Appendix A6.1
Dart+ Coastal North Level Crossing Assessment

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Abbreviations

Abbreviation	Definition
AADT	Annual Average Daily Traffic. The total two-way traffic volume passing a point or segment of a road for one full calendar year, divided by the number of days in a year (365).
CCTV	Closed-circuit television
DART	Dublin Area Rapid Transport
EMU	Electric multiple units
IÉ	Iarnród Éireann
MCA	Multi-Criteria Analysis
MMQ	Mean maximum queue
OSI	Ordnance Survey Ireland
PCU	Passenger Car Units
TPH	Trains per hour
TPHPD	Trains per hour per direction
TSS	Train service specification
WTT	Working timetable

1. INTRODUCTION

This report details the assessment undertaken to identify any potential impacts to the existing level crossings on the Howth Branch line due to alterations to service frequency associated with DART+ Coastal North.

The report contains:

- An explanation of the impacts of the Train Service Specification to services on the Howth Branch;
- The inputs, methodology and results for barrier opening times from a train operations perspective;
- Assessment of impacts of changed barrier opening times on vehicles;
- Assessment of impacts of changed barrier opening times on pedestrians and cyclists; and
- Conclusion of the overall impact of changes to services on the Howth Branch line.

2. EXISTING SITUATION

2.1 Train operations

IÉ currently operates trains on the Howth Branch as an extension of DART services from Bray or Greystones, integrated with trains going to Malahide. Howth and Malahide-bound services split at Howth Junction & Donaghmede Station, where Howth trains operate a stopping service at Sutton, Bayside, and Howth. Services average around 3 trains per hour (TPH) per direction, though on occasion IÉ schedules up to 4 TPH per direction during peak periods. Due to the interlinked nature of Howth services, they are vulnerable to delays from other parts of the network.

2.2 Level crossings

The Howth Branch line has four level crossings:

- Baldoyle Road Level Crossing (XQ001) – hereafter referred to as Kilbarrack to match signal diagrams provided by IÉ, numbered 917 on signal diagrams (11 000 AADT);
- Sutton Level Crossing (XQ002) – numbered 916 on signal diagrams (12 700 AADT);
- Cosh Level Crossing (XQ003) – number 915 on signal diagrams (650 AADT); and
- Claremont Level Crossing (XQ004) – numbered 913 on signal diagrams (160 AADT).

Kilbarrack Crossing (917) carries R809/Baldoyle Road over the Howth Branch line, which is a critical corridor for road traffic. Sutton Crossing (916) is adjacent to Sutton Station and carries the heavily used R106/Station Road, a principal means of access for the Howth peninsula. Cosh Crossing (915) carries Lauder's Lane over the railway line, connecting one side of the Sutton Golf Club to the other. Claremont Crossing (913) allows for access to a small residential development on a private road and provides exclusive access to the area for motor vehicles. An informal path leads off to the west - connecting to Claremont Road and an overbridge over the railway to Howth Road - but is unusable other than for foot and cycle traffic. An overview of the level crossing locations on the Howth Branch line is provided in Figure 2-1. Aerial views of the individual crossings are provided in the subsequent figures.

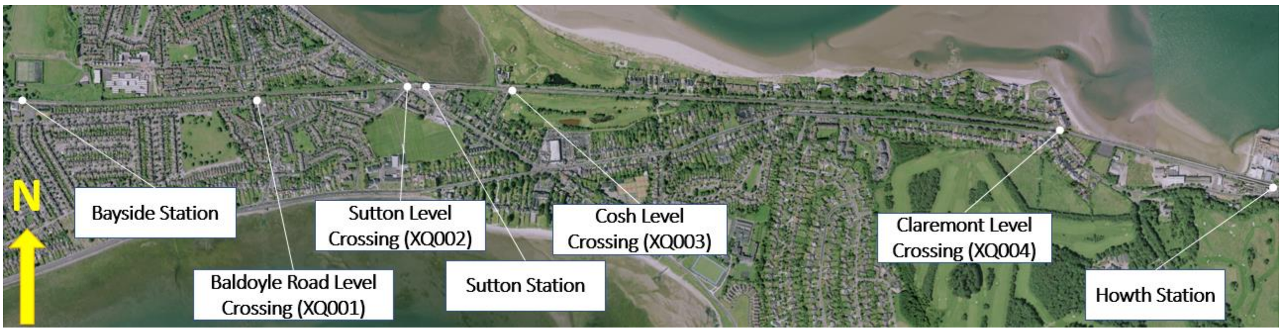

Figure 2-1 Overview of level crossing locations on the Howth Branch line (Source: OSI aerial imagery)

Figure 2-2 Baldoyle Road Level Crossing (XQ001, 917) (Kilbarrack) plan view (Source: OSI aerial mapping)

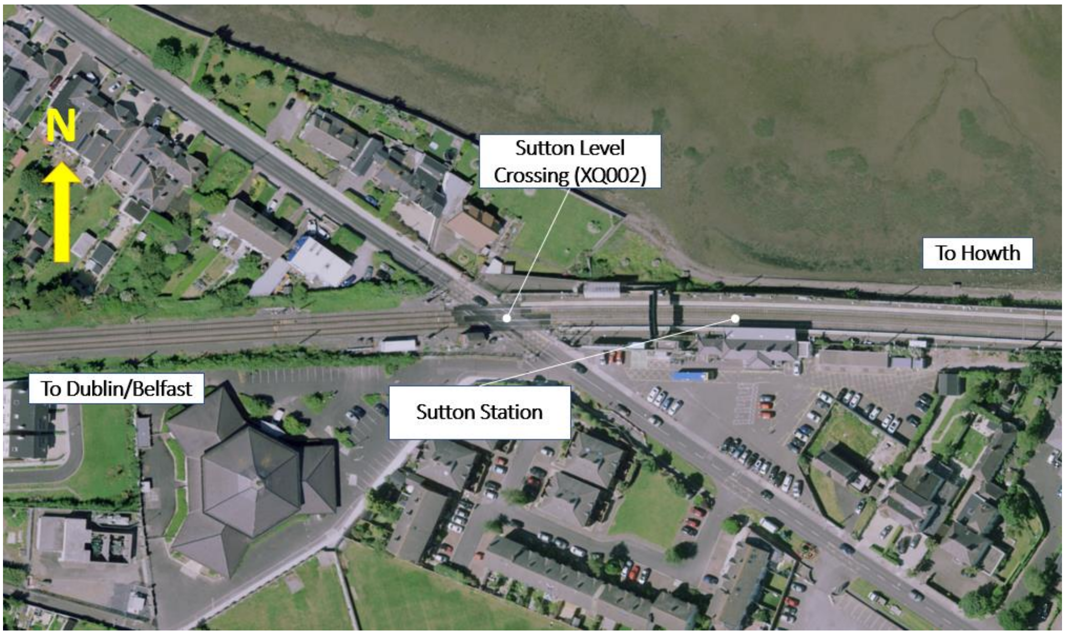

Figure 2-3 Sutton Level Crossing (XQ002, 916) plan view (Source: OSI aerial mapping)

Figure 2-4 Cosh Level Crossing (XQ003, 915) plan view (Source: OSI aerial mapping)

Figure 2-5 Claremont Level Crossing (XQ004, 913) plan view (Source: OSI aerial mapping)

Level crossing initiation must comply with the Commission for Railway Regulation guidelines which are set out to safeguard road users. During normal operations the level crossings operate as part of the signalling system and are automatically lowered when a train passes a trigger point (referred to as a ‘strike in point’). The Howth Branch level crossings can be operated under other procedures; however, IÉ has stated these are infrequent occurrences.

Sutton crossing (916) is unique in that, according to IÉ, it has a 10-15 second delay between the time a train passes its strike in point in the Howth direction and the level crossing barriers beginning to close.

This is to improve the operational efficiency of Sutton crossing (which is triggered at the same time as Kilbarrack due to their proximity), thereby limiting extraneous downtime while still maintaining a safe and compliant warning period. No other crossing on the Howth Branch line has a similar variation in operation.

The level crossing boom gates begin to rise immediately after a train clears sensors adjacent to the level crossing. If a train in the opposing direction is scheduled to pass the level crossing such that the barriers will not be fully up for at least 9 seconds, the level crossing will stay closed until that train passes and clears the crossing as well.

All crossings are equipped with full four-quadrant boom gates, completely cutting off access to the railway when closed. All crossings are remotely observed with CCTV to ensure that the crossing is clear of traffic when the boom gates are closed. Spotlights are co-mounted with the cameras to allow all day operation.

3. RAIL SYSTEM OPTIMISATION

3.1 Train Service Specification

As part of the DART+ Coastal North project, IÉ intends to increase the number of services on the Howth Branch while also improving reliability by separating operations from the rest of the DART network. This forms part of the Train Service Specification (TSS), which is the 'desired' number of train services on each branch of the DART network (i.e. trains per hour per direction [TPHPD]). This report adopts version TSS1C of the TSS.

The proposed track modifications will enable the operation of both a DART shuttle service and/or a direct through service (as existing) on the Howth Branch to/from Dublin City Centre. Whilst final operational decisions will be made subject to demand requirements and assessment, TSS 1C assumes all Howth trains will operate as a shuttle service between Howth and Howth Junction & Donaghmede stations allowing for the capacity and frequency of DART+ services on both the Northern Line and Howth Branch to be maximised. Services in TSS 1C are assumed to change from being 3-4TPH per direction and dictated by scheduling needs in other parts of the network to being a regular service of 6 full-length trains per hour per direction, (i.e. trains departing every 10 minutes).

These changes represent a substantial increase in capacity, both in frequency and size of individual services. Additionally, as a shuttle service, Howth Branch trains will be almost fully insulated from delays on other parts of the DART and IÉ network.

Changes to the service and operating condition of the line create the need to assess any impact on the barrier opening times and its associated effects on vehicles, pedestrians and cyclists.

The proposed services as part of DART+ Coastal North are shown in Figure 3-1. Of note is the regularity and shuttle nature of the Howth Branch services which forms the basis of the assessment as described in this report. In addition, different service patterns are modelled to evaluate how differently the level crossings will behave if services are more, or less, synchronized.

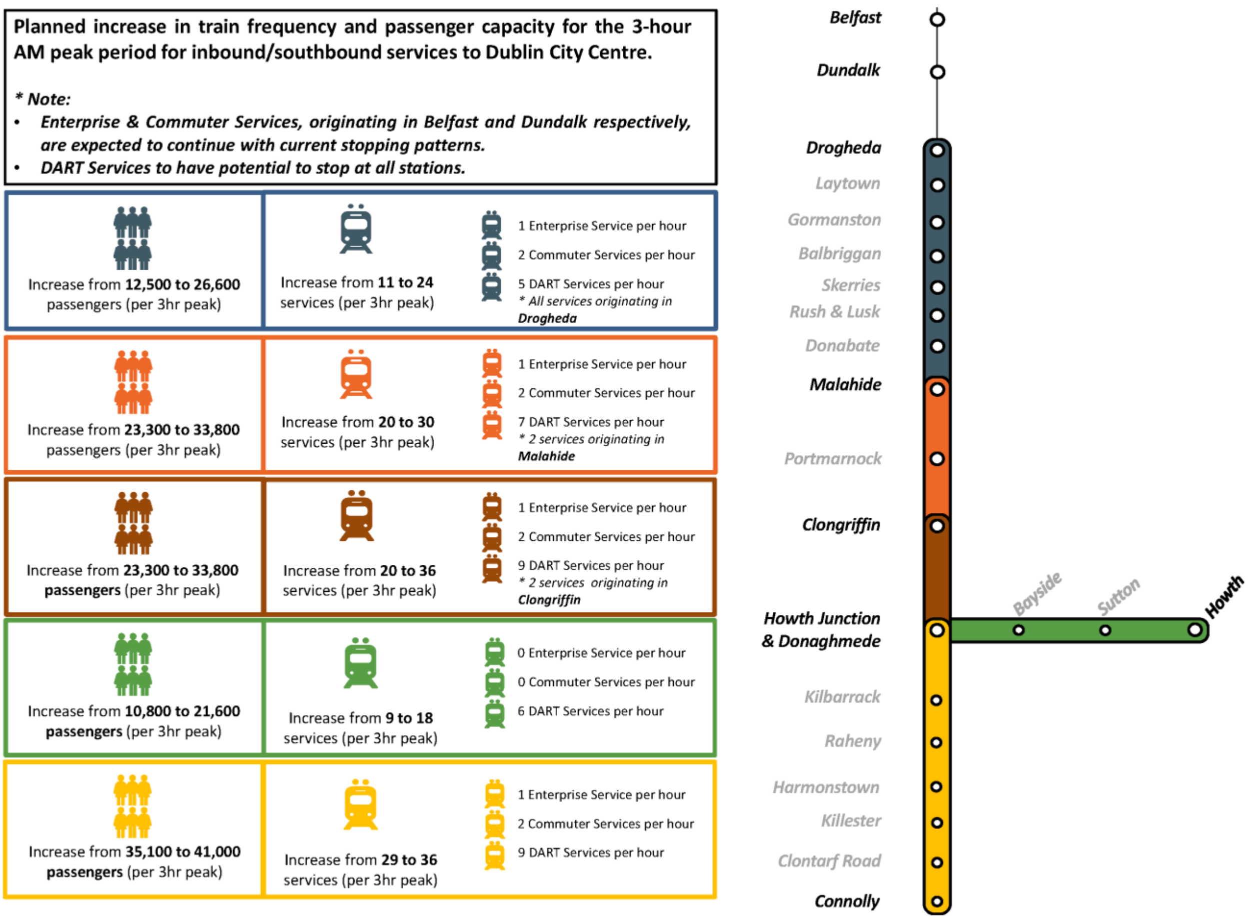

Figure 3-1 DART+ Coastal Services

3.2 Modelling Parameters

Following discussions with IÉ with respect to the signal operations and an analysis of level crossing closure times based on control centre data collected between January 12-14, and May 1-9, 2022, it emerged that there are currently significant variations in the duration of the level crossing closure times. These are mostly due to the following three reasons:

- The timetable structure
- Operational variance caused by train delays and different driver behaviours
- Human interference in the signalling system by the signaller

To create a common baseline for comparison, Arup developed four Howth Branch line timetable variants in the RailSys software. The modelled closure times are based on the average value between the 5th and 95th percentile of all observed closure times and are centred around the time when the trains pass each level crossing. The level crossing closure data was calculated based on control centre data received from IÉ. An illustration of the calculation method can be seen in Figure 3-2 below.

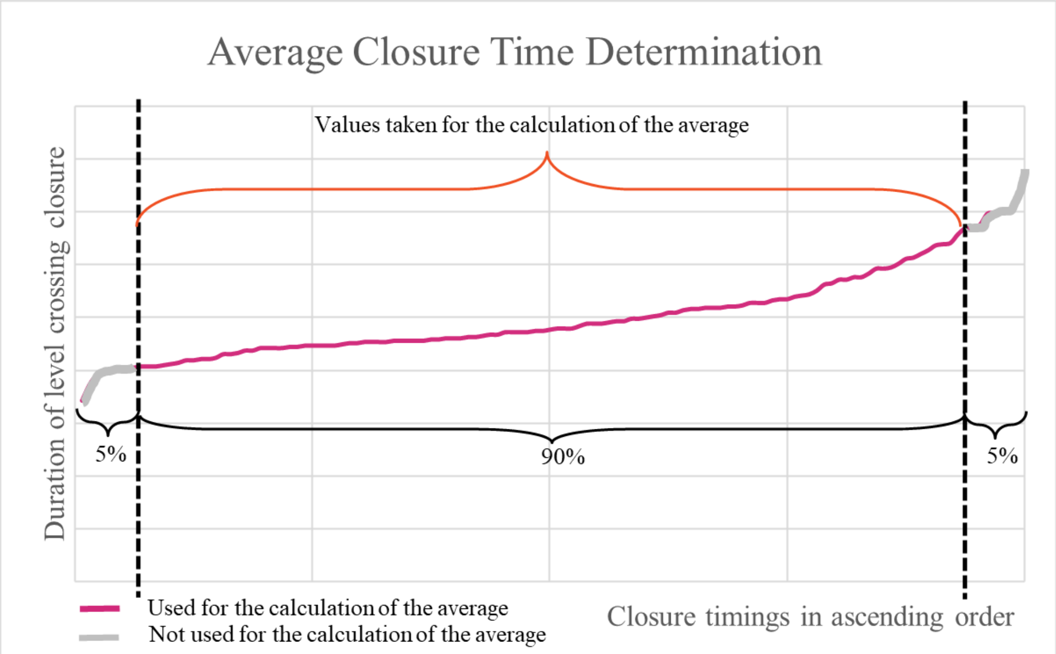

Figure 3-2 Example for the calculation of the average closure time

Arup, in agreement with IÉ, chose to exclusively model level crossing operations in their normally operated method, not including modelling non-standard scenarios such as non-stop trains or during perturbed operations. As such, trains in the current timetable are assumed to be DART EMU (Electric Multiple Unit) trainsets, and trains in the future scenario timetables are assumed to be XTRAPOLIS rolling stock as per agreement with IÉ. Due to the changes in rolling stock characteristic for the XTRAPOLIS rolling stock, a total journey time of 9 minutes has been assumed in both directions between Howth and Howth Junction, including a stop with 30 seconds dwell time at Bayside and Sutton for all services.

