N3 Virginia Bypass **11/10/2021**

Reference number 300568

PHASE 2 TRAFFIC MODELLING REPORT

N3 VIRGINIA BYPASS

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1.1 Background

1.1.1 Virginia is the last remaining town on the N3 National Route from Dublin to the Northern Ireland Border which has not been bypassed.

1.1.2 Congestion is a major problem for many of the 12,000+ vehicles travelling through Virginia Main Street daily and this has significant economic impact for businesses in the town. A high volume of this traffic is commuter traffic or long haul commercial traffic and these bring little or no value to the local economy. Tail backs into the town in excess of between 2 and 3km are a daily occurrence and this adds significant journey times of between 10 to 20 minutes (and more) both morning and evening above the expected journey time when driving through the town.

1.1.3 The existing level of traffic along the N3 between Virginia and Maghera is in the order of 13,000 Annual Average Daily Traffic and the average journey speed demonstrates that the existing single carriageway road does not have the capacity to accommodate the existing traffic flows at a Level of Service D.

1.1.4 The need for a bypass of Virginia was identified by Cavan County Council over thirty years ago and has been included as an objective in successive County Development Plans since then. This need was formally acknowledged by the inclusion of the N3 Virginia Bypass by the National Road Authority in the National Road Needs Study (1998).

1.1.5 The bypass scheme was initiated in 2000 by the National Roads Authority (NRA) and Cavan County Council and the following work has previously been completed;

- Phase 2 - Route Options Selection for the scheme was completed in 2002.
- Phase 3 - Design and Environmental Evaluation for scheme was completed in 2003 and Part 8 Planning was approved on 13th October 2003.
- Phase 4 – Statutory Process documentation was then completed and made ready for lodgement with An Bord Pleanála but the scheme was suspended in 2007 when work commenced on the N3 North of Kells to Cavan Scheme.

1.1.6 Subsequent to the 2003 Part 8 approval for an N3 Virginia Bypass, supplementary reports and other schemes were commissioned to investigate how congestion could be mitigated through N3 Virginia. This included:

- Virginia Bypass as a 2 + 1 scheme (2004 - 2007)
  - Phase 3 of the Project Management Guidelines (Design and Environmental Evaluation) was completed in 2005/2006 for a 2 + 1 road type but the scheme was suspended.
- N3 Edenburt to Cavan (2+2 Type 2 Dual Carriageway scheme) (2008 - 2012)
  - The scheme was suspended prior to completion of the Route Selection process in November 2012. The scheme remains suspended and has not been included in the current National Development Plan (2021 – 2030).

1.1.7 In view of the time that has elapsed since the 2003 Part 8 approval, the significant changes to design standards and environmental considerations and the substantial increase in traffic volumes, a new scheme would be reappraised from the first phase of the planning and design process.

1.2 Purpose of This Study

1.2.1 Virginia town and its environs experiences a level of both local and through traffic using the N3 that is contributing to congestion within the town centre, compounded by the relatively large number of Heavy Goods Vehicles (HGVs) passing through the town and making deliveries within the town. This has contributed to poor safety and environment for non-motorised, in particular vulnerable road users (VRU). The poor VRU safety and environment has been deteriorating within Virginia town centre and its environs, with shorter and intra-town trips that are more conducive to walking and cycling being discouraged and displaced with the prevailing traffic condition. In addition, several sections of the N3 in and around Virginia has been identified as High Collision Locations, with 4 fatal collisions and 10 serious injury collisions noted in the period 2012 – 2016.

1.2.2 Barry Transportation have been appointed to provide multi-disciplinary engineering consultancy services for delivery of the project and they have appointed SYSTRA Ltd to undertake the Project Appraisal, including the transport modelling elements of the project.

1.2.3 The project is currently at the Option Selection Phase (TII PAG Phase 2). This report describes the traffic modelling work undertaken by Systra, for the purpose of informing the selection of a Preferred Option.

1.3 Study Area

1.3.1 The traffic model study area focusses on the town of Virginia, extending south east along the N3 to encompass the town of Kells and North west along the N3 to encompass the village of New Inn. The strategic model area also includes the towns of Ballyjamesduff to the northwest and Bailieborough to the northeast.

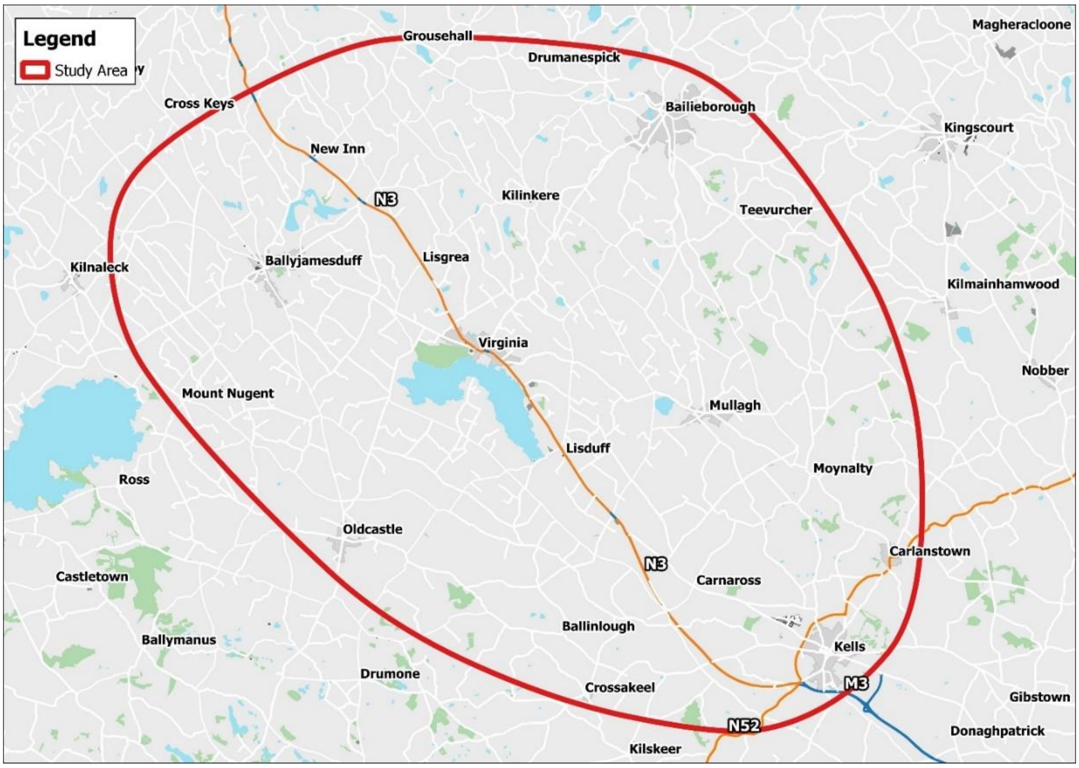


Figure 1-1 Study Area

1.4 Existing Conditions

Typical Journey Times

1.4.1 As mentioned above, congestion is a major problem for traffic travelling through Virginia Main Street daily and this has significant economic impact for businesses in the town. Tail backs into the town in excess of between 2 and 3km are a daily occurrence and this can add significant time above the expected journey time when driving through the town. Anecdotal evidence from locals suggest that congestion is at its worst during the Friday evening peak hour.

