There is no clear need for the short section of guardrailing to the north of the crossing and this could safely be removed. Given the short nature of the section of guardrailing in front of the school it does not seem essential, whether the crossing is Zebra or signalised. This is based upon the various disadvantages listed above and the fact that most crossing takes places within the crossing studs. The argument would be stronger for removing it in conjunction with a Zebra crossing since the visibility of pedestrians to vehicles is more important and a Zebra crossing is less likely to encourage pedestrians to rush into the road given they will experience minimal delay using the crossing.

Southern Crossing

6.3.4 The lengthier section of guardrailing at the southern crossing means that no pedestrian crossing was recorded immediately south of the crossing at any point. However pedestrians do cross south of the guardrailing, which suggests that the guardrailing is effective in preventing pedestrians following their direct desire line at this point.

6.3.5 The advantages of the guardrailing at the southern crossing are limited to preventing pedestrians crossing to the south of the crossing, where the potential for conflict with traffic is greater due to the junction with Port Hall Road.

6.3.6 Some disadvantages of the guardrailing are:

- To the north of the crossing there is no guardrailing, yet less than 3% of pedestrians crossed the road at this point, suggesting that even in the absence of guardrailing pedestrians will mostly choose to cross within the studs;
- The guardrailing reduces the effective width of footway, from its maximum width of 3m and in combination with the fencing that borders the inside of the footway may mean pedestrians feel enclosed between the two sides.
- Cyclists are trapped between the guardrailing and traffic, a feeling which may be enhanced if they choose to remain within the new cycle lane.

6.3.7 Given the vast majority of the guardrailing coincides with the entrance to Port Hall Road for much of its length pedestrians will be unlikely to cross in any case since they will not start or finish crossing in Port Hall Road itself. For pedestrians going to or from the northern footway of Port Hall Road wishing to cross Dyke Road, the crossing offers a small enough deviation from their desire line that they are likely to continue to use it irrespective of guardrailing. For pedestrians going to or from the southern footway of Port Hall Road the guardraillling does not at present deflect them far from their desire line, therefore it is probably having little impact on their crossing; if they wish to do so without using the formal crossing they will continue to do so and if they use the crossing they will continue to do so whether the guardrailing is there or not.

6.3.8 The combination of these factors suggests that the guardrailing is not offering significant benefits and could therefore be removed. The argument for this is particularly strong were the crossing to be converted to a Zebra crossing given pedestrians maybe more likely to deviate off their desire line to use a Zebra crossing given that there will be little or no delay before they can cross the road.

Conclusion: It would be beneficial to remove all of the guardrailing at both crossings.

7. SUMMARY AND CONCLUSIONS

7.1.1 Based on our analysis of the data our conclusions for crossing provision on this section of Dyke Road would be that:

- **Need for Crossing**
  - Current demand provides justification for two crossings within the study area;
- **Crossing Location**
  - The current crossing locations cannot be improved upon as they suit existing pedestrian desire lines and fit with local trip attractors;
- **Crossing Type**

Delay

- Pedestrians, vehicles and pedal cyclists would all benefit overall in terms of reduced delays if the two Pelican crossings were replaced with Zebra crossings;
- There would be a concern about the delay caused to traffic during the peak periods at the northern crossing if this were converted to a Zebra crossing, however the period for which this is a concern is very limited, coinciding only with school opening and closing periods;

Safety

- Given the traffic speed and flows on Dyke Road, both Zebra and Pelican crossings could be considered safe options and there is no overwhelming evidence that one type of crossing is safer than another;
- There are limited concerns about visibility that are more likely to affect a Zebra crossing, but these are not significant enough to rule one out at either location;

Provision for Cyclists

- There is not sufficient evidence of a cyclist desire line to suggest the introduction of a Toucan crossing at either location;

Raised crossings

- Would be particularly beneficial for the operation of Zebra crossings as well as contributing to the character of the road, the benefit for signalised

crossings would be less, but given that at the southern crossing any raised crossing could extend to a junction treatment of Port Hall Road, would still be beneficial;

- **Need for Guardrailing**
  - The guardrailing is unsightly, reduces the effective footway width, and provides limited safety benefit as it could be expected that the majority of pedestrians will continue to cross directly on the formal crossing, therefore it could be removed at all sites.

8. RECOMMENDATIONS

8.1 Preferred Option

8.1.1 Based on the conclusions drawn above the preferred option for pedestrian crossings on Dyke Road would be:

- The location of both crossings to be kept the same;
- Both Pelican crossings to be replaced with Zebra crossings;
- The Zebra crossings to be raised at both sites; and
- All guardrailing to be removed.

8.1.2 This option would offer an overall improvement in the level of delay experienced by traffic and especially pedestrians at both sites. Zebra crossings with no guardrailing would be more in keeping with the overall character of the area and the raised tables would help calm traffic as well as alerting drivers to the character of this section of Dyke Road. The possible disadvantages would be increased vehicle delay when pedestrian flows are highest and a perception that a Zebra crossing is less safe, given its lack of defined 'safe to cross' period that maybe of concern to Windlesham School in particular.