The modelling assumes that all level crossings are automatic and require safe closure before the signals can be set for the approaching train. Between barrier closures, the road will need to be open for a minimum of 20 seconds, otherwise the barriers will remain down, and the crossing closed. The crossing is assumed to begin to open once the train passes a clearance point, assumed to be 10m from the level crossing, and the barriers are assumed to take 8 seconds to open.

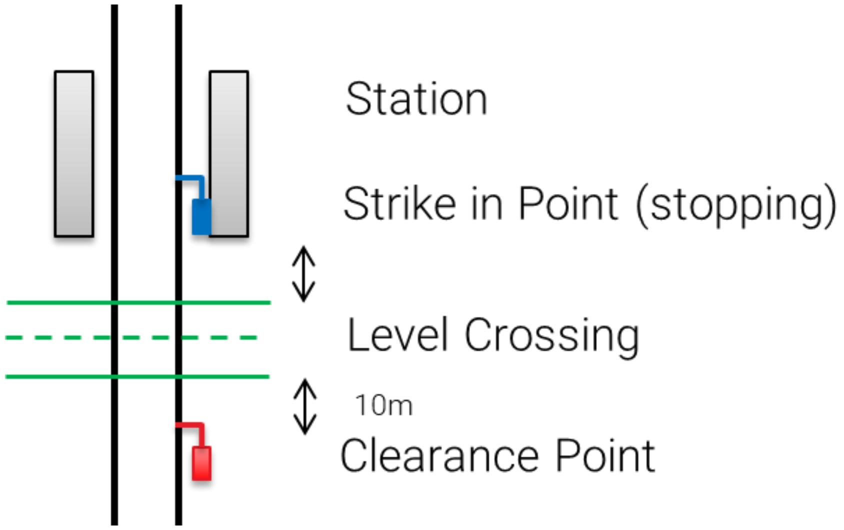

Figure 3-3 Example schematic for strike in and clearance points

Modelling has been undertaken with three objectives:

- To calibrate and validate the closure behaviour of the existing 3TPH Working Timetable, to use as a baseline assumption for future scenarios
- To examine the impact of an increase in train frequency for 4, 5 and 6 TPH
- To examine the sensitivity of level crossing closure times dependent on the timetable structure and/or performance of the 6 TPH TSS1C timetable

Modelling covers the following 14 service variations per direction:

- 3 TPH (Reflects Working Timetable – i.e. the baseline scenario);
- 4 TPH (regular intervals);
- 5 TPH (regular intervals);
- 6 TPH (regular intervals, reflects TSS 1C);
- 6 TPH with 1-minute offset;
- 6TPH with 2-minute offset;
- 6TPH with 3-minute offset;
- 6TPH with 4-minute offset;
- 6TPH with 5-minute offset;
- 6TPH with 6-minute offset;
- 6TPH with 7-minute offset;
- 6TPH with 8-minute offset;
- 6TPH with 9-minute offset; and
- 6TPH with 10-minute offset.

All offset scenarios are based on the 6 TPH TSS1C, with all down direction trains offset by a period of time. Since TSS1C is not necessarily the timetable to which trains will operate following implementation of the DART+ Programme, this serves as a sensitivity check to evaluate how differently the level crossings will behave if services are more, or less, synchronized.

Figure 4-1 shows an example for the determination of the "likelihood" of total level crossing closure minutes per hour with varying timetable structure and/or performance. The respective minimum and maximum values of this analysis will be used for the best- and worst-case traffic analysis.

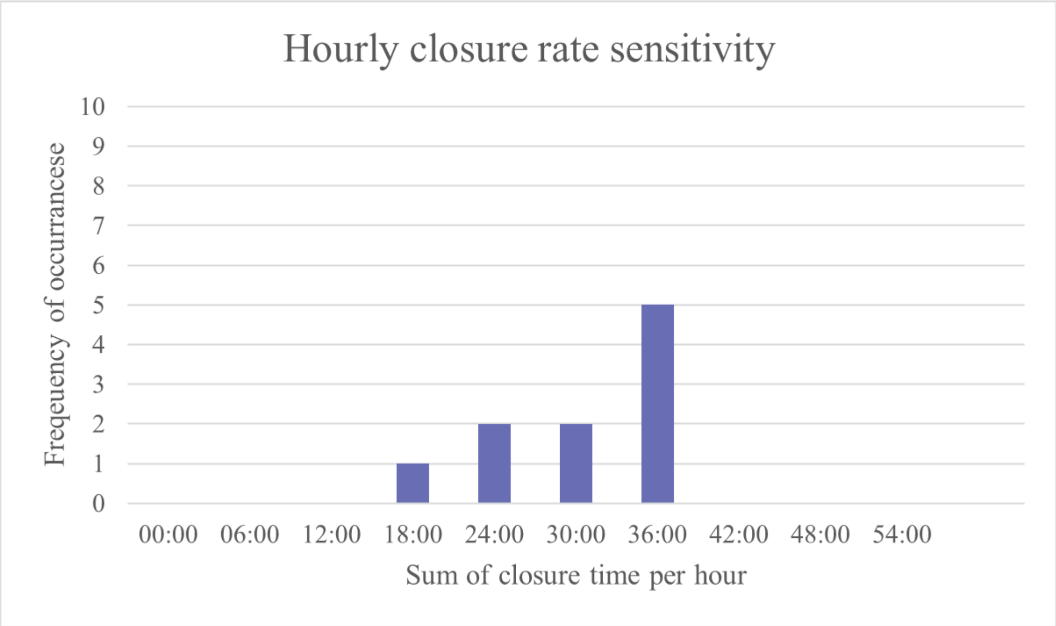

Figure 3-4 Example for the variation of the sum of hourly level crossing closure by frequency

3.3 Barrier Results

Arup modelled the level crossing closure times for the entire Howth Branch line for 14 different service variations. Summary results from the base case, which is the current 3 TPH working timetables, and the 6TPH TSS1C timetable are listed below in Table 3.1. Note that the results represent an average likelihood, not the rare occasion of a major incident or other irregular events.

TSS1C is the main service scenario, assuming trains will leave every 10 minutes, with services departing from Howth Junction & Donaghmede Station and services departing Howth Station separated by ten minutes. This scenario results in barriers being open between 27 minutes out of an hour to 47 minutes out of an hour, depending on the specific crossing.

The level crossing closures are highly sensitive to the exact meeting point of trains in any given scenario; having trains cross simultaneously is the best case, as it allows two trains to pass for one closure. By contrast, the worst scenario would be two trains separated by 20 seconds or less, meaning that the level crossing will be held down for the maximum amount of time.

To test the effect of differing meeting points - stemming from different service patterns - scenarios offsetting the departure time of down trains by 1 to 10 minutes were run. Since the level crossing closure times depend on the relative meeting point between down and up services, it is only necessary to offset trains in one direction. Offsets were continued up to + 10min, at which point a regular 6 TPH per direction service like the Howth Branch line will bring the timetable back to its starting point.

The results in the table below show that opening numbers increase and decrease but are not detrimentally impacted by a changing timetable or timetable performance. Intuitively, the fewer trains being run per hour, the longer the barriers will be open.

Table 3.1 Level Crossing Open Time Results – range of open time and total open time in any given hour for 6 TPH and 10 different timetable structures

	Claremont (913)	Cosh (915)	Sutton (916)	Kilbarrack (917) (Baldoyle Road)
TSS1c	6 - 12 Openings (02:22 to 07:09) Sum: 28:26 to 42:52	6 - 12 Openings (02:26 to 07:00) Sum: 29:13 to 42:02	6 - 12 Openings (02:18 to 07:49) Sum: 27:41 to 46:54	6 - 12 Openings (02:27 to 07:52) Sum: 29:10 to 47:10
3 TPH per direction (WTT)	5 Openings (02:23 to 12:21) Sum: 42:36	3 Openings (01:43 to 17:47) Sum: 46:12	3 Openings (04:39 to 17:07) Sum: 48:39	5 Openings (00:37 to 15:25) Sum: 44:24

To test the impact of an increase in train frequency to 4 and 5 TPHPD, estimates for the average sum of minutes of open time have been calculated for each respective frequency on a clockface pattern. The values presented below are subject to change with a change of departure time. The model results for these can be observed in the table. These have only been modelled to test the sensitivity of increasing train frequencies. Therefore, no transport assessment has been undertaken for these options. Note that in each respective timetable, trains in each direction start on the hour in these instances.

Table 3.2 Level Crossing Open Time Results – range of open time and total open time in any given hour for 4 and 5 TPH – not included in the vehicle impact assessment

	Claremont (913)	Cosh (915)	Sutton (916)	Kilbarrack (917) (Baldoyle Road)
5 TPH per direction	10 Openings Average: 03:22 Sum: 33:40	5 Openings Average: 07:00 Sum: 35:00	5 Openings Average: 09:49 Sum: 49:05	5 Openings Average: 07:10 Sum: 35:50
4 TPH per direction	8 Openings Average: 04:52 Sum: 44:24	4 -Openings Average: 10:00 Sum: 40:00	4 Openings Average: 12:49 Sum: 51:16	4 Openings Average: 10:10 Sum: 40:40

3.4 Traffic Impact

The potential to delay trains to better coordinate with the operation of the crossing, for example to intentionally delay trains so that both directions pass the level crossing at the same time, and that level crossing closures are therefore limited, was investigated through the above sensitivity tests.

In all modelled scenarios there will only be one set of trains per direction passing each other at the same time, and therefore the closure times can only be optimised for one crossing, in most cases to the detriment of the others. To approximate optimisations, we have varied the departure times of the train in 10 different sensitivity scenarios, which should approximate the optimisation sufficiently within practical considerations. The impact of the best-case scenario (6TPH TSS1C) on queueing was investigated (Section 4) and supplemented with sensitivity tests for less optimised scenarios.

4. ASSESSMENT OF PROPOSAL ON VEHICLES ON THE ROAD NETWORK

In this section of the report the effect of the future TSS1C and the associated level crossing operations along the Howth Branch has been investigated, looking specifically at the queueing at level crossings and nearby junctions during barrier closure times. A baseline DART service of 3 trains per hour per direction (3TPHPD), based on the modelled 3TPHPD barrier timings and level crossing closures during the AM peak has been modelled using junction modelling software, LinSig[1]. This has been compared to the proposed worst-case scenario of 6 TPHPD scenario. A sensitivity analysis has also been carried out to understand the reliance of queueing on the road network on train departure times for the 6TPHPD scenario.

4.1 Background Information

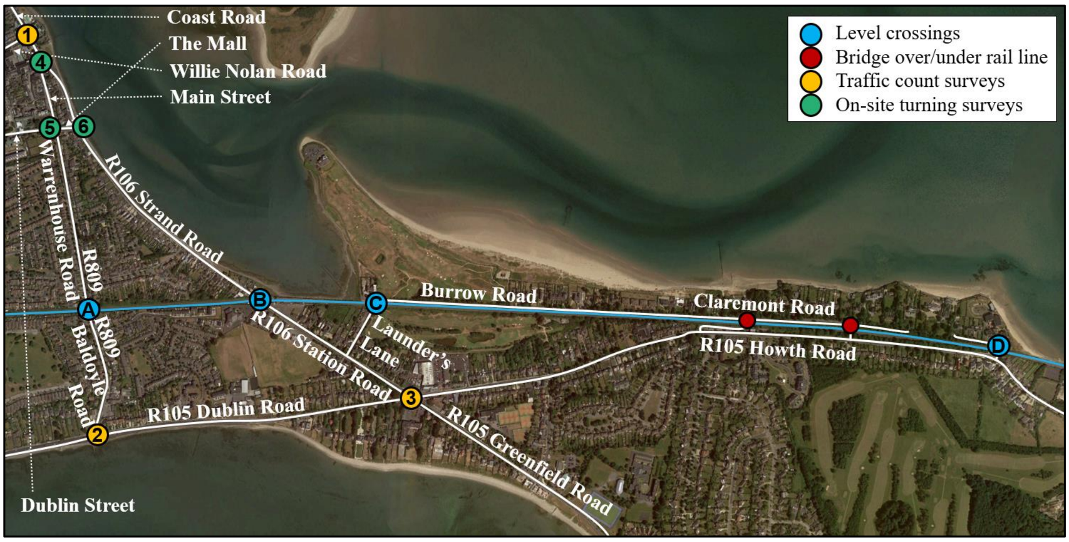

Figure 4-1 Overview of the area of interest along the Howth Branch line

4.1.1 Level Crossings

There are four level crossings situated along the Howth Branch line, shown in blue in Figure 4-1. They are as follows:

A. 917: Kilbarrack Level Crossing (XQ001) (Baldoyle Road) – rail line across the Baldoyle Road/ Warrenhouse Road;
B. 916: Sutton Level Crossing (XQ002) – rail line across Station Road, adjacent to Sutton Station;
C. 915: Cosh Level Crossing (XQ003) – rail line across Lauder's Lane; and
D. 913: Claremont Level Crossing (XQ004) - rail line across a Private Access Road.

[1] LinSig is an industry standard software tool which allows traffic engineers to model traffic signals and their effect on traffic capacities and queuing

The level of traffic passing through each of the level crossings varies.

Kilbarrack (917) and Sutton (916) Level Crossings are the two locations that have the highest volumes of vehicles crossing the rail line and have the greatest potential to cause delays on the wider road network if queues form at the level crossings. As a result, these two crossings have been analysed using modelling software and quantitative methods.

Cosh (915) and Claremont (913) Level Crossings have a much lower level of vehicle traffic crossing them as they are mainly used for local access, and they don't run the risk of causing long queues. As a result, for these crossings, qualitative analysis methods have been applied.

More information on the assessment methodology and rationale is provided in Section 4.2.

4.1.2 Existing Barrier Closure Timings

The Howth Branch currently operates as a through service, with alternating trains from Dublin serving Howth and Malahide. Three to four trains per hour travel in each direction along this line equating to a maximum of eight trains in total, per hour for both directions.

Iarnród Éireann (IE) has provided data on a working timetable (WTT). With this data, a timetable for 3 trains per hour per direction, based on the WTT, was modelled in RailSys. The RailSys model was calibrated using closure data from across the day and validated between the hours of 0730 and 1030. The output of the RailSys model has been used to calculate the closure timings and represents the baseline vehicular impact scenario for comparison purposes. This will be detailed further in Section 4.2.1.

4.1.3 Traffic Data

Traffic data is required to undertake the assessment and understand the impact on vehicles and queueing in the surrounding area. Traffic data surveys were carried out on Thursday 11th May 2023. These included classified vehicle junction turning count surveys over a 14-hour time period between 0600 and 2000 at the junctions within the study area and also at the level crossings within the study area. The data also included queue length surveys and pedestrian count surveys. The AM Peak Hour was determined to occur between 0800 and 0900 and the PM Peak Hour between 1730 and 1830. These are the busiest periods on the road network and the impact of the proposed level crossing closures were therefore assessed for these time periods.

Historical traffic data (2018/2019) was also available at some of the junctions adjacent to the Kilbarrack and Sutton level crossings.

A comparison of the most recent traffic data (2023) and the historic traffic data (2018/2019) has shown that traffic levels have to a large extent returned to pre-Covid levels in the study area. The most recent 2023 traffic count data were considered a suitable data source for the assessment.

Table 4-1 Recent vs Historic Traffic Volumes

Impact of Covid		AM Peak Hour			PM Peak Hour		
		2018/2019	2023	Diff	2018/2019	2023	Diff
Kilbarrack	NB	302	366	121%	439	472	108%
	SB	508	435	86%	342	345	101%
Sutton	NB	360	406	113%	379	401	106%
	SB	436	433	99%	365	358	98%

4.2 Assessment Methodology

4.2.1 Approach

Two methodologies of analysis have been used as part of this assessment. Kilbarrack (917) and Sutton (916) Level Crossings have been analysed through quantitative methods, and Cosh (915) and Claremont (913) Level Crossings have been assessed using qualitative analysis methods. These two level crossings have a much lower volume of traffic crossing them as they are mostly used for local access and therefore usually do not run a high risk of causing queuing that will affect the regional road network (refer to Figure 4-2).

The need for quantitative analysis at Kilbarrack (917) and Sutton (916) Level Crossings is driven by the high volume of vehicles using the crossings and the potential to, during barrier closure times, cause queuing and delays on the regional road network. Queuing could also be impacted at the junctions upstream and downstream from the level crossings.