1.4.2 Traffic survey data which was commissioned for this project during September/October 2020 backs this up. Some Journey times were extracted for a northbound and southbound route through Virginia town between two points (Lisduff and Lisgrea as shown in the map below).

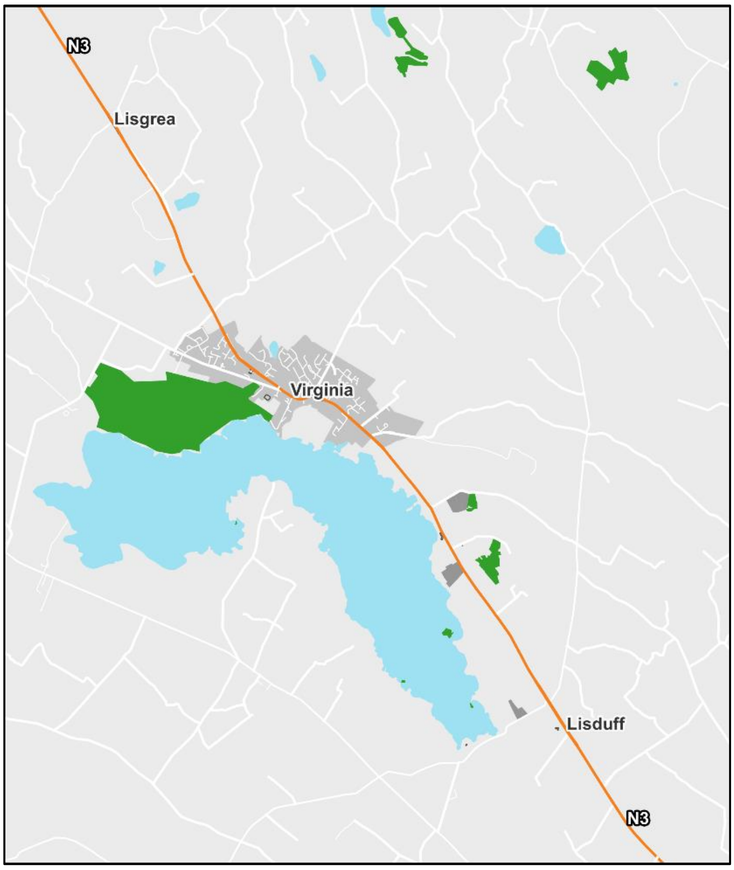


Figure 1-2 Journey Time Routes along the N3 between Lisduff and Lisgrea

1.4.3 Data from Friday the 25th of September 2020 showed that traffic travelling through the town in the northbound direction was 6 minutes slower during the evening peak hour (approx. 14 ½ minutes) compared with the average time taken outside of the peak hours (approx. 8 ½ minutes). Over the 9km distance between Lisduff and Lisgrea, this equates to an average speed of 37 kph during the Friday evening peak hour versus 64kph outside of the peak hours.

1.4.4 As the traffic surveys were undertaken during a period in which the country was under Level 3 travel restrictions (which involved limited numbers for social gatherings and advising people to not travel outside their county, amongst other restrictions), the data does not represent the typical scenario. So the same exercise was undertaken in Google Maps for a typical Friday evening during the peak hour. It suggests that for the same route, taken on a Friday after 4pm can take anywhere between 16 – 30 minutes as shown below. This equates to an average speed over the 9km distance of between 18 – 34 kph and is double the 14 ½ minute journey time from the 2020 traffic surveys mentioned above.

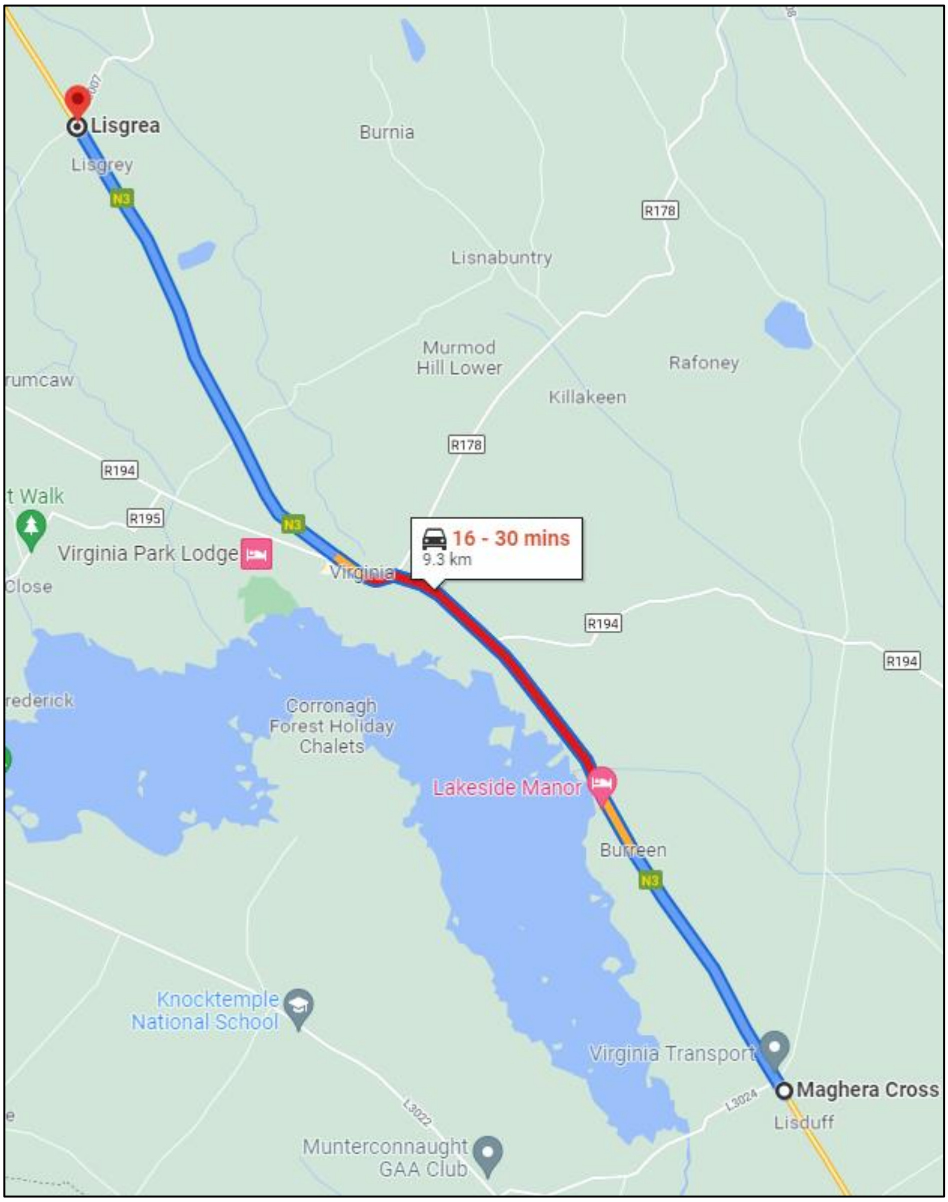


Figure 1-3 Northbound route through Virginia town on a typical Friday evening as suggested by Google Maps ©