8.2 Secondary Option

8.2.1 A second option for the pedestrian crossings on Dyke Road would be:

- To keep the locations of both crossings the same;
- To replace the southern crossing with a Zebra crossing, but keep the northern crossing as a Pelican crossing;
- To raise both crossings; and
- To remove all guardrailing bar the piece immediately outside the entrance to Windlesham school.

8.2.2 This option would offer some of the improvements of the preferred option, whilst allaying some of the concerns regarding the increased peak time delay to traffic. Keeping one section of guardrailing outside Windlesham School would continue to prevent the fear of children running straight into the road from the school, whilst its short nature means its negative impact is limited. This section of guardrailing could alternatively be located inside the school grounds. However the Pelican crossing would cause greater overall delay than the Zebra crossing, and there would be a mismatch in crossing type over a short distance.

SYSTRA provides advice on transport, to central, regional and local government, agencies, developers, operators and financiers.

A diverse group of results-oriented people, we are part of a strong team of professionals worldwide. Through client business planning, customer research and strategy development we create solutions that work for real people in the real world.

For more information visit www.systra.co.uk

Abu Dhabi
AS Business Centre, First Floor, Suites 201-213,
Al Ain Road, Umm al Nar, P.O. Box 129865,
Abu Dhabi, UAE
T: +971 2 558 3809 F: +971 2 558 9961

Birmingham
Second Floor, 37a Waterloo Street
Birmingham B2 5TJ United Kingdom
T: +44 (0)121 233 7680 F: +44 (0)121 233 7681

Dublin
1st Floor, 12/13 Exchange Place,
Custom House Docks, IFSC, Dublin 1 Ireland
T: +353 (0)1 542 6000 F: +353 (0)1 542 6001

Edinburgh
Prospect House, 5 Thistle Street, Edinburgh EH2 1DF
United Kingdom
T: +44 (0)131 220 6966

Glasgow
Seventh Floor, 78 St Vincent Street
Glasgow G2 5UB United Kingdom
T: +44 (0)141 225 4400

Lille
86 Boulevard Carnot, 59000 Lille, France
T: +33 (0)3 74 07 00 F: +33 (0)1 53 17 36 01

London
Seventh Floor, 15 Old Bailey
London EC4M 7EF United Kingdom
T: +44 (0)20 7529 6500 F: +44 (0)20 3427 6274

Lyon
11, rue de la République, 69001 Lyon, France
T: +33 (0)4 72 10 29 29 F: +33 (0)4 72 10 29 28

Manchester
25th Floor, City Tower, Piccadilly Plaza
Manchester M1 4BT United Kingdom
T: +44 (0)161 236 0282 F: +44 (0)161 236 0095

Marseille
76, rue de la République, 13002 Marseille, France
T: +33 (0)4 91 37 35 15 F: +33 (0)4 91 91 90 14

Newcastle
PO Box 438, Newcastle upon Tyne, NE3 9BT
United Kingdom
T: +44 (0)191 2136157

Paris
72 rue Henry Farman, 75015 Paris, France
T: +33 (0)1 53 17 36 00 F: +33 (0)1 53 17 36 01

Woking
Dukes Court, Duke Street
Woking, Surrey GU21 5BH United Kingdom
T: +44 (0)1483 728051 F: +44 (0)1483 755207

Hong Kong
14th Floor West, Warwick House, TaiKoo Place,
979 King's Road, Island East, Hong Kong
T: +852 2529 7037 F: +852 2527 8490

Shenzhen
Room 905, Excellence Mansion, No.98, No.1 Fuhua Road,
Futian Central Zone, Shenzhen, PRC, Post Code：518048
T：+86 755 3336 1898 F：+86 755 3336 2060

Shenzhen - Beijing Branch Office
Room 1503, Block C, He Qiao Mansion, No. 8 Guanghua Road,
Chaoyang District, Beijing, PRC, Post Code：100026
T：+86 10 8557 0116 F：+86 10 8557 0126

Beijing Joint Venture
Room 1507, Main Building, No. 60, Nan Li Shi Road,
Xi Cheng District, Beijing, PRC, Post Code：100045
T：+86 10 8807 3718 F：+86 10 6804 3744

Mumbai
Antriksh, Unit no. 301, 3rd Floor, CTS Nos.
773, 773/1 to 7, Makwana Road, Marol, Andheri East ,
Mumbai 400069
T: +91 22 2647 3134
B 307, Great Eastern Summit Sector - 15, CBD Belapur Navi
Mumbai - 400 614
T: +91 22 2757 2745

New Delhi
5th Floor Guru Angad Bhawan, 71 Nehru Place, New Delhi
110019
T: +91 11 2641 3310

Noida
3/F, C-131, Sector 2, Noida-201301, U.P.
T: +91 120 432 6999

Singapore
25 Seah Street #04-01 Singapore 188381
T：+65 6227 3252 F：+65 6423 0178

Thailand
37th Floor, Unit F, Payatai Plaza Building,128/404-405 Payathai
Road, Rajthewee, Bangkok 10400, Thailand
T：+662 216 6652 F：+662 216 6651

Vietnam
5/F Perfect Building, Le Thi Hong Gam St, District 1,
Ho Chi Minh City, Vietnam
T：+84 8 3821 7183 F：+84 8 3821 6967

SYSTRA