Even though some localised impact on queuing is expected, it was assumed that there would be no significant impact on trip distribution (i.e. diversion of traffic), mode choice (i.e. reduction of vehicle traffic) or route choice (i.e. large scale switch between Sutton and Kilbarrack) as a result of the changes to level crossing closures. Government policy is to encourage modal shift and a reduction in car dependency, and the DART + Coastal North scheme is one of the instruments whereby this will be achieved. However, in the interest of a reasonable worst case robust assessment on road operations, it was assumed that the same volume of car traffic that currently arrives at the level crossings would continue to arrive in future.

The expected impact as a result of the overall scheme and the proposed DART + increase in service frequency and capacity is assessed in the Environmental Impact Assessment Report (EIAR). The traffic assessment as part of the EIAR will confirm the degree to which car demand at the level crossings might change in future due to changes in trip distribution, mode choice or route choice. Deterministic modelling techniques (through the application of LinSig) are particularly suitable for assessing potential queueing as it allows the optimisation of signal timings and is a quick and easy tool with immediate results and is ideal for optioneering. This technique does not focus on modelling different modes of transport or the wider traffic assignment, which would normally be addressed by microsimulation or tactical / strategic modelling techniques (for example through the application of Vissim or Saturn). Microsimulation or tactical / strategic modelling techniques are time consuming and require large amounts of data.

The NTA's tactical / strategic Regional Modelling System (RMS) will be applied in the detailed EIAR assessment to assess different modes and the wider traffic assignment and the impact on car demand at the level crossings.

The level crossing closure times were simulated in a LinSig network model as signalised junctions which, in effect, represents the barriers being closed. This allowed for an understanding of the mean maximum queue (MMQ) that builds up at both the level crossings and the junctions upstream and downstream of the level crossings.

The following extract from the LinSig software manual further explains the Mean Maximum Queue: "It is the sum of the Maximum Back of Uniform Queue and the Random & Oversaturation Queue. It represents the maximum queue within a typical cycle averaged over all the cycles within the modelled time period. When a Lane is oversaturated the Maximum Queue within each cycle will grow progressively over the modelled time period. This means that the Mean Maximum Queue will be approximately half the final queue at the end of the modelled time period."

If the approaching arms to the level crossing or a junction do not have a degree of saturation exceeding 100%, the MMQ is likely to be reflective of what would happen on the ground. It will be longer 50% of the time and shorter 50% of the time, but it is likely to remain within the available queueing capacity. This is assuming a uniform arrival pattern. Should the arrival pattern change to a more concentrated pattern / platoon it could be that queues will be longer. To mitigate against this risk, we highlighted any issues where queues exceed 75% of the available capacity.

The offset for the signal timings for the junctions upstream and downstream of the level crossings, were set to be optimised in the LinSig simulation in the baseline and proposed scenarios, to allow them to sync up with the opening and closing times of the level crossings, see Figure 4-2.

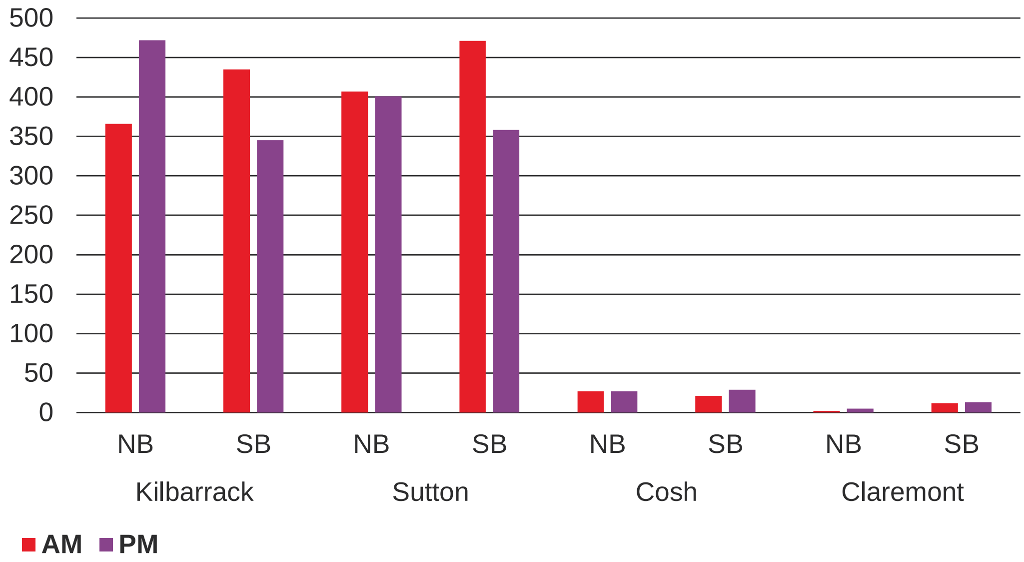

Figure 4-2 Level Crossing Traffic Volumes

4.2.2 Modelled vs Observed Queue Lengths

Queue lengths are generally not used for validation purposes due to the difficulty in measuring them on street, however comparing modelled levels of queuing to those observed on street can indicate where inaccuracies may exist in a model.

Queue length surveys were carried out and were compared to the modelled queue length outputs from the LinSig model, to provide some confidence in the process and to illustrate that the model is a suitable tool for this type of assessment within a known margin of error.

In Table 4.2 the modelled and observed queue lengths as a result of the “observed level crossing signals” are presented. The observed level crossing times were as shown in Table 4.1:

Table 4.1 Observed Level Crossing Closure Times

Baseline 3TPH per direction	Peak Hour	Number of closures per hour	Total baseline closure time per hour	Minimum baseline closure time	Maximum baseline closure time
Kilbarrack (917) Level Crossing	0800-0900	4	00:15:20	00:02:25	00:05:17
	1730-1830	3	00:12:56	00:04:05	00:04:20
Sutton (916) Level Crossing	0800-0900	3	00:14:54	00:04:06	00:05:52
	1730-1830	4	00:16:32	00:02:40	00:05:38

From the observed data, the average queue lengths and the longest queue lengths on the approaches to the level crossings were recorded. It was found that queue lengths, expressed in Passenger Car Units (PCUs) from the model, were slightly overestimated at Sutton Level Crossing southbound. On the other hand, it was found that queue lengths from the model, were slightly underestimated at Kilbarrack Level Crossing southbound during the AM Peak Hour.

Table 4.2 Kilbarrack (917) Modelled Queue Lengths vs Observed Queue Lengths

Queue Lengths (PCUs)	Observed		Modelled MMQ	Comment
AM Peak	Average	Longest		
Kilbarrack (917) Level Crossing SB	42	86	34	Model underestimates queue
Kilbarrack (917) Level Crossing NB	16	58	19	Model within range
Kilbarrack (917) Level Crossing SB	7	24	22	Model within range
Kilbarrack (917) Level Crossing NB	12	58	32	Model within range

Table 4.3 Sutton (916) Modelled Queue Lengths vs Observed Queue Lengths

Queue Lengths (PCUs)	Observed		Modelled	Comment
AM Peak	Average	Longest		
Sutton (916) Level Crossing SB	15	23	38	Model overestimates Queue
Sutton (916) Level Crossing NB	14	39	35	Model within range
Sutton (916) Level Crossing SB	6	23	31	Model overestimates Queue
Sutton (916) Level Crossing NB	9	30	30	Model within range

During the non-statutory consultation, residents and interest groups highlighted that at certain times of the year (such as during hot summer days), higher traffic volumes and excessive queue lengths occur. In order to take this into account, calibration factors were devised to adjust modelled outputs to be representative of the longest observed queue lengths during the survey period. These factors are based on the factor difference between the modelled queue length vs the observed queue length (refer to Table 4.4).

Table 4.4 Calibration Factors

Time Period	Level Crossing and Direction	Average Queue Length Factor	Longest Queue Length Factor
AM Peak	Kilbarrack SB	1.24	2.53
	Kilbarrack NB	1	3.05
PM Peak	Kilbarrack SB	1	1.09
	Kilbarrack NB	1	1.81
AM Peak	Sutton SB	1	1
	Sutton NB	1	1.11
PM Peak	Sutton SB	1	1
	Sutton NB	1	1

4.2.3 Baseline 3TPH Per Direction – Kilbarrack (917) and Sutton (916) Level Crossings

The baseline scenario of 3TPHPD travel has been modelled during the AM peak using the level crossing closure time data for the RailSys model, as shown in Table 4.5.

During the AM peak hour Kilbarrack (917) Level Crossing closes five times per hour and Sutton (916) Level Crossing closes three times per hour with 3 TPHPD passing through each one. Table 4.5 shows the closure times across the full one-hour period.

For the purposes of the analyses an averaged closure time was assessed. Fluctuations in the timetable were addressed as part of a sensitivity analysis in Section 4.6.

Table 4.5 Baseline Level Crossing Closure Times for 3TPH per direction

Baseline 3TPH per direction	Number of closures per hour	Total baseline closure time per hour	Minimum baseline closure time	Maximum baseline closure time	Assessed Timetable
Kilbarrack (917) Level Crossing	5	00:14:31	00:01:41	00:04:35	00:02:54
Sutton (916) Level Crossing	3	00:11:08	00:03:22	00:04:23	00:03:43

4.2.4 Proposed 6TPH Per Direction– Kilbarrack (917) and Sutton (916) Level Crossings

The proposed scheme is described in detail in Section 3. The scenario for six trains per hour per direction (6TPHPD) has been modelled as this represents the largest increase in the number of trains when compared to the Baseline scenario and is therefore the worst-case scenario.

Under the 6TPH TSS1C scenario, the Howth Branch line will run as a shuttle service. Six trains per hour per direction will pass through each of the level crossings, equating to a total of 12 trains passing per hour.

The proposed opening and closure times of the level crossings barriers are calculated based on outputs from the RailSys model, as provided in Section 3. With six trains per hour per direction, this in effect means a train departs each end station every 10 minutes. This is presented in Table 4.6.

Table 4.6 Proposed Level Crossing Closure Times for 6TPH per direction

Proposed 6TPH TSS1C	Number of Closures per hour	Total proposed closure time per hour	Minimum proposed closure time	Maximum proposed closure time	Assessed Timetable
Kilbarrack (917) Level Crossing	6 or 12	00:12:50 to 00:30:50	00:02:08	00:05:08	00:04:50 6 times per hour
Sutton (916) Level Crossing	6 or 12	00:13:06 to 00:31:30	00:02:11	00:05:11	00:02:11 6 times per hour

The signal timings for the junctions upstream and downstream of the level crossings, were set to be optimised in the LinSig simulation, to allow them to coordinate with the opening and closing times of the level crossings. These junctions are labelled 1, 2, 3, 4, 5 and 6 in Figure 4-3 onwards.

4.3 Modelling Results - Kilbarrack (917) Level Crossing and Dublin Road/Baldoyle Road Junction (XQ001)

4.3.1 Baseline 3TPH Per Direction – AM Peak Hour

Surveys have shown 366 vehicles travelling northbound and 435 travelling southbound across the rail line between 08:00 and 09:00 at Kilbarrack level crossing.

In the Baseline scenario of 3TPHPD, Kilbarrack (917) Level Crossing (point A) produces a MMQ of 204 meters at the level crossing in the southbound direction, equating to 37% of the possible capacity of the link.

The northbound MMQ at the level crossing is 114 meters and takes up 33% of the available space.

The southbound arm of the Dublin Road/Baldoyle Road Junction has a MMQ of 108 meters that takes up 31% of the available space (Junction 2).

The northbound arm of the Warrenhouse Road/Dublin Street Junction has an MMQ of 36 meters that takes up 7% of the available space (Junction 5).

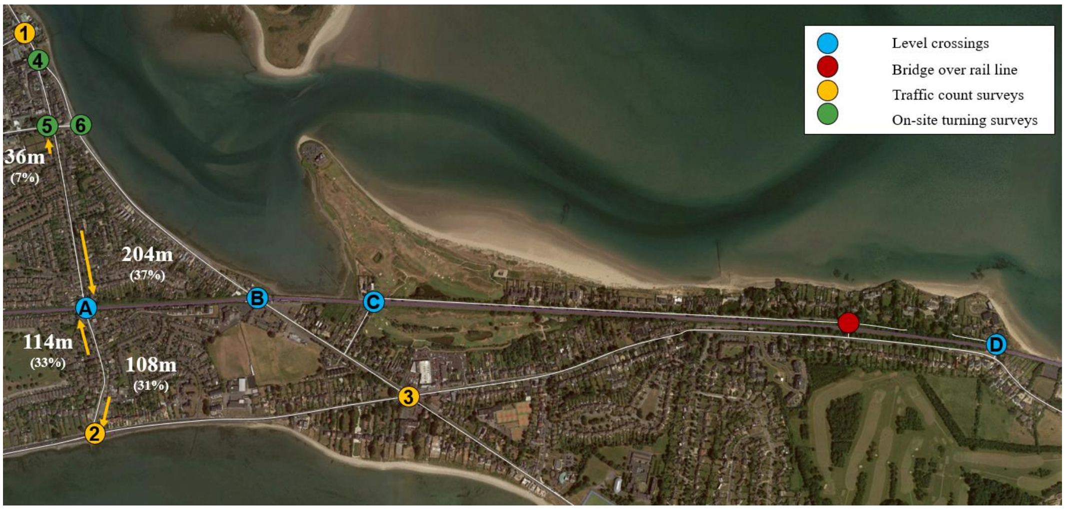

Figure 4-3 Baseline 3TPH Per Direction MMQ Results – AM Peak

The modelled queue lengths in the subsequent tables for the 3TPHPD signals will not correspond to the observed queue lengths in Table 4.2. The observed scenario is based on an irregular timetable, the 3TPH scenarios are based on a regular timetable. A sensitivity analysis at the end of the report is included to address the possibility of the timetable not being regular in practice. The queue lengths presented here are the likely average queue lengths, but at times, could exceed this and could reach the highest observed queue lengths or longer.

Table 4.7 Baseline 3TPH Per Direction MMQ Results – AM Peak

Baseline 3TPH	Link Length	75% Link Length	MMQ (PCUs)	MMQ	% of 75% Link Length occupied
Kilbarrack (917) Level Crossing SB	550m	413m	34	204m	49%
Kilbarrack (917) Level Crossing NB	350m	263m	19	114m	43%
Dublin Road/ Baldoyle Road Junction SB Arm	350m	263m	18	108m	41%
Warrenhouse Road Junction NB Arm	550m	413m	6	36m	9%

These results show that in the baseline scenario all queues are within the available capacity assuming the 3TPHPD timetable and assuming only 75% of the link length would be available, in the case of a more concentrated arrival pattern (see Section 4.2.1).

An estimation of the potential fluctuation in queue lengths at the level crossing is provided in Table 4.8. This estimation takes into account potential underestimation of queue lengths by the model and the application of calibration factors discussed in Section 4.2.2.

Table 4.8R Range of potential queue lengths 3TPHPD AM

Baseline 3TPH	Link Length	Modelled Queue Length	Maximum or Adjusted Average Queue Length	Adjusted Longest Queue Length
Kilbarrack (917) Level Crossing SB	550m	204m	252m	516m
Kilbarrack (917) Level Crossing NB	350m	114m	114m	348m

These results show that in the baseline scenario all queues are within the available link length capacity assuming the 3TPHPD timetable based on average expected queue lengths. All queues are also within the available link length capacity in a reasonable worst-case scenario of a more concentrated arrival pattern based on the longest expected queue lengths.

4.3.2 Proposed 6TPH Per Direction – AM Peak Hour

Under the proposed 6TPHPD TSS1C scenario Kilbarrack (917) Level Crossing (point A) produces a MMQ of 324 meters at the level crossing in the southbound direction, equating to 59% of the possible capacity of the link.

The northbound MMQ at the level crossing is 180 meters and only takes up 51% of the available space on this link.

The southbound arm of the Dublin Road/Baldoyle Road Junction has a MMQ of 108 meters (31% of capacity) (Junction 2).

The northbound arm of the Warrenhouse Road/Dublin Street Junction has an MMQ of 36 meters that takes up 7% of the available space (Junction 5).