1.4.5 The same exercise was undertaken for the equivalent route in the southbound direction along the N3. Data from Thursday the 8th of October 2020 showed that traffic travelling through the town in the southbound direction was 5 minutes slower during the evening peak (approx. 14 minutes) compared with the average time taken outside of the peak hours (approx. 9 minutes). Over the 9km distance between Lisgrea and Lisduff, this equates to an average speed of 38 kph during the evening peak hour versus 60kph outside of the peak hours.

1.4.6 As mentioned above, these surveys were undertaken during a period where travel restrictions were in place and don't represent the typical scenario. So the same exercise was undertaken in Google Maps and suggests that for the same route, on a typical Thursday evening after 4pm can take anywhere between 10 – 18 minutes as shown below. This equates to an average speed over the 9km distance of between 30 – 54 kph and is 4 minutes slower than the journey time from the 2020 traffic surveys mentioned above.

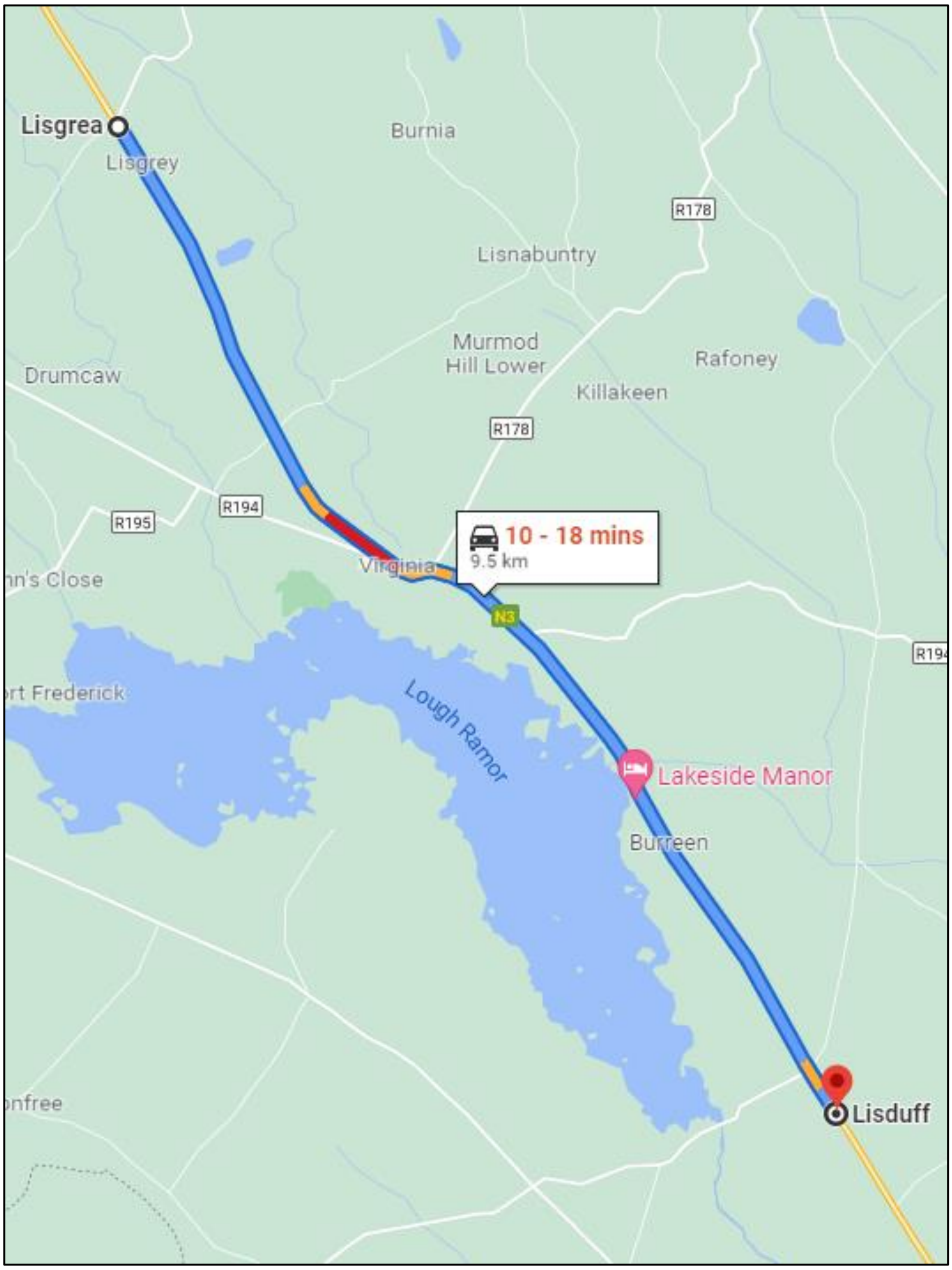


Figure 1-4 Southbound route through Virginia town on a typical Thursday evening as suggested by Google Maps ©

Analysis of traffic profiles

1.4.7 A TII Traffic Monitoring Unit (TMU) is located on the N3 within the study area, between Derver roundabout in Co. Meath and Maghera, Co. Cavan An analysis of the weekly traffic profile from this N3 TII traffic counter (for 2019 – pre Covid-19 movement restrictions) is shown below in Figure 1-5.