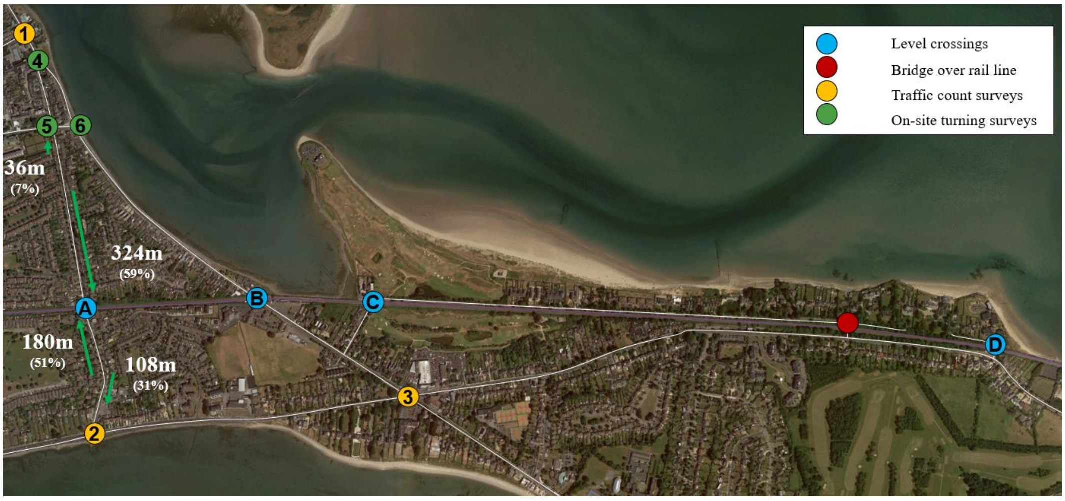

Figure 4-4 Proposed 6TPHPD MMQ Results – AM Peak

The modelled queue lengths in the subsequent tables for the 6TPHPD signals will not correspond to the observed queue lengths in Table 4.2. The observed scenario is based on an irregular timetable, the 6TPH scenarios are based on a regular timetable. A sensitivity analyses at the end of the report is included to address the possibility of the timetable not being regular in practice. The queue lengths presented here are the likely average queue lengths, but at times, could exceed this and reach the highest observed queue lengths or longer.

Table 4.9 Proposed 6TPH Per Direction MMQ Results – AM Peak

Proposed 6TPH TSS1C	Link Length	75% Link Length	MMQ (PCUs)	MMQ	% of 75% Link Length occupied
Kilbarrack (917) Level Crossing SB	550m	413m	54	324m	78%
Kilbarrack (917) Level Crossing NB	350m	263m	30	180m	68%
Dublin Road/ Baldoyle Road Junction SB Arm	350m	263m	18	108m	41%
Warrenhouse Road Junction NB Arm	550m	413m	6	36m	9%

These results show that in the baseline scenario all queues are within the available capacity assuming the 6TPH TSS 1C timetable and assuming only 75% of the link length would be available, in case of a more concentrated arrival pattern.

An estimation of the potential fluctuation in queue lengths at the level crossing is provided in Table 4.10. This estimation takes into account potential underestimation of queue lengths by the model and the application of calibration factors discussed in Section 4.2.2.

Table 4.10 Range of potential queue lengths 6TPH AM

Proposed 6TPH	Link Length	Modelled Queue Length	Maximum or Adjusted Average Queue Length	Adjusted Longest Queue Length
Kilbarrack (917) Level Crossing SB	550m	324m	400m	820m
Kilbarrack (917) Level Crossing NB	350m	180m	180m	549m

These results show that in the proposed scenario all queues are within the available link length capacity assuming the 6TPHPD timetable based on average expected queue lengths. However, in a reasonable worst-case scenario of a more concentrated arrival pattern, there is a possibility that the longest southbound queue may block back across the Warrenhouse Road/Dublin Street Junction north of Kilbarrack (917) Level Crossing. In addition, there is a possibility that the longest northbound queue may block back across the Dublin Road/Baldoyle Road Junction south of Kilbarrack (917) Level Crossing.

4.3.3 Baseline 3TPH Per Direction – PM Peak Hour

Surveys have shown 472 vehicles travelling northbound and 345 travelling southbound across the rail line between 17:30 and 18:30 at Kilbarrack level crossing.

In the baseline scenario of 3TPHPD, Kilbarrack (917) Level Crossing (point A) produces a MMQ of 132 meters at the level crossing in the southbound direction, equating to 24% of the possible capacity of the link.

The northbound MMQ at the level crossing is 192 meters and takes up 55% of the available space.

The southbound arm of the Dublin Road/Baldoyle Road Junction has a MMQ of 72 meters that takes up 21% of the available space (Junction 2).

The northbound arm of the Warrenhouse Road/Dublin Street Junction has an MMQ of 66 meters that takes up 12% of the available space (Junction 5).

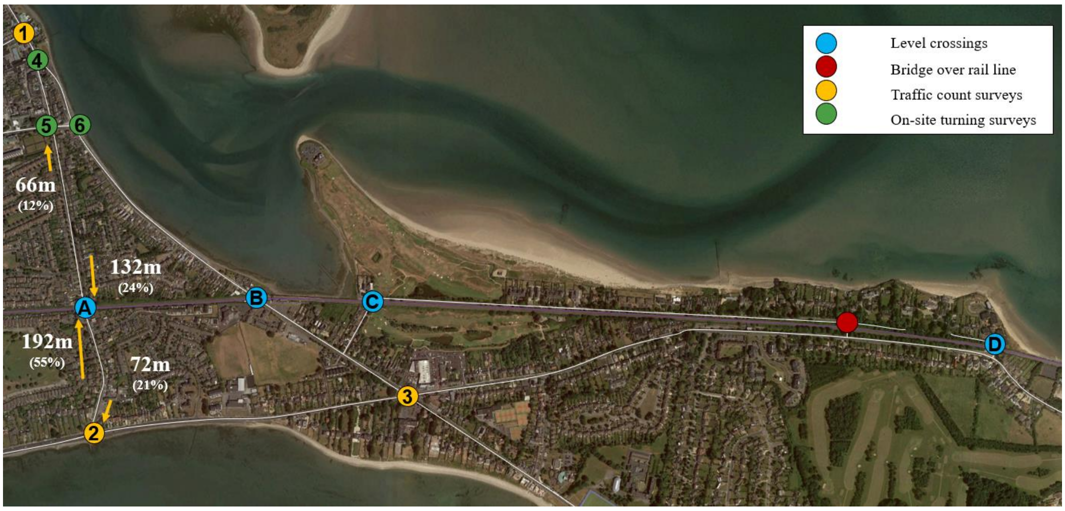

Figure 4-5 Baseline 3TPH Per Direction MMQ Results – PM Peak

The modelled queue lengths in the subsequent tables for the 3TPHPD signals will not correspond to the observed queue lengths in Table 4.2. The observed scenario is based on an irregular timetable, the 3TPH scenarios are based on a regular timetable. A sensitivity analysis at the end of the report is included to address the possibility of the timetable not being regular in practice. The queue lengths presented here are the likely average queue lengths but at times, could exceed this and reach the highest observed queue lengths or longer.

Table 4.11 Baseline 3TPH Per Direction MMQ Results – PM Peak

Baseline 3TPH	Link Length	75% Link Length	MMQ (PCUs)	MMQ	% of 75% Link Length occupied
Kilbarrack (917) Level Crossing SB	550m	413m	22	132m	32%
Kilbarrack (917) Level Crossing NB	350m	263m	32	192m	73%
Dublin Road/ Baldoyle Road Junction SB Arm	350m	263m	12	72m	27%
Warrenhouse Road Junction NB Arm	550m	413m	11	66m	16%

These results show that in the baseline scenario all queues are within the available capacity assuming the 3TPHPD timetable and assuming only 75% of the link length would be available, in case of a more concentrated arrival pattern (see section 4.2.1).

An estimation of the potential fluctuation in queue lengths at the level crossing is provided in Table 4.12. This estimation takes into account potential underestimation of queue lengths by the model and the application of calibration factors discussed in Section 4.2.2.

Table 4.12 Range of potential queue lengths 3TPH PM

Baseline 3TPH	Link Length	Modelled Queue Length	Maximum Average Queue Length	Adjusted Longest Queue Length
Kilbarrack (917) Level Crossing SB	550m	132m	132m	144m
Kilbarrack (917) Level Crossing NB	350m	192m	192m	348m

These results show that in the baseline scenario all queues are within the available link length capacity assuming the 3TPH timetable based on average expected queue lengths. All queues are also within the available link length capacity in a reasonable worst-case scenario of a more concentrated arrival pattern based on the longest expected queue lengths (see section 4.2.1).

4.3.4 Proposed 6TPH Per Direction – PM Peak Hour

Under the proposed 6TPHPD TSS1C scenario, Kilbarrack (917) Level Crossing (point A) produces a MMQ of 210 meters at the level crossing in the southbound direction, equating to 38% of the possible capacity of the link.

The northbound MMQ at the level crossing is 306 meters and takes up 87% of the available space on this link.

The southbound arm of the Dublin Road/Baldoyle Road Junction has a MMQ of 72 meters (21% of capacity) (Junction 2).

The northbound arm of the Warrenhouse Road/Dublin Street Junction has an MMQ of 66 meters that takes up 12% of the available space (Junction 5).

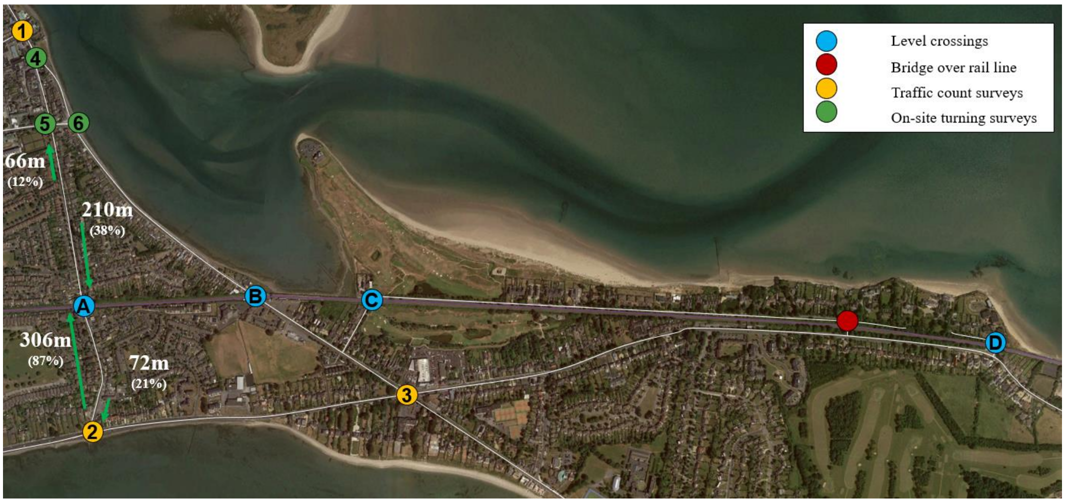

Figure 4-6 Proposed 6TPH Per Direction MMQ Results – PM Peak

The modelled queue lengths in the subsequent tables for the 6TPH signals will not correspond to the observed queue lengths in Table 4.2. The observed scenario is based on an irregular timetable, the 6TPH scenarios are based on a regular timetable. A sensitivity analysis at the end of the report is included to address the possibility of the timetable not being regular in practice.

The queue lengths presented here are the likely average queue lengths but at times, could exceed this and reach the highest observed queue lengths or longer.

Table 4.13 Proposed 6TPH Per Direction MMQ Results – PM Peak

Proposed 6TPH TSS1C	Link Length	75% Link Length	MMQ (PCUs)	MMQ	% of 75% Link Length occupied
Kilbarrack (917) Level Crossing SB	550m	413m	35	210m	51%
Kilbarrack (917) Level Crossing NB	350m	263m	51	306m	116%
Dublin Road/ Baldoyle Road Junction SB Arm	350m	263m	12	72m	27%
Warrenhouse Road Junction NB Arm	550m	413m	11	66m	16%

These results show that in the baseline scenario most queues are within the available capacity assuming the 6TPHPD TSS 1C timetable and assuming only 75% of the link length would be available, in case of a more concentrated arrival pattern (see section 4.2.1). Reaching 116% of the available space at Kilbarrack northbound arm in the PM peak means that it is likely that the queue will block back beyond the available space fairly regularly.

An estimation of the potential fluctuation in queue lengths at the level crossing is provided in Table 4.17. This estimation takes into account potential underestimation of queue lengths by the model and the application of calibration factors discussed in Section 4.2.2.

Table 4.14 Range of potential queue lengths 6TPH PM

Proposed 6TPH	Link Length	Modelled Queue Length	Maximum Average Queue Length	Adjusted Longest Queue Length
Kilbarrack (917) Level Crossing SB	550m	210m	210m	229m
Kilbarrack (917) Level Crossing NB	350m	306m	306m	555m

These results show that in the proposed scenario all queues are within the available link length capacity assuming the 6TPH timetable based on average expected queue lengths. However, in a reasonable worst-case scenario of a more concentrated arrival pattern, there is a possibility that the longest northbound queue may block back across the Dublin Road/Baldoyle Road Junction south of Kilbarrack (917) Level Crossing.

4.3.5 Comparison

Queuing depends on two factors – the duration of the closure and the frequency of the closure. An increase in frequency of the closure will not necessarily result in an increase in queueing as the duration of these closures may be shorter and therefore will prevent long queues from forming.

Level crossing closures at Kilbarrack (917) Level Crossing will increase from approximately 4 or 5 times per hour to 6 or 12 times per hour. The duration of these closures may also increase to varying degrees, depending on the future operational timetable. These results are summarised in Table 4.15.

For the purposes of the analyses an averaged closure time was assessed. Fluctuations in the time table were addressed as part of a sensitivity analysis in Section 4.6.

Table 4.15 Comparison of Level Crossing Closure Times – Kilbarrack (917)

Kilbarrack (917) Level Crossing	Number of closures per hour	Total closure time per hour	Minimum closure time	Maximum closure time	Assessed Timetable
Baseline 3TPH per direction	5	00:14:31	00:01:41	00:04:35	00:02:54
Proposed 6TPH TSS1C	6 or 12	00:12:50 to 00:30:50	00:02:08	00:05:08	00:04:50 6 times per hour

Comparing the mean maximum queue lengths at Kilbarrack (917) Level Crossing and at the Dublin Road/Baldoyle Road Junction, the proposed scenario of 6TPHPD shows an increase in most queues, however, all mostly remain within the available queueing capacity. Queues may occasionally block back along the Kilbarrack northbound arm in the PM peak towards the Baldoyle Road & Dublin Road junction.

Figure 4-7 Comparison – Kilbarrack (917) Level Crossing and Dublin Road/Baldoyle Road Junction SB Arm Queue Length Modelling Results – AM Peak

Figure 4-8 Comparison – Kilbarrack (917) Level Crossing and Dublin Road/Baldoyle Road Junction SB Arm Queue Length Modelling Results – PM Peak

Table 4.16 Comparison – Kilbarrack (917) Level Crossing and Dublin Road/Baldoyle Road Junction SB Arm Queue Length Modelling Results – AM Peak

Location	Baseline MMQ Duration: 00:02:54 Frequency: 5 times / hour	Proposed MMQ Duration: 00:04:50 Frequency: 6 times / hour	% Change in Queue Length
Kilbarrack (917) Level Crossing SB	204m	324m	+59%
Kilbarrack (917) Level Crossing NB	114m	180m	+58%
Dublin Road/ Baldoyle Road Junction SB Arm	108m	108m	0%
Warrenhouse Road Junction NB Arm	36m	36m	0%

Table 4.17 Comparison – Kilbarrack (917) Level Crossing and Dublin Road/Baldoyle Road Junction SB Arm Queue Length Modelling Results – PM Peak

Location	Baseline MMQ Duration: 00:02:54 Frequency: 5 times / hour	Proposed MMQ Duration: 00:04:50 Frequency: 6 times / hour	% Change in Queue Length
Kilbarrack (917) Level Crossing SB	132m	210m	+59%
Kilbarrack (917) Level Crossing NB	192m	306m	+59%
Dublin Road/ Baldoyle Road Junction SB Arm	72m	72m	0%
Warrenhouse Road Junction NB Arm	66m	66m	0%

4.4 Modelling Results - Sutton (916) Level Crossing and Sutton Cross Junction (XQ002)

4.4.1 Baseline 3TPH Per Direction – AM Peak Hour

Surveys have shown 406 vehicles travelling northbound and 433 travelling southbound across the rail line between 08:00 and 09:00 at Sutton level crossing.

In the baseline scenario of 3TPHPD, Sutton (916) Level Crossing (point B) produces an MMQ of 228 meters at the level crossing in the southbound direction, equating to 30% of the possible capacity of the link.

The northbound MMQ at the level crossing is 210 meters and takes up 42% of the available space.

The southbound arm of Sutton Cross Junction also has a MMQ of 48 metres, taking up 10% of the capacity of the link (Junction 3).

The northbound arm of the Strand Road / R809 Junction has an MMQ of 6 meters that takes up 1% of the available space (Junction 6).