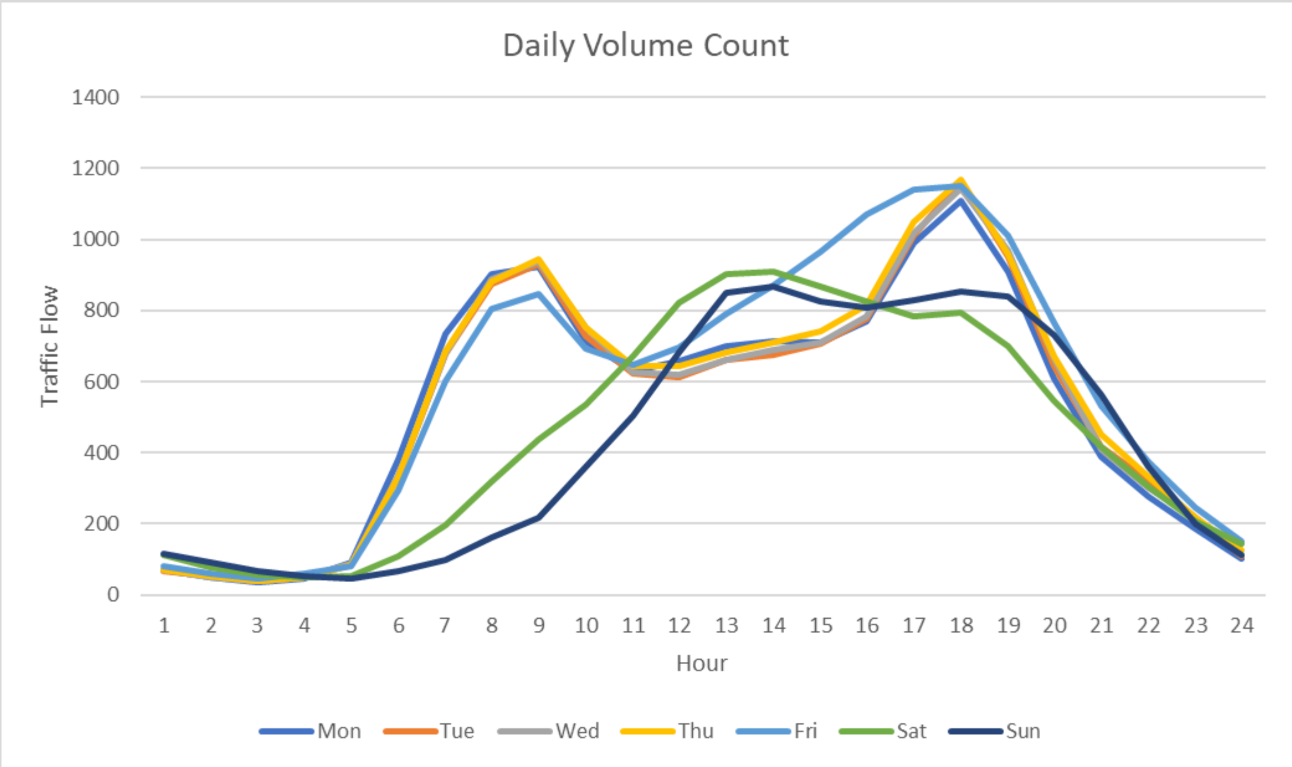


Figure 1-5 ATC Traffic Profile

1.4.8 The graph above highlights the following points–

- The daily profile above is similar to that which would be observed on many roads in Ireland, with two peaks (morning and evening) during the weekdays (implying significant commuter flows), and the PM having higher levels of two-way traffic (implying a wider mix of purposes than simply the return flow of AM peak commuters). But the weekend days also show a high afternoon flow which would be representative of shopping patterns.
- Friday conditions are markedly different from other weekdays, with a lower morning peak at 8am and higher flows leading up to the PM peak (a longer peak period).
- The remaining weekdays show a similar pattern, with some day-to-day variations.

P Factor

1.4.9 TII PAG Unit 16.1 (October 2016): Expansion Factors for Short Period Traffic Counts, discusses the daily profile of traffic and the concept of 'peaky' or 'flat' profiles. The unit states that 'In order to represent the 'Peakiness' of a traffic flow profile over a particular day, the concept of a 'p-factor' has been derived. The p-factor simply describes the scale of the reduction in flow between the AM Peak and the quietest period of the afternoon (the Inter-Peak), and from the Inter-Peak back up to the PM Peak'. It is defined as follows:

$$p = a + b - 2c$$

- Where: p = the peakiness index
- a = the maximum hourly proportion of traffic between 00:00 and 12:00 on a weekday

- b = the maximum hourly proportion of traffic between 12:00 and 24:00 on a weekday
- c = the minimum hourly proportion of traffic between 08:00 and 18:00 on a weekday

1.4.10 The 'p-factor' has been calculated as 0.061 for the N3 based on the daily traffic profile illustrated in Figure 1-5. PAG Unit 16.1 states that "the maximum p-factor is 1.0, in which case all traffic flow would occur during 2 individual peak hours of the day, separated by a cessation of all traffic during the afternoon.

1.4.11 The national mean p-factor taken from the Permanent counters located throughout out the country was found to be 0.071. The p-factor for the N3 is lower than the mean p-factor nationally which would indicate slightly higher inter peak traffic levels.

1.5 Proposed Options

1.5.1 Five main bypass options have been identified within the scheme study area, as shown in the figure below, which are to be appraised according to the TII Project Appraisal Guidelines, Phase 2, Option Selection.

- **Option A** - This option was originally envisaged as an online upgrade option. During the Stage 2 assessment process, it became evident that such an upgrade would not meet the objectives of the scheme. The option was then amended so that it would encompass an online upgrade for a distance of approximately 3km, south of Maghera. From there it veers to the northwest to join the Option C alignment at Carrigabruise. The option crosses the R194 Mullagh Road at Cornashesk and the R178 Bailieborough Road at Aghnadrung. It follows the Option C alignment for a distance of approximately 8.5km, veering to the north west to meet the existing N3 at Cornaslieve north of Virginia. From here the option would consist of an online upgrade, passing through Lisgrea Cross before terminating approximately 400-500m to the north of the crossroads. It crosses the Blackwater River once, north of Virginia. Link roads from the existing N3 to the option at Burrencarragh and from the R194 Ballyjamesduff Road to the option at Cornaslieve were also investigated for this option.
- **Option B** - This option is approximately 18.5km in length and commences at the N3/R147 roundabout at Derver. It is the only option that passes to the west of Virginia town and Lough Ramor. From Derver the option goes in a south-westerly direction, crossing the Blackwater River and veering to the north west after approximately 2km. The option crosses the Cross Water River and passes through Munterconnaught. It crosses the R195 Oldcastle Road at Eighter, before veering to the north east and crossing the R194 Ballyjamesduff Road at Lurgan. It crosses the Dunancory River before meeting the existing N3 north of Lisgrea Cross.
- **Option C** - This option is approximately 14.7km in length and commences at the N3/R147 roundabout at Derver. It passes to the east of Virginia town and Lough Ramor. From Derver the road follows roughly parallel to the existing N3, before veering slightly more to the north at Carrigabruise townland. The option crosses the R194 Mullagh Road at Cornashesk and the R178 Bailieborough Road at Aghnadrung. It crosses the Blackwater River three times north of Virginia before meeting the existing N3 north of Lisgrea Cross. This Option also includes Link roads from the existing N3 close to the northern and southern tie-ins, at Burrencarragh to the south of Virginia

and from the R194 Ballyjamesduff Road to the option alignment at Cornaslieve north of Virginia town.

Approximately 60% of the option is common to the route of the N3 Virginia Bypass which achieved Part 8 planning approval in 2003.

- **Option D** - This option is approximately 15.2km in length and commences at the N3/R147 roundabout at Derver. It passes to the east of Virginia town and Lough Ramor. From Derver the road passes first in a northerly, then north westerly direction, roughly parallel to the existing N3. The option crosses the R194 Mullagh Road at Cornashesk and the R178 Bailieborough Road at Curracloghan. The option crosses the Blackwater River once, north of Virginia, and meets the existing N3 north of Lisgrea Cross.
- **Option E** - This option is approximately 15.5km in length and commences at the N3/R147 roundabout at Derver. It passes to the east of Virginia town and Lough Ramor. From Derver the road passes in an approximately northerly direction, then veering north westerly, roughly parallel to the existing N3. The option crosses the R194 Mullagh Road at Corfad and the R178 Bailieborough Road at Cornashesk. It crosses the Blackwater River once, north of Virginia, and meets the existing N3 north of Lisgrea Cross.

1.5.2 In addition to the core options above, multiple option variations (combinations of sections from the core options) have also been assessed.

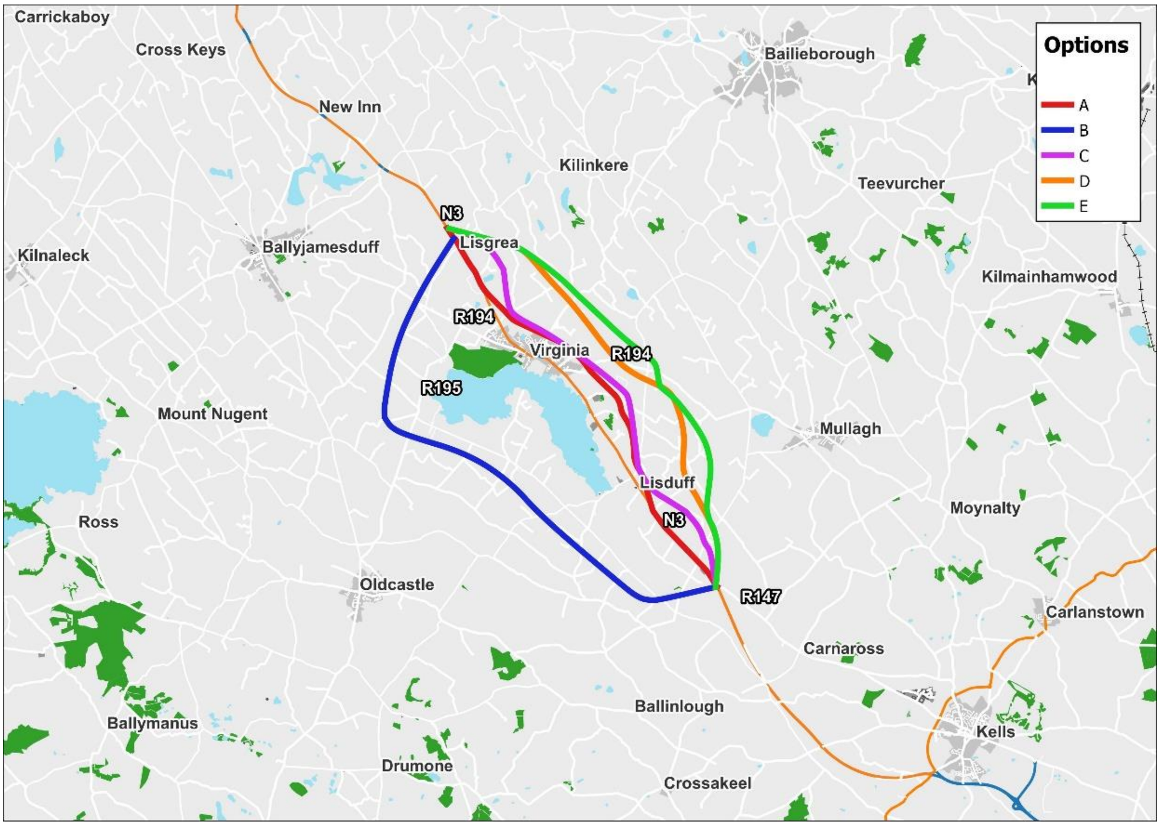


Figure 1-6 All Options

1.6 Modelling Overview

Base Year Model Development

1.6.1 The National Transport Authority (NTA) East regional model (ERM) has been used as a starting point for the development of the single project Local Area Model (LAM) for the appraisal of scheme options. The ERM is a multi-modal transport model based in SATURN and CUBE Voyager covering the east of the country (Leinster). While the model focuses on Dublin, Cavan is included and exists on the periphery.

1.6.2 The highway element of the ERM provides the basic road network, zoning structure, trip matrices and traffic growth forecasts for the development of the LAM. Hence the Virginia LAM has been developed using SATURN strategic modelling software.

1.6.3 The ERM has also been used to identify the area of influence of the scheme and the associated study area for the LAM. The study area captures any potential competition with alternative routes or rerouting of traffic as a result of the proposed scheme. This study area has been cordoned from the ERM base models to form the initial LAM. The cordoned version of the LAM was then refined with additional detail added where necessary to ensure the physical characteristics of the road network are reflective of the existing network.

1.6.4 The zoning structure of the LAM was also refined at this stage. The ERM zonal structure is based on the CSO Electoral Divisions (ED) boundaries with each zone containing one or more EDs. These zones have been refined based on the CSO small area boundary system for consistency, to allow demographic data to be linked to each LAM zone.

1.6.5 Once the LAM road network and zone structure were appropriately refined the model was calibrated and validated against observed data in accordance with criteria set out in PAG Unit 5.1.

Time Periods Modelled

1.6.6 For the purposes of this Study, a Local Area Model has been developed for the following time periods:

- AM Peak Hour
- Average Inter-Peak Hour
- PM Peak Hour

Forecast Year Models

1.6.7 Future growth in travel demand for the LAM has been taken from the ERM for the assessment years for this project (2028 and 2043). Annualised external (external zones of the LAM) growth rates have been calculated by cordoning the modelled study area from the future year ERM models which provide traffic forecasts through the study area. Internal (zones within the LAM) growth rates have been based on the ERM zonal growth rates between base year and future year. This internal growth was proportioned between the disaggregated LAM zones based on base year proportions or in accordance with relevant planning information (Development Plans, LAPs, etc) where appropriate. These growth rates are then applied to the calibrated base year matrices in order to create future year highway demand matrices.

1.7 Report Structure

1.7.1 The remainder of this Report is structured as follows:

- **Chapter 2- Data Collection:** summarises all the data that was used to calibrate and validate the Virginia Local Area Model (LAM);
- **Chapter 3 - Model Development:** describes the development of the base year Virginia LAM;
- **Chapter 4 - Model Calibration:** summarises the calibration results comparing them back to the surveyed traffic data;
- **Chapter 5 - Model Validation:** summarises the validation results comparing them back to the surveyed journey times and count information;
- **Chapter 6 - Future Year Model Development:** sets out the development of the future year ERM and Virginia LAM models for the scheme opening and design years;
- **Chapter 7 - Analysis of Options:** summarises the performance of each option based on certain key performance indicators;
- **Chapter 8 - Emerging Preferred Option:** provides the results of the multiple criteria process and details the preferred option that has been selected;
- **Chapter 9 - Summary and Conclusion:** summarises the key points in the traffic modelling report.