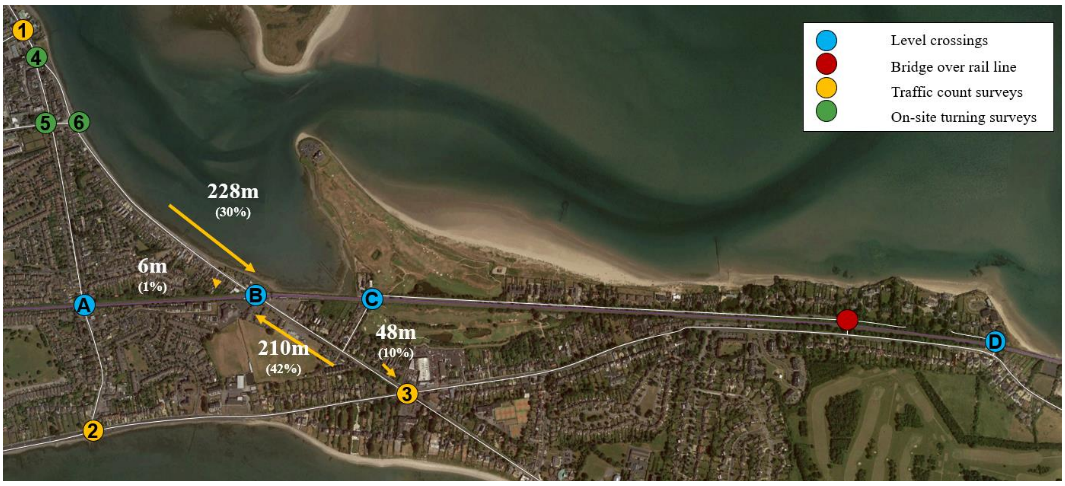

Figure 4-9 Baseline 3TPH Per Direction MMQ Results – AM Peak

The modelled queue lengths in the subsequent tables for the 3TPH signals will not correspond to the observed queue lengths in Table 4.2. The observed scenario is based on an irregular timetable, the 3TPH scenarios are based on a regular timetable. A sensitivity analysis at the end of the report is included to address the possibility of the timetable not being regular in practice. The queue lengths presented here are the likely average queue lengths but at times, could exceed this and reach the highest observed queue lengths or longer.

Table 4.18 Baseline 3TPH Per Direction MMQ Results – AM Peak

Baseline 3TPH Per Direction	Link Length	75% Link Length	MMQ (PCUs)	MMQ	% of 75% Link Length occupied
Sutton (916) Level Crossing SB	760m	570m	38	228m	40%
Sutton (916) Level Crossing NB	500m	375m	35	210m	56%
Sutton Cross Junction SB Arm	500m	375m	8	48m	13%
Strand Road NB Arm	750m	563m	1	6m	1%

These results show that in the baseline scenario all queues are within the available capacity assuming the 3TPH timetable and assuming only 75% of the link length would be available, in case of a more concentrated arrival pattern.

An estimation of the potential fluctuation in queue lengths at the level crossing is provided in Table 4.8. This estimation takes into account potential underestimation of queue lengths by the model and the application of calibration factors discussed in Section 4.2.2.

Table 4.19 Range of potential queue lengths 3TPH AM

Baseline 3TPH	Link Length	Modelled Queue Length	Maximum Average Queue Length	Maximum or Adjusted Longest Queue Length
Sutton (916) Level Crossing SB	760m	228m	228m	228m
Sutton (916) Level Crossing NB	500m	210m	210m	234m

These results show that in the baseline scenario all queues are within the available link length capacity assuming the 3TPH timetable based on average expected queue lengths. All queues are also within the available link length capacity in a reasonable worst-case scenario of a more concentrated arrival pattern, based on the longest expected queue lengths.

4.4.2 Proposed 6TPH Per Direction – AM Peak Hour

Under the proposed 6TPH TSS1C scenario, Sutton (916) Level Crossing (point B) produces a MMQ of 144 meters at the level crossing in the southbound direction, equating to 19% of the possible capacity of the link.

The northbound MMQ at the level crossing is 132 meters and only takes up 26% of the available space on this link.

The southbound arm of Sutton Cross Junction also has a MMQ of 42 meters, taking up 8% of the capacity of the link (Junction 3).

The northbound arm of the Strand Road / R809 Junction has an MMQ of 6 meters that takes up 1% of the available space (Junction 6).

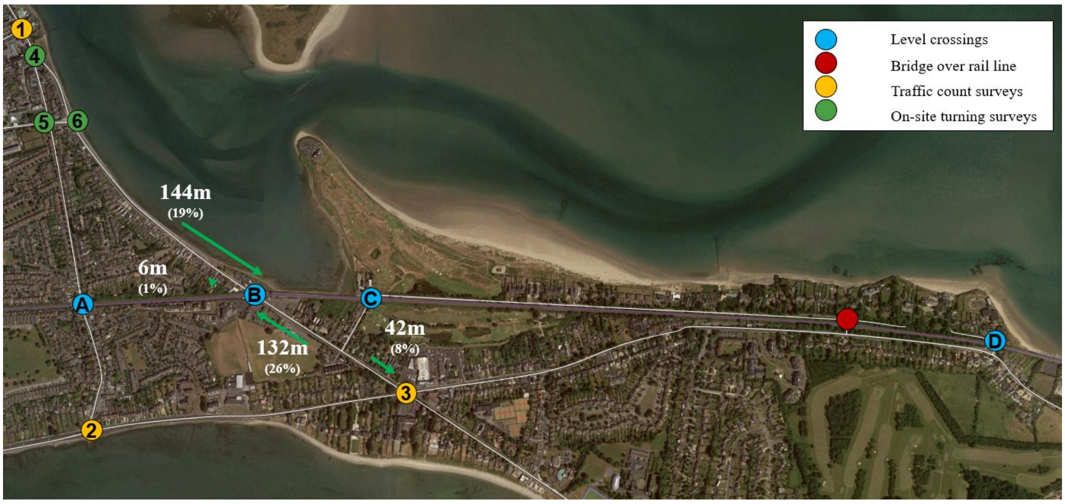

Figure 4-10 Proposed 6TPH Per Direction MMQ Results – AM Peak

The modelled queue lengths in the subsequent tables for the 6TPH signals will not correspond to the observed queue lengths in Table 4.2. The observed scenario is based on an irregular timetable, the 6TPH scenarios are based on a regular timetable.

A sensitivity analyses at the end of the report is included to address the possibility of the timetable not being regular in practice. The queue lengths presented here are the likely average queue lengths but at times, could exceed this and reach the highest observed queue lengths or longer.

Table 4.20 Proposed 6TPH Per Direction MMQ Results – AM Peak

Proposed 6TPH TSS1C	Link Length	75% Link Length	MMQ (PCUs)	MMQ	% of 75% Link Length occupied
Sutton (916) Level Crossing SB	760m	570m	24	144m	25%
Sutton (916) Level Crossing NB	500m	375m	22	132m	35%
Sutton Cross Junction SB Arm	500m	375m	7	42m	11%
Strand Road NB Arm	750m	563m	1	6m	1%

These results show that in the baseline scenario all queues are within the available capacity assuming the 6TPH TSS 1C timetable and assuming only 75% of the link length would be available, in case of a more concentrated arrival pattern.

An estimation of the potential fluctuation in queue lengths at the level crossing is provided in Table 4.21. This estimation takes into account potential underestimation of queue lengths by the model and the application of calibration factors discussed in Section 4.2.2.

Table 4.21 Range of potential queue lengths 6TPH AM

Proposed 6TPH	Link Length	Modelled Queue Length	Maximum Average Queue Length	Maximum or Adjusted Longest Queue Length
Sutton (916) Level Crossing SB	760m	144m	144m	144m
Sutton (916) Level Crossing NB	500m	132m	132m	147m

These results show that in the proposed scenario all queues are within the available link length capacity assuming the 6TPH timetable based on average expected queue lengths. All queues are also within the available link length capacity in a reasonable worst-case scenario of a more concentrated arrival pattern based on the longest expected queue lengths.

4.4.3 Baseline 3TPH Per Direction – PM Peak Hour

Surveys have shown 401 vehicles travelling northbound and 458 travelling southbound across the rail line between 17:30 and 18:30 at Sutton Level Crossing.

In the baseline scenario of 3TPHPD, Sutton (916) Level Crossing produces (point B) an MMQ of 186 meters at the level crossing in the southbound direction, equating to 24% of the possible capacity of the link.

The northbound MMQ at the level crossing is 180 meters and takes up 36% of the available space.

The southbound arm of Sutton Cross Junction also has a MMQ of 42 metres, taking up 8% of the capacity of the link (Junction 3).

The northbound arm of the Strand Road / R809 Junction has an MMQ of 6 meters that takes up 1% of the available space (Junction 6).

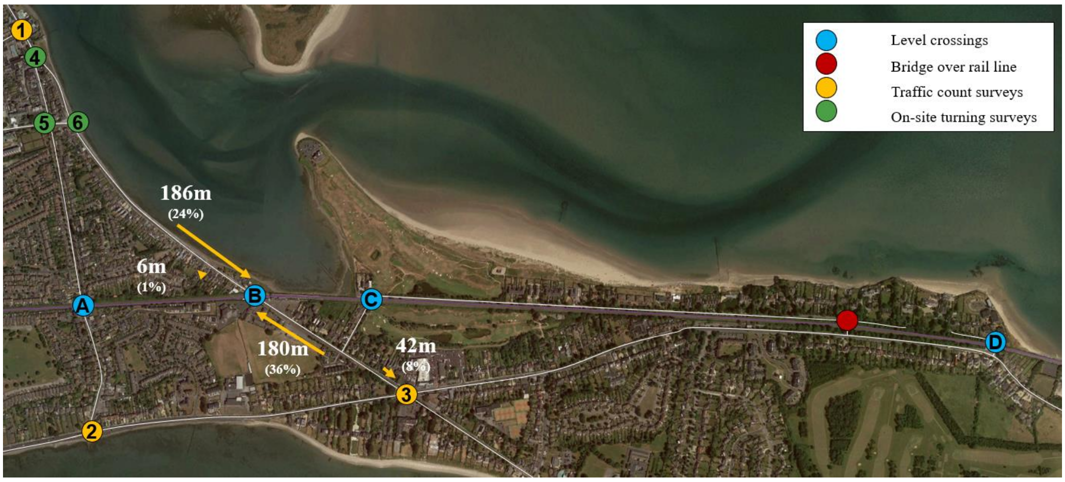

Figure 4-11 Baseline 3TPH Per Direction MMQ Results – PM Peak

The modelled queue lengths in the subsequent tables for the 3TPH signals will not correspond to the observed queue lengths in Table 4.2. The observed scenario is based on an irregular timetable, the 3TPH scenarios are based on a regular timetable. A sensitivity analyses at the end of the report is included to address the possibility of the timetable not being regular in practice. The queue lengths presented here are the likely average queue lengths but at times, could exceed this and reach the highest observed queue lengths or longer.

Table 4.22 Baseline 3TPH Per Direction MMQ Results – PM Peak

Baseline 3TPH Per Direction	Link Length	75% Link Length	MMQ (PCUs)	MMQ	% of 75% Link Length occupied
Sutton (916) Level Crossing SB	760m	570m	31	186m	33%
Sutton (916) Level Crossing NB	500m	375m	30	180m	48%
Sutton Cross Junction SB Arm	500m	375m	7	42m	11%
Strand Road NB Arm	750m	563m	1	6m	1%

These results show that in the baseline scenario all queues are within the available capacity assuming the 3TPH timetable and assuming only 75% of the link length would be available, in case of a more concentrated arrival pattern.

An estimation of the potential fluctuation in queue lengths at the level crossing is provided in Table 4.30. This estimation takes into account potential underestimation of queue lengths by the model and the application of calibration factors discussed in Section 4.2.2.

Table 4.23 Range of potential queue lengths 3TPH PM

Baseline 3TPH	Link Length	Modelled Queue Length	Maximum Average Queue Length	Maximum Longest Queue Length
Sutton (916) Level Crossing SB	760m	186m	186m	186m
Sutton (916) Level Crossing NB	500m	180m	180m	180m

These results show that in the baseline scenario all queues are within the available link length capacity assuming the 3TPH timetable based on average expected queue lengths. All queues are also within the available link length capacity in a reasonable worst-case scenario of a more concentrated arrival pattern based on the longest expected queue lengths.

4.4.4 Proposed 6TPH Per Direction – PM Peak Hour

Under the proposed 6TPH TSS1C scenario, Sutton (916) Level Crossing (point B) produces a MMQ of 114 meters at the level crossing in the southbound direction, equating to 15% of the possible capacity of the link.

The northbound MMQ at the level crossing is 114 meters and only takes up 23% of the available space on this link.

The southbound arm of Sutton Cross Junction also has a MMQ of 36 meters, taking up 7% of the capacity of the link (Junction 3).

The northbound arm of the Strand Road / R809 Junction has an MMQ of 6 meters that takes up 1% of the available space (Junction 6).

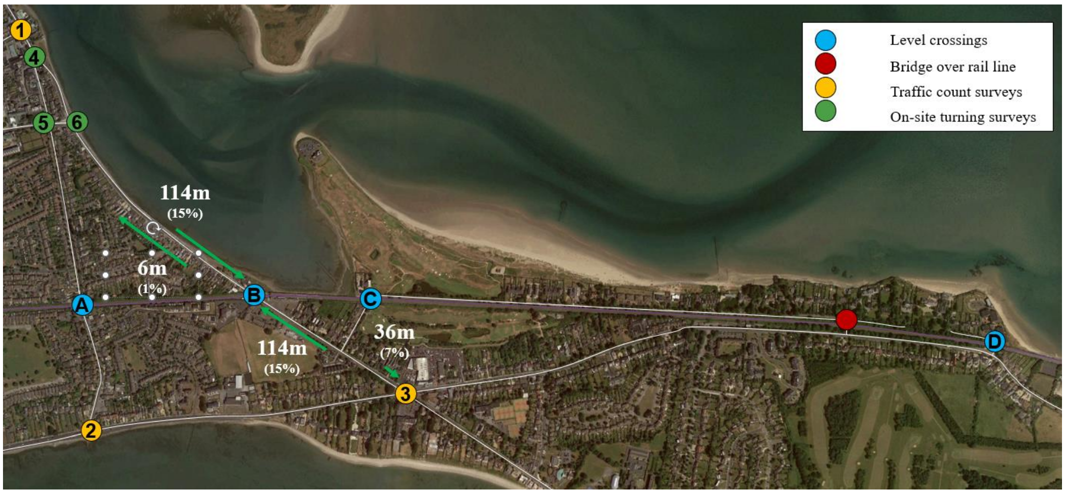

Figure 4-12 Proposed 6TPH Per Direction MMQ Results – PM Peak

The modelled queue lengths in the subsequent tables for the 6TPH signals will not correspond to the observed queue lengths in Table 4.2. The observed scenario is based on an irregular timetable, the 6TPH scenarios are based on a regular timetable. A sensitivity analyses at the end of the report is included to address the possibility of the timetable not being regular in practice.

The queue lengths presented here are the likely average queue lengths but at times, could exceed this and reach the highest observed queue lengths or longer.

Table 4.24 Proposed 6TPH Per Direction MMQ Results – PM Peak

Proposed 6TPH TSS1C	Link Length	75% Link Length	MMQ (PCUs)	MMQ	% of 75% Link Length occupied
Sutton (916) Level Crossing SB	760m	570m	19	114m	20%
Sutton (916) Level Crossing NB	500m	375m	19	114m	30%
Sutton Cross Junction SB Arm	500m	375m	6	36m	10%
Strand Road NB Arm	750m	563m	1	6m	1%

These results show that in the baseline scenario all queues are within the available capacity assuming the 6TPH TSS 1C timetable and assuming only 75% of the link length would be available, in case of a more concentrated arrival pattern.

An estimation of the potential fluctuation in queue lengths at the level crossing is provided in Table 4.25. This estimation takes into account potential underestimation of queue lengths by the model and the application of calibration factors discussed in Section 4.2.2.

Table 4.25 Range of potential queue lengths 6TPH PM

Proposed 6TPH	Link Length	Modelled Queue Length	Maximum Average Queue Length	Maximum Longest Queue Length
Sutton (916) Level Crossing SB	760m	114m	114m	114m
Sutton (916) Level Crossing NB	500m	114m	114m	114m

These results show that in the proposed scenario all queues are within the available link length capacity assuming the 6TPH timetable based on average expected queue lengths. All queues are also within the available link length capacity in a reasonable worst-case scenario of a more concentrated arrival pattern based on the longest expected queue lengths.

4.4.5 Comparison

Queuing depends on two factors – the duration of the closure and the frequency of the closure. An increase in frequency of the closure will not necessarily result in an increase in queueing as the duration of these closures may be shorter and therefore will prevent long queues from forming.

Level crossing closures at Sutton (916) Level Crossing will increase from approximately 3 or 4 times per hour to 6 or 12 times per hour. The duration of these closures may also increase to varying degrees, depending on the future operational timetable. These results are summarised in Table 4.26.