2. DATA COLLECTION

2.1 Summary

2.1.1 A comprehensive set of traffic count data was collected and used to calibrate and validate the Virginia LAM. This chapter provides an overview of the data collection exercise undertaken to facilitate this model development process.

2.1.2 These traffic surveys were carried out In September and October 2020 and, in summary, included the following:

- Automatic Traffic Count (ATC) data at 26 locations covering two consecutive weeks;
- Junction Turning Count (JTC) data at 33 locations;
- Journey Time Surveys along 3 routes in the study area;
- And Origin Destination Surveys at 26 locations.

2.2 Automatic Traffic Counts

2.2.1 ATC's were undertaken at 26 locations across the network, as illustrated in the figure below, over a 2-week period from the 21st of September to the 4th of October. The ATC data provides information on:

- The daily and weekly profile of traffic within the study area;
- Busiest time periods and locations of highest traffic demand on the network;
- Any issues on the network during the survey period e.g. accidents, road closures etc; and
- Typical speed of traffic on the network.

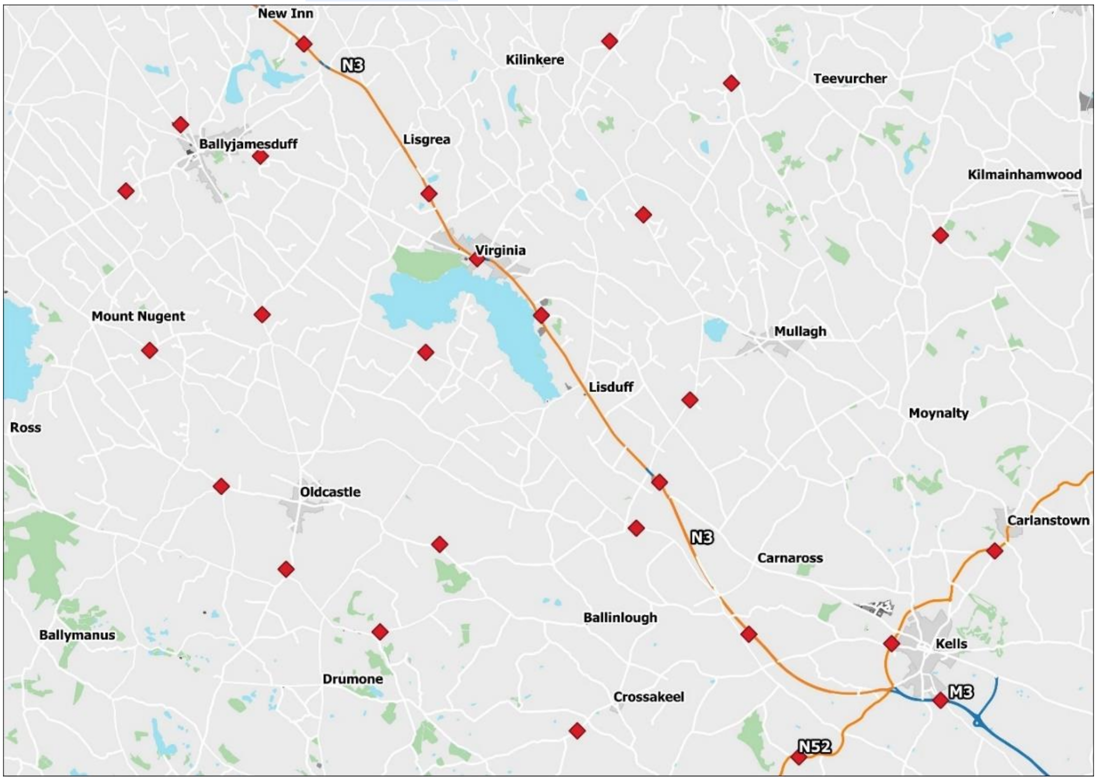


Figure 2-1 Traffic Count ATC Locations

2.3 Junction Turning Count Surveys

2.3.1 JTC's were undertaken at 33 locations across the network, illustrated the figure below. All JTC sites were surveyed on the 22nd of September and summarised by 15 minute time intervals.

2.3.2 As indicated in the Figure below, all the main junctions within the study area have been included and provide information on the volume, and types of vehicles, making turning movements at each location. This data is utilised within the LAM calibration to ensure that the flow of vehicles through the main junctions on the network is being represented accurately.

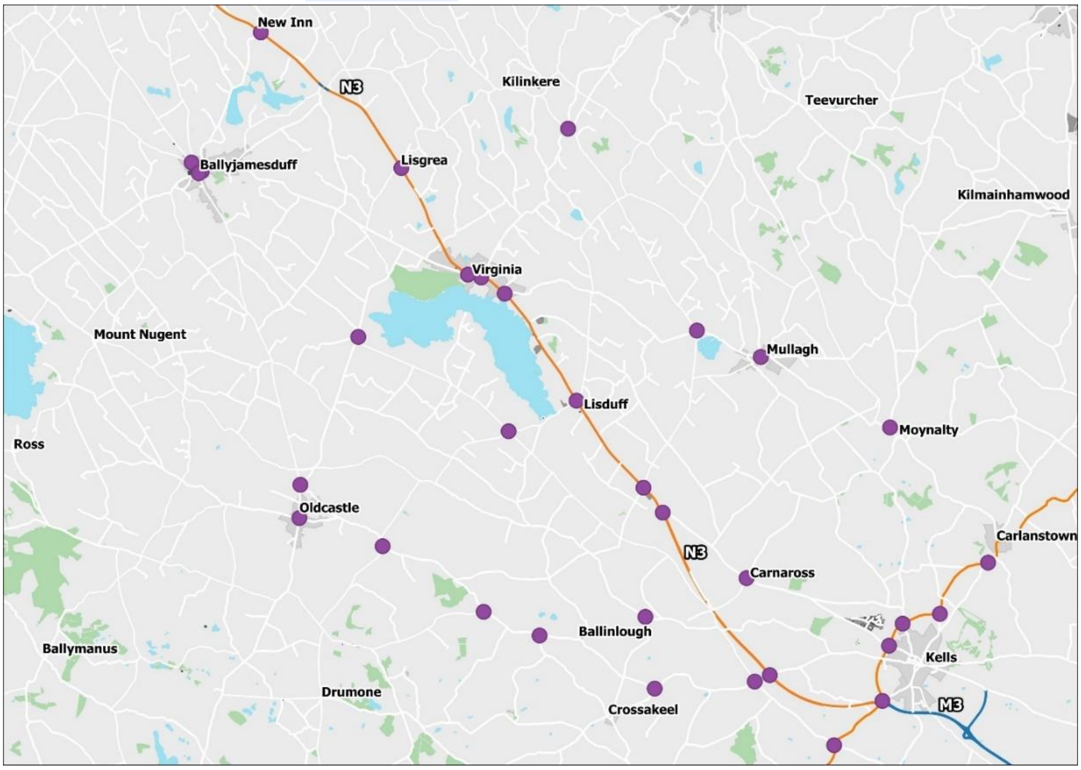


Figure 2-2 Traffic Count JTC Locations

2.4 Journey Time Surveys

2.4.1 In addition to the above traffic count data, journey time validation has also been undertaken along a series of key routes through the area. These are utilised in order to ensure that delays experienced on the network are accurately replicated in the model. Figure 2-3 details the three journey time routes that have been compared to observed data, ensuring that the model accurately represents existing travel times. All routes are 2-way (both-directions) and travel time data was collected over 12 hours from 7am to 7pm.

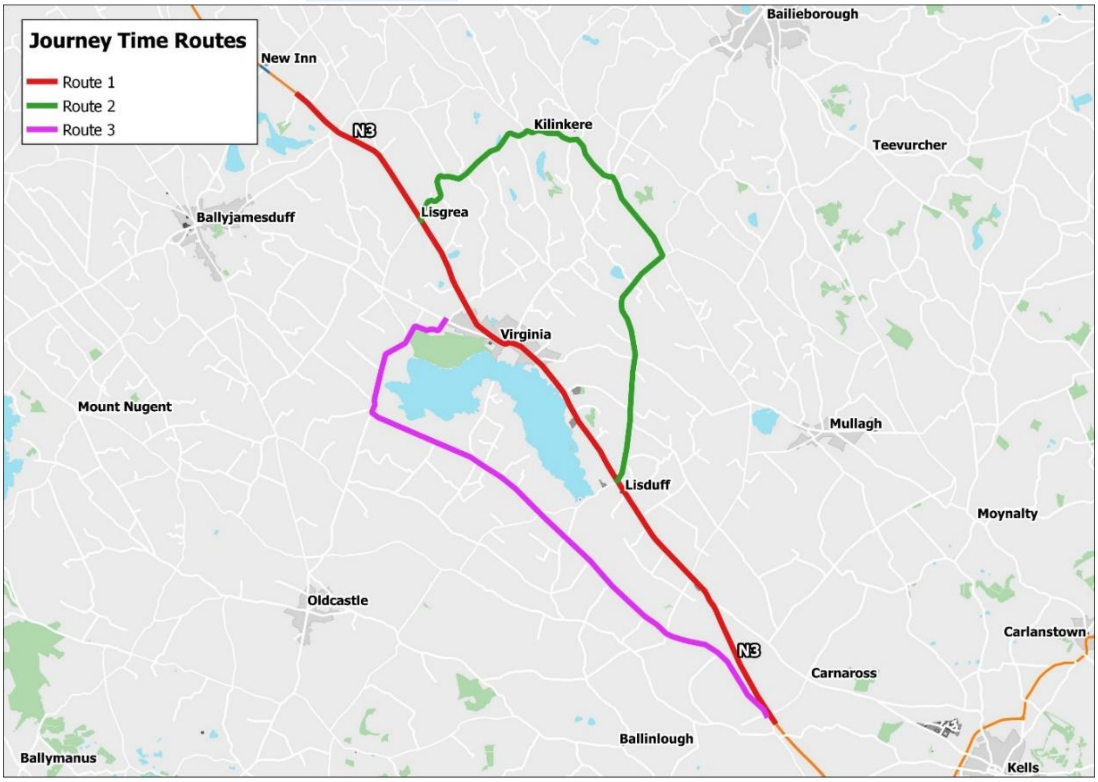


Figure 2-3 Journey Time Routes

2.5 Origin Destination Surveys

2.5.1 Automatic Number Plate Registration (ANPR), origin-destination, surveys were carried out at 26 locations as indicated in the figure below.

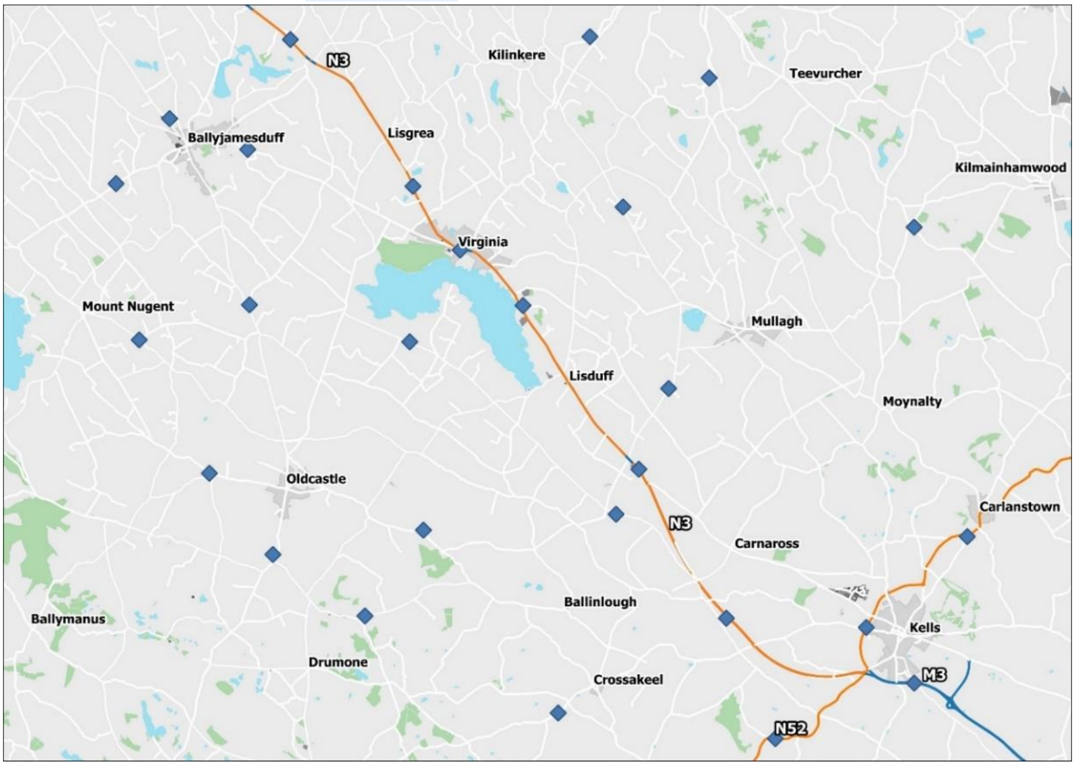


Figure 2-4 O-D Survey Sites

2.6 Impact of Covid-19 restrictions

2.6.1 In response to the COVID-19 pandemic, the Irish Government imposed restrictions on the movement of people in order to contain the spread of the virus. This commenced with the closure of all schools and colleges from March 13th 2020. Further restrictions, involving the retention of essential services only, were announced on March 24th 2020. On the evening of Friday March 27th 2020, a Government announcement was made which advised all citizens to stay at home and to only leave their homes for a limited number of reasons. The restrictions implemented by Government in order to tackle the spread of the COVID-19 virus have had significant impact on national road traffic volumes which have reduced by up to 70% when compared to the same time last year.