For the purposes of the analyses an averaged closure time was assessed. Fluctuations in the time table were addressed as part of a sensitivity analyses in Section 4.6.

Table 4.26 Comparison of Level Crossing Closure Times – Sutton (916)

Sutton (916) Level Crossing	Number of closures per hour	Total closure time per hour	Minimum closure time	Maximum closure time	Assessed Timetable
Baseline 3TPH per direction	3	00:11:08	00:03:22	00:04:23	00:03:43
Proposed 6TPH TSS1C	6 or 12	00:13:06 to 00:31:30	00:02:11	00:05:11	00:02:11 6 times per hour

Comparing the mean maximum queue lengths at Sutton (916) Level Crossing and at the Sutton Cross Junction, the proposed scenario of 6TPHPD shows a decrease in most queues, and all remain within the available queueing capacity.

The average closure time is forecast to reduce with 6TPH from 03:43 to 02:11 in the TSS1C assessed timetable. The shorter closure time allows less queueing to build up and queues are able to dissipate faster.

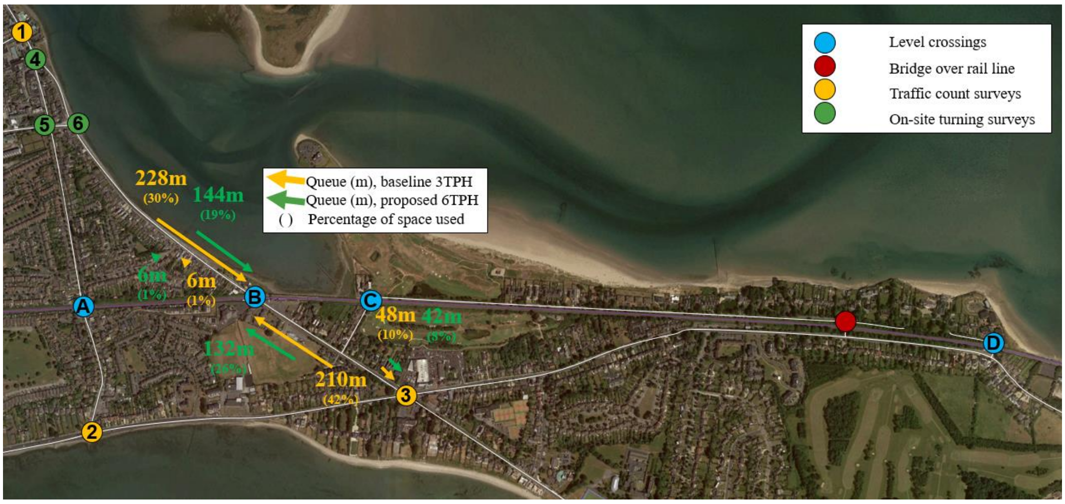

Figure 4-13 Comparison – Sutton (916) Level Crossing and Sutton Cross Junction SB Arm Queue Length Modelling Results – AM Peak

Figure 4-14 Comparison – Sutton (916) Level Crossing and Sutton Cross Junction SB Arm Queue Length Modelling Results – PM Peak

Table 4.27 Comparison – Sutton (916) Level Crossing and Sutton Cross Junction SB Arm Queue Length Modelling Results – AM Peak

Location	Baseline MMQ Duration: 00:03:43 Frequency: 3 times / hour	Proposed MMQ Duration: 00:02:11 Frequency: 6 times / hour	% Change in Queue Length
Sutton (916) Level Crossing SB	228m	144m	-37%
Sutton (916) Level Crossing NB	210m	132m	-37%
Sutton Cross Junction SB Arm	48m	42m	-13%
Strand Road NB Arm	6m	6m	0%

Table 4.28 Comparison – Sutton (916) Level Crossing and Sutton Cross Junction SB Arm Queue Length Modelling Results – PM Peak

Location	Baseline MMQ Duration: 00:03:43 Frequency: 3 times / hour	Proposed MMQ Duration: 00:02:11 Frequency: 6 times / hour	% Change in Queue Length
Sutton (916) Level Crossing SB	186m	114m	-39%
Sutton (916) Level Crossing NB	180m	114m	-37%
Sutton Cross Junction SB Arm	42m	36m	-14%
Strand Road NB Arm	6m	6m	0%

4.5 Qualitative Assessment of Cosh (915) (XQ003) and Claremont (913) (XQ004) Level Crossings

For Cosh (915) and Claremont (913) Level Crossings, the assessment was carried out by comparing both the frequency and length of barrier closures in the baseline 3TPH per direction scenario to the proposed 6TPH TSS1C scenario.

The baseline and proposed opening and closure times of the level crossing barriers at Cosh (915) and Claremont (913) are calculated from the outputs from the RailSys model, described in Section 3.

4.5.1 Cosh (915) Level Crossing

Level crossing closures at Cosh (915) Level Crossing will increase from approximately 3 or 4 times per hour to 6 or 12 times per hour. The duration of these closures may also increase to varying degrees, depending on the operational timetable. These results are summarised in Table 4.29.

For the purposes of the analyses an averaged closure time was assessed. Fluctuations in the timetable were addressed as part of a sensitivity analyses in Section 4.6.

Table 4.29 Comparison of Level Crossing Closure Times – Cosh (915)

Location	Number of Closures per hour	Total closure time per hour	Minimum single closure time	Maximum single closure time	Assessed Timetable
Baseline Cosh (915) Level Crossing	3	00:11:13	00:02:16	00:05:13	00:03:44
Proposed Cosh (915) Level Crossing	6 or 12	00:17:58 to 00:30:03	00:02:30	00:05:01	00:05:01 6 times per hour

The volume of vehicles crossing Cosh (915) Level Crossing is relatively low. Surveys have shown only 23 vehicles travelling northbound and 25 travelling southbound across the rail line between 08:00 and 09:00; and 48 northbound and 24 southbound between 17:30 and 18:30. Based on the findings of the Kilbarrack and the Sutton Level Crossing assessments it is anticipated that this level crossing will operate slightly worse for vehicles, but it is not expected to have a significant impact in terms of queueing due to the low volumes of vehicles that cross the level crossing.

4.5.2 Claremont (913) Level Crossing

Level crossing closures at Claremont (913) Level Crossing will increase from approximately 5 or 6 times per hour to 6 or 12 times per hour. The duration of these closures may also increase to varying degrees, depending on the operational timetable. These results are summarised in Table 4.30.

For the purposes of the analyses an averaged closure time was assessed. Fluctuations in the timetable were addressed as part of a sensitivity analyses in Section 4.6.

Table 4.30 Comparison of Level Crossing Closure Times – Claremont (913)

Location	Number of Closures per hour	Total closure time per hour	Minimum single closure time	Maximum single closure time	Assessed Timetable
Baseline Claremont (913) Level Crossing	6	00:15:47	00:02:38	00:02:38	00:02:38
Proposed Claremont (913) Level Crossing	6 or 12	00:17:08 to 00:31:34	00:02:38	00:04:51	00:02:38 6 times per hour

The volume of vehicles crossing Claremont (913) Level Crossing is relatively low. Surveys have shown only 4 vehicles travelling northbound and 8 travelling southbound across the rail line between 08:00 and 09:00; and 10 northbound and 2 southbound between 17:30 and 18:30. Based on the findings of the Kilbarrack and the Sutton level crossings it is anticipated that this level crossing will operate slightly worse for vehicles, but it is not expected to have a significant impact in terms of queueing due to the low volumes of vehicles that cross the level crossing.

4.6 Sensitivity Analysis – Kilbarrack (917) (XQ001) and Sutton (916) (XQ002) Level Crossings

The 3TPHPD closure times are based on the existing timetable. In this timetable trains meet or do not meet at different times, creating varying lengths of closure times.

The proposed 6TPH closure times are based on theoretical clockface timetables. These theoretical timetables ignore any variance caused by human input. Trains meet at exactly the same time, resulting in the exact same closure time in each instance.

The difference between the theoretical and the practical timetable means, for example, that a closure time of 03:34 is tested in the 3TPH scenario at Sutton but a shorter closure time of 02:11 is tested when train frequency doubles in the 6TPH scenario.

To better understand how any changes to the departure times of the trains effect queueing along the surrounding road network a sensitivity analysis was undertaken. This sensitivity analysis was done by inputting the barrier results from the 6TPHPD 1 to 9 minute offset outlined in Section 3. A 10-minute offset is the same as a regular timetable.

4.6.1 Level Crossings Closure Timings

4.6.1.1 Kilbarrack (917) Level Crossing (Baldoyle Road)

At Kilbarrack (917) Level Crossing an offset of 6 to 9 minutes requires the level crossing barriers to close 12 times per hour, meaning that only one train passes through the level crossing during each closure. The rest of the offsets have six closures per hour with two trains passing through each time.

The duration of closure is influenced by the different offsets, with the 5-minute offset having the longest single closure time of 5 minutes and 8 seconds.

Table 4.31 Kilbarrack (917) Level Crossing Closure Times for 6TPH per direction for Clock Face and 1–9 minute offset

Kilbarrack (917) Level Crossing	Number of Closures per hour	Total forecast closure time per hour	Average forecast single closure time
Regular	6	00:28:59	00:04:50
Offset +1min	6	00:22:59	00:03:50
Offset +2min	6	00:12:50	00:02:08
Offset +3min	6	00:18:50	00:03:08
Offset +4min	6	00:24:50	00:04:08
Offset +5min	6	00:30:50	00:05:08
Offset +6min	12	00:21:17	00:02:29
Offset +7min	12	00:28:49	00:02:29
Offset +8min	12	00:28:49	00:02:29
Offset +9min	12	00:28:49	00:02:29

4.6.1.2 Sutton (916) Level Crossing

At Sutton (916) Level Crossing an offset of 3 to 6 minutes requires the level crossing barriers to close 12 times per hour, meaning that only one train passes through the level crossing during each closure. The rest of the offsets have six closures per hour with two trains passing through each time.

The duration of closure is influenced by the different offsets, with 7-minute offset having the longest single closure time of 5 minutes and 11 seconds.

Table 4.32 Sutton (916) Level Crossing Closure Times for 6TPH per direction for Clock Face and 1-9 minute offset

Sutton (916) Level Crossing	Number of Closures per hour	Total forecast closure time per hour	Average forecast single closure time
Clock Face	6	00:13:06	00:02:11
Offset +1min	6	00:24:25	00:04:04
Offset +2min	6	00:30:25	00:05:04
Offset +3min	12	00:31:30	00:02:38
Offset +4min	12	00:31:30	00:02:38
Offset +5min	12	00:31:30	00:02:38
Offset +6min	12	00:31:30	00:02:38
Offset +7min	6	00:31:06	00:05:11
Offset +8min	6	00:25:06	00:04:11
Offset +9min	6	00:19:06	00:03:11

4.6.1.3 Cosh (915) and Claremont (913) Level Crossings

The closure times at Cosh (915) Level Crossing will vary between 2 minutes and 30 seconds and 5 minutes and 1 second, depending on the offset.

The closure times at Claremont (913) Level Crossing will vary between 2 minutes and 38 seconds and 4 minutes and 51 seconds, depending on the offset.

4.6.2 Modelling Results

Two additional scenarios were developed in the LinSig model to test the impact of a potential 5-minute offset and a potential 7-minute offset on queueing at Kilbarrack (917) and Sutton (916) Level Crossings. These two off-sets presented the longest potential closure times. Table 4.33 summarises the input assumptions of the two main scenarios, as discussed earlier in Section 4.6, and the two additional sensitivity scenarios.

For the purposes of the analyses an averaged closure time was assessed. Fluctuations in the time table and resulting closure times, i.e. those resulting from a 5min offset or a 7min offset are outlined in Table 4.33.

Table 4.33 Sensitivity Tests

Baseline 3TPH per direction	Number of closures per hour	Assessed Timetable
Kilbarrack (917) Level Crossing	5	00:02:54
Sutton (916) Level Crossing	3	00:03:43
Proposed 6TPH TSS1C	**Number of closures per hour**	**Assessed Timetable**
Kilbarrack (917) Level Crossing	6	00:04:50
Sutton (916) Level Crossing	6	00:02:11
Offset +5min Proposed 6TPH TSS1C	**Number of closures per hour**	**Sensitivity Analysis**
Kilbarrack (917) Level Crossing	6	00:05:08
Sutton (916) Level Crossing	12	00:02:38
Offset +7min Proposed 6TPH TSS1C	**Number of closures per hour**	**Sensitivity Analysis**
Kilbarrack (917) Level Crossing	12	00:02:29
Sutton (916) Level Crossing	6	00:05:11

Table 4.34 and Table 4.35 summarise the outputs for Kilbarrack (917) Level Crossing for the AM and PM peak hour. The impact on available queuing capacity is shown for both sensitivity scenarios – 5-minute offset and 7-minute offset. There will be an increase in most queues, however these will mostly remain within the available queueing capacity. In a reasonable worst-case due to a more concentrated arrival pattern queues may occasionally block back along the Kilbarrack northbound arm in the PM peak.

Table 4.34 Results of Sensitivity Analysis Modelling – Kilbarrack (917) – AM Peak

5-min offset 6TPH 7-min offset 6TPH	Link Length	75% Link Length	MMQ (PCUs)	MMQ	% of 75% Link Length occupied
Kilbarrack (917) Level Crossing SB	550m	413m	57 30	342m 180m	83% 44%
Kilbarrack (917) Level Crossing NB	350m	263m	32 17	192m 102m	73% 39%
Dublin Road/ Baldoyle Road Junction SB Arm	350m	263m	18 18	108m 108m	41% 41%
Warrenhouse Road Junction NB Arm	550m	413m	2 2	12m 12m	3% 3%

Table 4.35 Results of Sensitivity Analysis Modelling – Kilbarrack (917) – PM Peak

5-min offset 6TPH 7-min offset 6TPH	Link Length	75% Link Length	MMQ (PCUs)	MMQ	% of 75% Link Length occupied
Kilbarrack (917) Level Crossing SB	550m	413m	36 19	216m 114m	60% 28%
Kilbarrack (917) Level Crossing NB	350m	263m	54 28	324m 168m	123% 64%
Dublin Road/ Baldoyle Road Junction SB Arm	350m	263m	12 12	72m 72m	10% 10%
Warrenhouse Road Junction NB Arm	550m	413m	4 4	24m 24m	5% 5%

An estimation of the potential fluctuation in queue lengths at the level crossing is provided in Table 4.36. This estimation takes into account potential underestimation of queue lengths by the model and the application of calibration factors discussed in Section 4.2.2.

Table 4.36 Range of potential queue lengths 6TPH AM

5-min offset 6TPH 7-min offset 6TPH	Link Length	Modelled Queue Length	Adjusted Average Queue Length	Adjusted Longest Queue Length
Kilbarrack (917) Level Crossing SB	550m	342m 180m	422m 222m	865m 455m
Kilbarrack (917) Level Crossing NB	350m	192m 102m	192m 102m	586m 311m

These results show that in the proposed scenario all queues are within the available link length capacity assuming the 6TPH timetable based on average expected queue lengths. However, in a reasonable worst-case scenario of a 5-min offset, there is a possibility that the longest southbound queue may block back across the Warrenhouse Road/Dublin Street Junction north of Kilbarrack (917) Level Crossing. In addition, there is a possibility that the longest northbound queue may block back across the Dublin Road/Baldoyle Road Junction south of Kilbarrack (917) Level Crossing.

Table 4.37 Range of potential queue lengths 6TPH PM

5-min offset 6TPH 7-min offset 6TPH	Link Length	Modelled Queue Length	Maximum Average Queue Length	Adjusted Longest Queue Length
Kilbarrack (917) Level Crossing SB	550m	216m 114m	216m 114m	236m 124m
Kilbarrack (917) Level Crossing NB	350m	324m 168m	324m 168m	587m 305m

These results show that in the proposed scenario all queues are within the available link length capacity assuming the 6TPH timetable based on average expected queue lengths. However, in a reasonable worst-case scenario of a 5-min offset, there is a possibility that the longest northbound queue may block back across the Dublin Road/Baldoyle Road Junction south of Kilbarrack (917) Level Crossing.

Table 4.38 and Table 4.39 summarise the outputs for Sutton (916) Level Crossing for the AM and PM peak hour. The impact on available queuing capacity is shown for both sensitivity scenarios – 5-minute offset and 7-minute offset. There will be an increase in most queues, however all will mostly remain within the available queueing capacity.

Table 4.38 Results of Sensitivity Analysis Modelling – Sutton (916) – AM Peak

5-min offset 6TPH 7-min offset 6TPH	Link Length	75% Link Length	MMQ (PCUs)	MMQ	% of 75% Link Length occupied
Sutton (916) Level Crossing SB	760m	570m	28 52	168m 312m	29% 55%
Sutton (916) Level Crossing NB	500m	375m	26 48	156m 288m	42% 77%
Sutton Cross Junction SB Arm	500m	375m	7 7	42m 42m	11% 11%
Strand Road NB Arm	750m	563m	3 3	18m 18m	3% 3%

Table 4.39 Results of Sensitivity Analysis Modelling – Sutton (916) – PM Peak

5-min offset 6TPH 7-min offset 6TPH	Link Length	75% Link Length	MMQ (PCUs)	MMQ	% of 75% Link Length occupied
Sutton (916) Level Crossing SB	760m	570m	23 42	138m 252m	24% 44%
Sutton (916) Level Crossing NB	500m	375m	22 41	132m 246m	35% 66%
Sutton Cross Junction SB Arm	500m	375m	6 6	36m 36m	10% 10%
Strand Road NB Arm	750m	563m	3 3	18m 18m	3% 3%

An estimation of the potential fluctuation in queue lengths at the level crossing is provided in Table 4.40. This estimation takes into account potential underestimation of queue lengths by the model and the application of calibration factors discussed in Section 4.2.2.

Table 4.40 Range of potential queue lengths 6TPH AM

5-min offset 6TPH 7-min offset 6TPH	Link Length	Modelled Queue Length	Maximum Average Queue Length	Maximum or Adjusted Longest Queue Length
Sutton (916) Level Crossing SB	760m	168m 312m	168m 312m	168m 312m
Sutton (916) Level Crossing NB	500m	156m 288m	156m 288m	174m 321m

These results show that in the proposed scenario all queues are within the available link length capacity assuming the 6TPH timetable based on average expected queue lengths. All queues are also within the available link length capacity in a reasonable worst-case scenario of a 7-min offset based on the longest expected queue lengths.

Table 4.41 Range of potential queue lengths 6TPH PM

5-min offset 6TPH 7-min offset 6TPH	Link Length	Modelled Queue Length	Maximum Average Queue Length	Maximum Longest Queue Length
Sutton (916) Level Crossing SB	760m	138m 252m	138m 252m	138m 252m
Sutton (916) Level Crossing NB	500m	132m 246m	132m 246m	132m 246m

These results show that in the baseline scenario all queues are within the available link length capacity assuming the 6TPH timetable based on average expected queue lengths. All queues are also within the available link length capacity in a reasonable worst-case scenario of a 7-min offset based on the longest expected queue lengths.

Table 4.42 Comparison Sensitivity Analysis– Kilbarrack (917) – AM Peak

Location	Baseline MMQ Duration: 00:02:54 Frequency: 5 times / hour	Sensitivity Analysis MMQ 5-min offset Duration: 00:05:08 Frequency: 6 times / hour 7-min offset Duration: 00:02:29 Frequency: 12 times / hour	% Change in Queue Length
Kilbarrack (917) Level Crossing SB	204m	342m 180m	+68% -12%
Kilbarrack (917) Level Crossing NB	114m	192m 102m	+68% -11%
Dublin Road/ Baldoyle Road Junction SB Arm	108m	108m 108m	0% 0%
Warrenhouse Road Junction NB Arm	36m	12m 12m	-66% -66%

Table 4.43 Comparison Sensitivity Analysis – Kilbarrack (917) – PM Peak

Location	Baseline MMQ Duration: 00:02:54 Frequency: 5 times / hour	Sensitivity Analysis MMQ 5-min offset Duration: 00:05:08 Frequency: 6 times / hour 7-min offset Duration: 00:02:29 Frequency: 12 times / hour	% Change in Queue Length
Kilbarrack (917) Level Crossing SB	132m	216m 114m	+64% -9%
Kilbarrack (917) Level Crossing NB	192m	324m 168m	+69% -13%
Dublin Road/ Baldoyle Road Junction SB Arm	72m	72m 72m	0% 0%
Warrenhouse Road Junction NB Arm	66m	24m 24m	-64% -64%

The results show that increases in queue lengths may be experienced along the approaches to Kilbarrack (917) Level Crossing.

Table 4.44 Comparison Sensitivity Analysis – Sutton (916) – AM Peak

Location	Baseline MMQ Duration: 00:03:43 Frequency: 3 times / hour	Sensitivity Analysis MMQ 5-min offset Duration: 00:02:38 Frequency: 12 times / hour 7-min offset Duration: 00:05:11 Frequency: 6 times / hour	% Change in Queue Length
Sutton (916) Level Crossing SB	228m	168m 312m	-26% +37%
Sutton (916) Level Crossing NB	210m	156m 288m	-26% +37%
Sutton Cross Junction SB Arm	48m	42m 42m	-13% -13%
Strand Road NB Arm	6m	18m 18m	+200% +200%

Table 4.45 Comparison Sensitivity Analysis – Sutton (916) – PM Peak

Location	Baseline MMQ Duration: 00:03:43 Frequency: 3 times / hour	Sensitivity Analysis MMQ 5-min offset Duration: 00:02:38 Frequency: 12 times / hour 7-min offset Duration: 00:05:11 Frequency: 6 times / hour	% Change in Queue Length
Sutton (916) Level Crossing SB	186m	138m 252m	-26% +35%
Sutton (916) Level Crossing NB	180m	132m 246m	-27% +37%
Sutton Cross Junction SB Arm	42m	36m 36m	-14% -14%
Strand Road NB Arm	6m	18m 18m	+200% +200%

The results show that increases in queue lengths may be experienced along the approaches to Sutton (916) Level Crossing.

4.7 Summary of Vehicle Assessment

Queuing depends on two factors – the duration of the closure and the frequency of the closure. An increase in frequency of the closure will not necessarily result in an increase in queueing as the duration of these closures may be shorter and therefore will prevent long queues from forming; if the volume of traffic is able to dissipate within the available opening times. In general, more frequent, shorter openings are likely to perform better than less frequent, longer openings, even if the total open time within the hour decreases.

The frequency of level crossing closures at Kilbarrack (917) Level Crossing will increase from approximately 4 or 5 times per hour to 6 or 12 times per hour. Kilbarrack (917) Level Crossing will operate slightly worse for vehicles as the likelihood of vehicles incurring delay at the level crossing will increase due to the increased frequency of level crossing closures here. The duration of these closures may also increase to varying degrees, depending on the operational timetable. Observed closure times ranged between 2 and 5 minutes during the AM Peak Hour and around 4 minutes during the PM Peak Hour. The closure times are likely to be between 3 and 5 minutes in future during both the AM Peak Hour and the PM Peak Hour with the implementation of TSS1C.

Comparing the mean maximum queue lengths at Kilbarrack (917) Level Crossing and at the Dublin Road/Baldoyle Road Junction, the assessed TSS1C timetable for 6TPHPD shows an increase in most queues, however all remain within the available queueing capacity. The sensitivity analyses show that queue lengths are dependent on the timetable and may increase further depending on the offset but will mostly remain within the available queueing capacity.

At Kilbarrack Level Crossing sensitivity analyses were carried out to test queueing during a reasonable worst-case scenario, assuming a concentrated arrival pattern or a 5-min offset. It was concluded that there is a possibility that a long southbound queue may occasionally form which may block back across the Warrenhouse Road/Dublin Street Junction north of Kilbarrack (917) Level Crossing, during the AM peak hour. In addition, there is a possibility that a long northbound queue may occasionally form that may block back across the Dublin Road/Baldoyle Road Junction south of Kilbarrack (917) Level Crossing during both the AM and PM peak hours.

The frequency of level crossing closures at Sutton (916) Level Crossing will increase from approximately 3 or 4 times per hour to 6 or 12 times per hour. Sutton (916) Level Crossing will operate slightly worse for vehicles as the likelihood of vehicles incurring delay at the level crossing will increase due to the increased frequency of level crossing closures here. The duration of these closures may also increase to varying degrees, depending on the operational timetable. Observed closure times ranged between 4 and 6 minutes during the AM Peak Hour and between 2.5 and 5.5 minutes during the PM Peak Hour. The closure times are likely to be between 2 and 4 minutes in the future during both the AM Peak Hour and the PM Peak Hour with the implementation of TSS1C.

Comparing the mean maximum queue lengths at Sutton (916) Level Crossing and at the Sutton Cross Junction, the assessed TSS1C timetable for 6TPHPD shows a decrease in most queues, and all remain within the available queueing capacity.

The sensitivity analyses show that queue lengths are dependent on the timetable and may increase depending on the offset but will remain within the available queueing capacity.

It is anticipated that Cosh (915) and Claremont (913) Level Crossings will operate slightly worse for vehicles as the likelihood of vehicles incurring delay at the level crossing will increase due to the increased frequency of level crossing closures here. However, it is not expected to have a significant impact in terms of queueing due to the low volumes of vehicles that cross at these level crossings.

4.8 Comparative assessment with other level crossings on the DART Network

4.8.1 Introduction

There are other level crossings operating across the DART network. To better understand how the operational parameters for the Howth Branch level crossings compared to other level crossing operations, a benchmarking exercise was carried out. This exercise compared current level crossing operations along the DART network to the planned level crossing operations along the Howth Branch.

There are existing level crossings at various points along the DART+ West line at six locations – Ashtown, Coolmine, Porterstown, Clonsilla, Barberstown and Blakestown as well as at five locations on the DART+ Coastal South line, at Lansdowne, Sandymount Avenue, Serpentine, Sydney Parade and Strand Road. The existing operational regimes at these locations were compared to the existing and planned operations along the Howth Branch's four locations – Baldoyle Road, Sutton, Cosh and Claremont.

4.8.2 Data Collection

DART West: The "Technical Note: Need for Dart+ West Level Crossing Closures", contains information on the current traffic volumes, closure times and number of closures at the six level crossings along the DART+ West network. The information presented is based on CCTV observations on 22nd March 2019.

DART+ Coastal South: Traffic data surveys were undertaken on 24th May 2022 at the five level crossings along the DART+ Coastal South network. Data on traffic flows, closure times and number of closures were collected.

DART+ Coastal North: Traffic data surveys were carried out on 11th May 2023 at the four level crossings along the Howth Branch line. Data on traffic flows, closure times and number of closures were collected.

4.8.3 Analysis

The DART+ Coastal North level crossings on the Howth Branch are currently closed for approximately 25% of the AM peak hour. In comparison, DART+ West level crossings are currently closed for 40-70% of the AM peak hour and in the case of DART+ Coastal South, the level crossings are currently closed for 45-65% of the AM peak hour.

With the implementation of the DART+ Coastal North project, the Howth Branch level crossing closure durations are predicted to increase to just over 50% of the AM peak hour. This correlates with existing closure times for other level crossings within the network, such as Porterstown (55%) and Clonsilla (52%) on the DART+ West network, as well as Sydney Parade (53%), Sandymount Ave (55%) and Strand Road (45%) on the DART+ Coastal South network (refer to Figure 4.15).

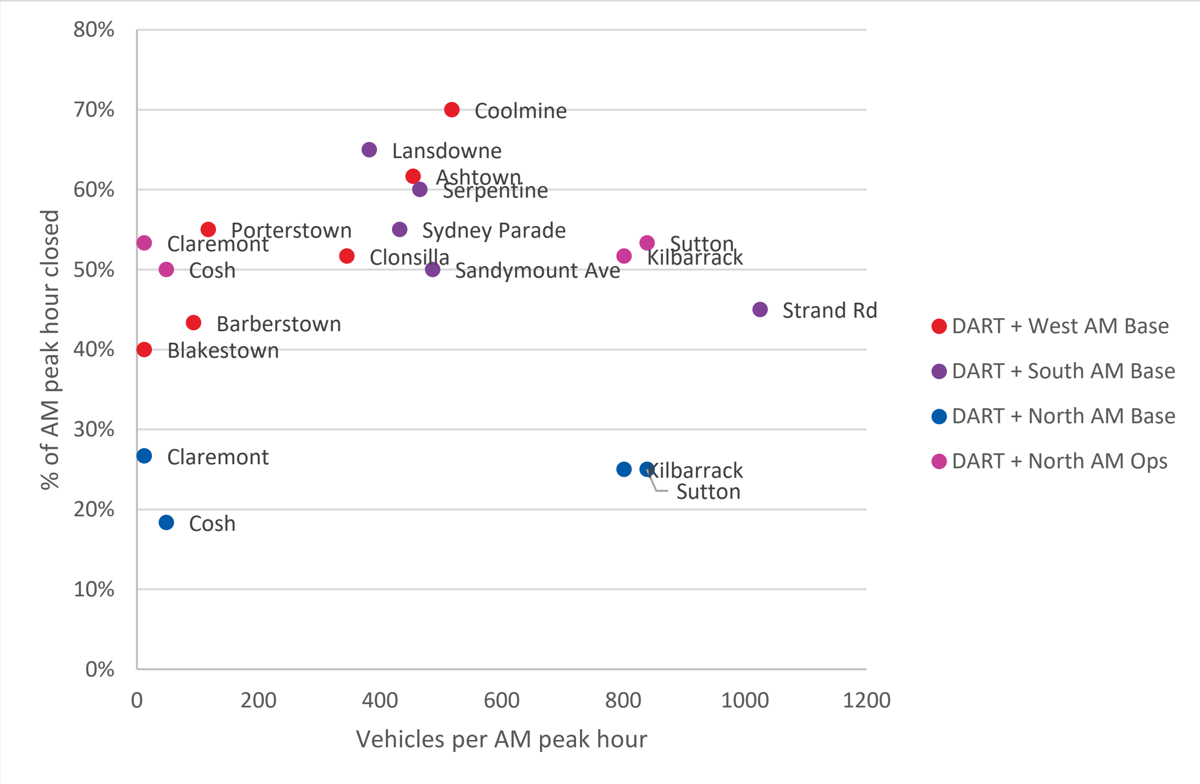

Figure 4-15 % of AM Peak Hour Closed vs Traffic Volume Affected

Traffic volumes at the level crossings across the Howth Branch are currently approximately 1,700 vehicles in the AM peak hour, with the level crossings currently closed for approximately 25% of the time within this peak period. By comparison, at the level crossings along the DART+ Coastal South line, traffic volumes are currently approximately 2,800 vehicles in the AM peak hour, with the level crossing currently closed for approximately 55% of the time within this peak period. With the implementation of DART+ Coastal North, it is envisaged that the traffic volumes would remain relatively the same, but with level crossing closure durations increasing to approximately 50% of the peak hour (refer to Figure 4-16).

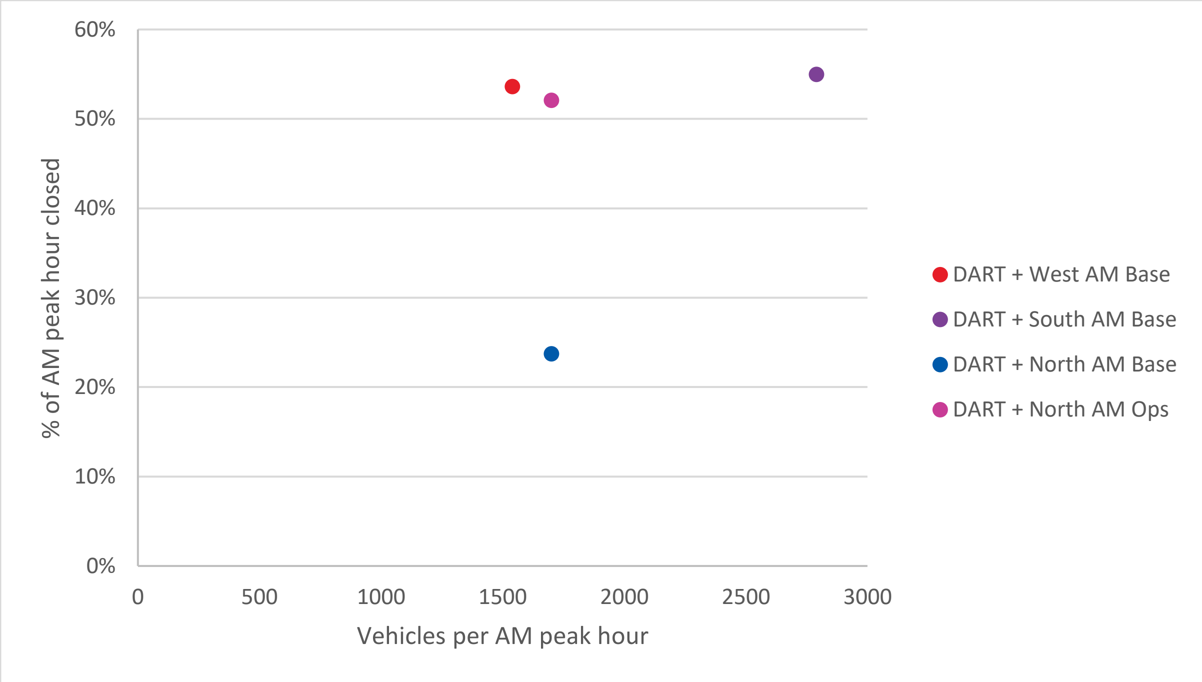

Figure 4-16 % of AM Peak Hour Closed vs Traffic Volume Affected - Summary

We also compared the number of closures of the level crossings on the DART network. Currently the level crossings on the Howth Branch are closed up to 6 times in the AM peak hour. The level crossings on the DART+ West network are currently closed up to 9 times in the AM peak hour and the level crossings on the DART+ Coastal South network are closed up to 12 times in the AM peak hour (refer to Figure 4-17).

With the implementation of DART+ Coastal North, the Howth Branch level crossings are estimated to increase level crossing closure frequencies to between 6 and 12 times in the AM peak hour, equivalent to current level crossing operations on the DART+ Coastal South line.

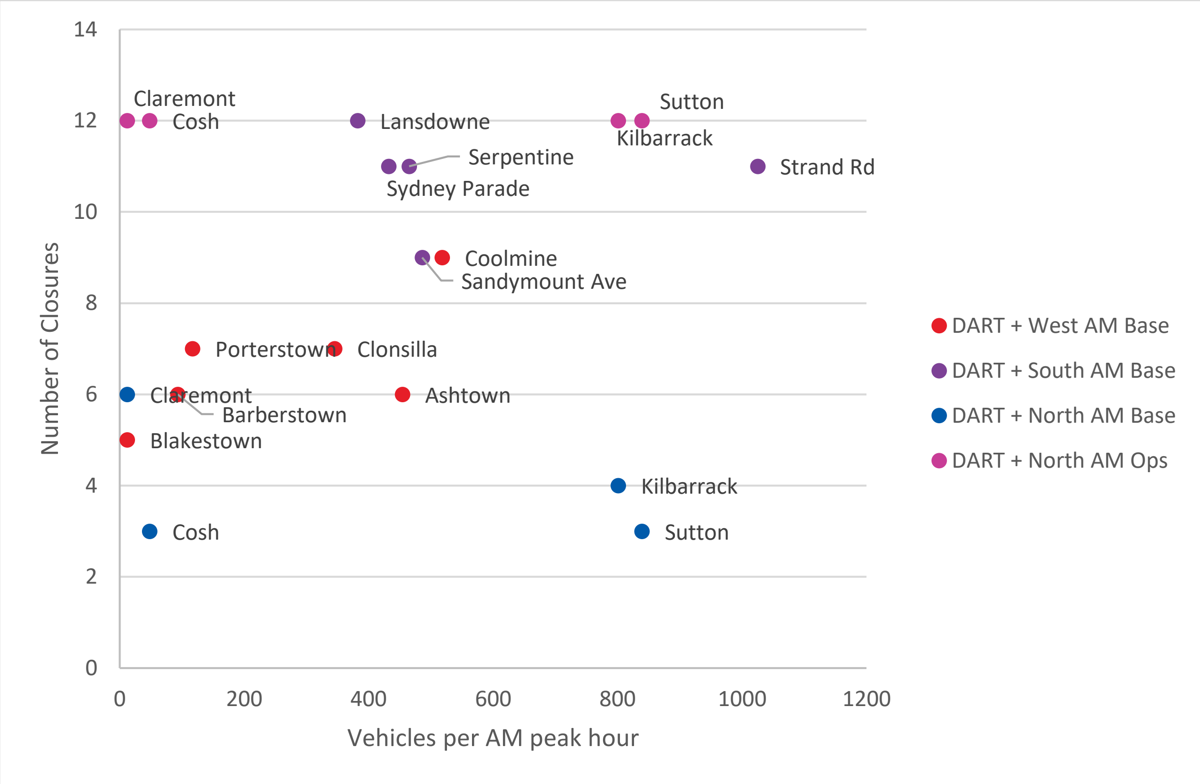

Figure 4-17 Number of Closures vs Traffic Volume Affected

When we compare again traffic levels against numbers of closures, we see that approximately 1,700 vehicles currently cross the Howth Branch level crossings (refer to Figure 4-18) which currently close approximately 6 times in the AM peak hour. The implementation of the DART + Coastal North project will mean that 1,700 vehicles may continue to cross; and closure frequencies may increase to up to 12 times in the AM peak hour in future. This corresponds to current operations on the DART+ Coastal South network, where 2,800 vehicles currently cross; and where level crossings currently close up to 12 times in the AM peak hour.

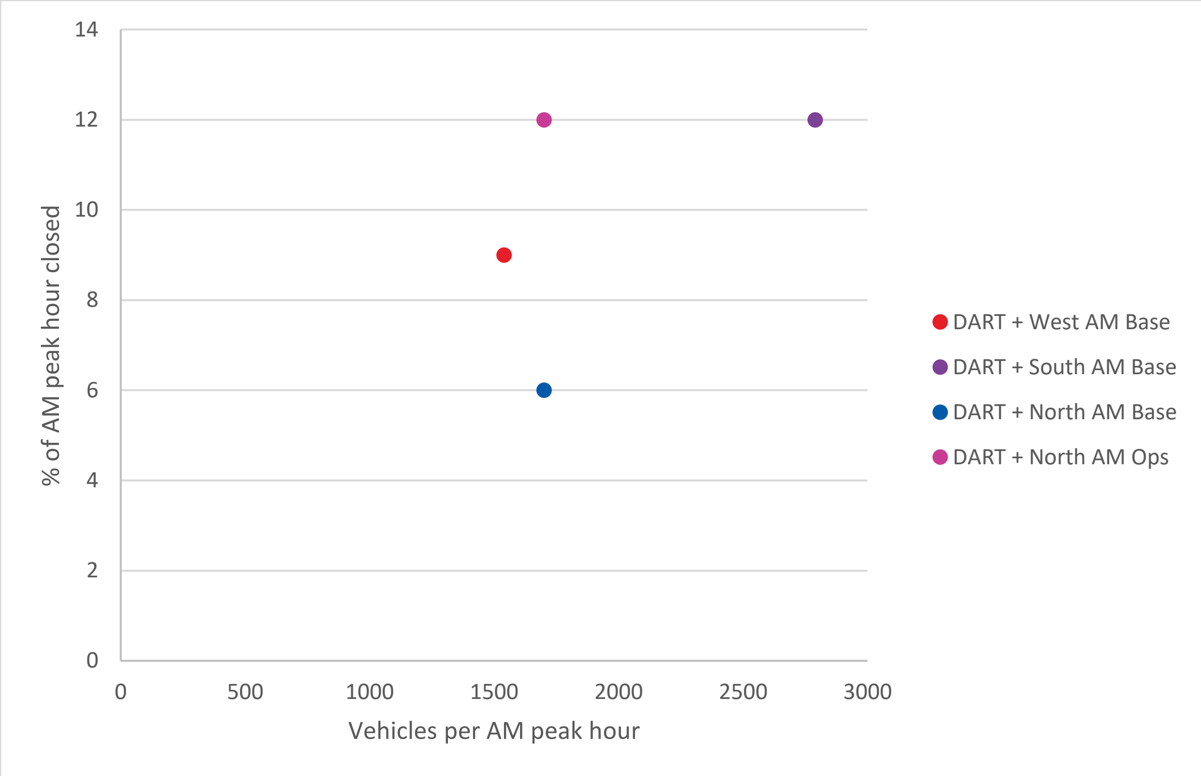

Figure 4-18 Number of Closures vs Traffic Volume Affected - Summary

4.8.4 Findings

There are level crossings across the wider DART network which provide connectivity across the rail line for vehicles, cyclists and pedestrians. These level crossings, under the current operational parameters, are considered to provide adequate levels of service. The implementation of the DART+ programme will increase the capacity and frequency of service within the network. In some parts of the network, there will be a requirement for interventions at level crossings, given the anticipated increase in level crossing closure frequency and durations. However, on the DART+ Coastal North network, on the Howth Branch, while the proposed increased level crossing closure frequency and duration will increase, it will remain in line with, and below, current level crossing closure durations and frequencies in other parts of the network.

5. ASSESSMENT OF PROPOSAL ON PEDESTRIANS AND CYCLISTS AT LEVEL CROSSINGS

In this section of the report, the effect of changes to the operating conditions of the Howth Branch line and associated level crossings on pedestrians and cyclists has been investigated. The baseline service of 3 trains per hour per direction (3TPHPD) and level crossing closures has been compared to the proposed worst-case scenario of 6 trains per hour per direction (6TPHPD TSS1C). All four level crossings were assessed using qualitative analysis methods, similar to the ones used in Section 4.

The assessment looked at the changes to the quality of service for pedestrians and cyclists using the level crossings. The operation and barrier closure times of the level crossings for the baseline 3TPHPD and proposed 6TPHPD TSS1C scenarios are described in Section 4.6.1.

Figure 5-1 Overview of the area of interest for Pedestrian Assessment

5.1 Kilbarrack (917) Level Crossing (XQ001) (Baldoyle Road) Pedestrian Assessment

There are pedestrian footpaths on both sides of the road on Warrenhouse Road and Baldoyle Road, running the full length of both roads. These footpaths also cross the Kilbarrack (917) Level Crossing. Surveys have shown 616 pedestrians per day crossing the level crossing between 06:00 and 20:00, of which 14% are children younger than 16 years of age.

Level crossing closures at Kilbarrack (917) Level Crossing will increase from approximately 4 or 5 times per hour to 6 or 12 times per hour and therefore the likelihood for a pedestrian to encounter a level crossing closure will increase. The wait time at these closures is likely to be around 2 minutes to 5 minutes. These modelled results are summarised in Table 5.1.

Table 5.1 Comparison of Level Crossing Closure Times – Kilbarrack (917)

Kilbarrack (917) Level Crossing	Number of closures per hour	Total closure time per hour	Minimum closure time	Maximum closure time
Baseline 3TPH per direction	5	00:14:31	00:01:41	00:04:35
Proposed 6TPH TSS1C	6 or 12	00:12:50 to 00:30:50	00:02:08	00:05:08

5.2 Sutton (916) Level Crossing (XQ002) Pedestrian Assessment

There are pedestrian footpaths running the full length on both sides of Station Road. These footpaths also cross the Sutton (916) Level Crossing. Sutton Train Station is located adjacent to the level crossing, which would attract pedestrians and cyclists. Fingal County Council is proposing plans to develop the Sutton to Malahide Pedestrian and Cycle Scheme. At this stage, the preferred option for the scheme development is to cross the rail line at the Sutton (916) Level Crossing . This option may require land take as the area is constrained on both sides by private residential and commercial properties. The level crossing itself is also constrained in terms of any possibilities to widen it to construct the required cycling infrastructure. During consultation with Fingal County Council, it was indicated that an alternative option along Lauder's Lane and the coastline may need to be considered.

Surveys have shown 921 pedestrians per day crossing the level crossing between 06:00 and 20:00, of which 11% are children younger than 16 years of age.

Level crossing closures at Sutton (916) Level Crossing will increase from approximately 3 or 4 times per hour to 6 or 12 times per hour and therefore the likelihood for a pedestrian to encounter a level crossing closure will increase. The wait time at these closures is likely to be around 2 minutes to 5 minutes. These modelled results are summarised in Table 5.2.

Table 5.2 Comparison of Level Crossing Closure Times – Sutton (916)

Sutton (916) Level Crossing	Number of closures per hour	Total closure time per hour	Minimum closure time	Maximum closure time
Baseline 3TPH per direction	3	00:11:08	00:03:22	00:04:23
Proposed 6TPH TSS1C	6 or 12	00:13:06 to 00:31:30	00:02:11	00:05:11

5.3 Cosh (915) Level Crossing (XQ003) Pedestrian Assessment

There is only a pedestrian footpath on the west side of Lauder's Lane running the full length of the road. There is also a footpath on the southern side of Burrow Road, just north of the level crossing. Sutton Golf Course is split in two by the railway tracks, with the crossing providing the only way to get between the two sections of the course. As a result, golfers use this crossing regularly throughout the day. There is a footpath on both sides of Cosh (915) Level Crossing. Surveys have shown 510 pedestrians crossing the level crossing between 06:00 and 20:00.

Level crossing closures at Cosh (915) Level Crossing will increase from approximately 3 or 4 times per hour to 6 or 12 times per hour and therefore the likelihood for a pedestrian to encounter a level crossing closure will increase. The wait time at these closures is likely to be around 2 minutes to 5 minutes. These modelled results are summarised in Table 5.3.

Table 5.3 Comparison of Level Crossing Closure Times – Cosh (915)

Cosh (915) Level Crossing	Number of closures per hour	Total closure time per hour	Minimum closure time	Maximum closure time
Baseline 3TPH per direction	3	00:11:13	00:02:16	00:05:13
Proposed 6TPH TSS1C	6 or 12	00:17:58 to 00:30:03	00:02:30	00:05:01

5.4 Claremont (913) Level Crossing (XQ004) Pedestrian Assessment

The Howth Road has a pedestrian footpath on both sides of the road running the full length of the road. These footpaths also cross the Claremont (913) Level Crossing on both sides. The private access road to the north of Claremont (913) Level Crossing has no pedestrian facilities along it. Out of all four of the level crossings this is the least used by pedestrians as it provides access to a small number of residential units. Surveys have shown only 97 pedestrians per day crossing the level crossing between 06:00 and 20:00.

Level crossing closures at Claremont (913) Level Crossing will increase from approximately 5 or 6 times per hour to 6 or 12 times per hour and therefore the likelihood for a pedestrian to encounter a level crossing closure will increase. The wait time at these closures is likely to be around 2 minutes to 5 minutes. These modelled results are summarised in Table 5.4.

Table 5.4 Comparison of Level Crossing Closure Times – Claremont (913)

Location	Number of Closures per hour	Total closure time per hour	Minimum single closure time	Maximum single closure time
Baseline Claremont (913) Level Crossing	6	00:15:47	00:02:38	00:02:38
Proposed Claremont (913) Level Crossing	6 or 12	00:17:08 to 00:31:34	00:02:38	00:04:51

5.5 Summary of Pedestrian Assessment

Level crossing closures will increase from 3 to 6 times per hour to 6 or 12 times per hour and therefore the likelihood for a pedestrian incurring delay at the level crossing will increase. The wait time at these closures is likely to continue to be around 2 minutes to 5 minutes.

6. CONCLUSION

Proposed changes to the Howth Branch line under the DART+ Coastal North project, as defined in the Train Service Specification TSS1C, will enable both a service frequency and capacity increase, along with improvement to the reliability of timetabling. Implementing a DART shuttle service improves the reliability of the Howth Branch as the shuttle service would not be susceptible to delays along the Northern line.

The level crossing closures are highly sensitive to the exact meeting point of trains in any given scenario; having trains cross simultaneously at a level crossing is the best case, as it allows two trains to pass during one closure. By contrast, the worst scenario would be two trains separated by just less than 20 seconds, meaning that the level crossing will be held down for the maximum amount of time.

The effect of these changes on the barrier opening times of level crossings has been assessed for several timetable scenarios, which serves as a sensitivity check to evaluate how differently the level crossings will behave depending on the level of synchronization of rail services; and how this may in turn impact on queues. There is the ability to optimise the timetable around minimising barrier closures to one of the two major road crossings (Sutton or Kilbarrack but not both).

The likelihood of vehicles incurring delay at the level crossing will increase due to the increased frequency of level crossing closures. It was also found that there will be an impact on queue lengths in the study area – in some cases queue lengths may reduce, while, in other cases queue lengths may increase. The sensitivity analysis has shown that queue lengths are likely to remain within the available queueing capacity, in all these cases. Queues may occasionally block back along the Kilbarrack southbound and northbound arms in the AM and PM peak hours depending on the vehicle arrival pattern and/or the train timetable scenario.

Similarly, the likelihood for pedestrians to incur delay at a level crossing will increase. However, the wait time for pedestrians at these closures is likely to continue to be around 2 minutes to 5 minutes.

When the frequency and number of level crossing closures, in the TSS1C is considered, relative to existing level crossing operations across the DART network, the frequency and duration of closure in the future scenario on the Howth Branch, is in line with the existing level crossings on the DART+ West or the DART+ Coastal South line.

Access for emergency services is another consideration in the assessment of level crossings. In terms of emergency services - the areas to the north and south of the rail line are normally served by the Kilbarrack fire station and the requirement to cross the rail line will therefore be rare. For other services there will be additional queues due to longer closure times, however emergency services are able to bypass a general traffic queue and travel up to the level crossing. The likelihood of being delayed at the level crossing will increase due to increased frequency of closures. A number of alternative routes are currently, and will in future, be available to emergency services in case of delays at the level crossing (for example the R104, R107, R139 and R809).

The assessment therefore concludes that the level crossings can continue to operate and provide an appropriate level of cross connectivity and accessibility whilst meeting the increased DART service frequency requirement.