2.6.2 Since this, the Government developed a national framework for living with COVID-19. This included a 5 level system for re-opening society and business. As the country changed levels, restrictions were removed which has seen a corresponding increase in traffic levels, however, in general, traffic levels and patterns are yet to return to similar levels observed prior to Covid-19 restrictions.

2.6.3 The traffic surveys that were used to develop the Virginia LAM were undertaken during the last week of September and the first week of October in 2020. The majority of the country was under "Level 3" travel restrictions at this time which involved limited numbers for social gatherings and advising people to not travel outside their county, amongst other restrictions. Therefore, as these restrictions will have resulted in non-typical travel patterns within the study area, an analysis of TII's Traffic Monitoring Units (TMU) has been undertaken to establish the impact.

2.6.4 The analysis illustrated below compares the average weekday traffic that travelled through the TMU (on the N3 just south of Virginia town) for the 2 week period that the counts were undertaken in 2020 versus the same 2 week period in 2019.

2.6.5 The figure below shows a consistent profile in both years with a drop in traffic across the whole day during 2020 compared with the same period in 2019. The AM peak hour in 2020 shows a decrease of 13% compared to 2019 while the PM peak hour shows an 11% drop compared to 2019. The full 24 hour flows in 2020 are 12% lower than in 2019.

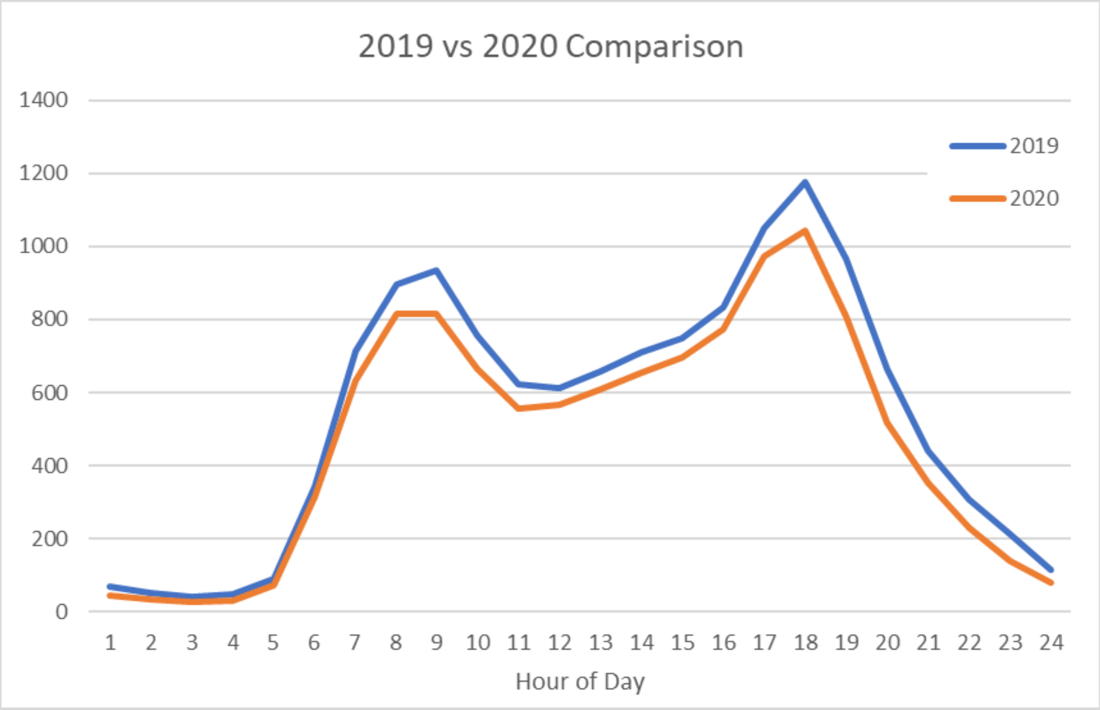


Figure 2-5 N3 (South of Virginia) TII Traffic Counter Data Analysis

2.6.6 This analysis shows that the 2019 and 2020 traffic flows show a similar profile, however the 2020 traffic flows are approximately 12% lower than those in 2019 (pre Covid 19 Movement Restrictions). As a result of this, the forecast AADTs output from the models (which have been calibrated to 2020 data) are likely to be approximately 12% lower than if the model had been developed using “typical” or Pre-Covid Traffic data. Additionally, it follows that the calculated benefits of each option are also likely to be underestimated.

2.6.7 Notwithstanding the above, the Virginia Local Area Model developed will still provide a robust and consistent platform with which to assess the various options during Phase 2 of this project. During Phase 3, the models will be updated using survey data collected when Covid-19 travel restrictions have been removed and new travel patterns have been established.

3. MODEL DEVELOPMENT

3.1 Introduction

3.1.1 This chapter describes the development of the base year Virginia Local Area Model (VLAM) with reference to the following aspects:

- Modelling software used;
- Model time periods; and
- Network development.

3.2 East Regional Model (ERM) Overview

3.2.1 The ERM is a strategic multi-modal transport model representing travel by all the primary surface modes – including, walking and cycling (active modes), and travel by car, bus, rail, tram, light goods and heavy goods vehicles, and broadly covers the eastern side of the country with a focus on Dublin.

General Model Structure

3.2.2 The ERM sits within the overall NTA Regional Modelling System which comprises of the following three main components, namely:

- The National Demand Forecasting Model (NDFM);
- 5 Regional Models (including the ERM); and
- A suite of Appraisal Modules

3.2.3 The NDFM takes input land-use attributes such as population, no. of employees etc., and estimates the total quantity of daily travel demand produced by, and attracted to, each of the 18,488 Census Small Areas in Ireland.

3.2.4 The ERM is comprised of the following key elements:

- **Trip End Integration:** The Trip End Integration module converts the 24 hour trip ends output by the NDFM into the appropriate zone system and time period disaggregation for use in the Full Demand Model (FDM);
- **The Full Demand Model (FDM):** The FDM processes travel demand, carries out mode and destination choice, and outputs origin-destination travel matrices to the assignment models. The FDM and assignment models run iteratively until an equilibrium between travel demand and the cost of travel is achieved; and
- **Assignment Models:** The Road, Public Transport, and Active Modes assignment models receive the trip matrices produced by the FDM and assign them in their respective transport networks to determine route choice and the generalised cost for each origin and destination pair.

3.2.5 Destination and mode choice parameters within the ERM have been calibrated using two main sources: Census 2016 Place of Work, School or College - Census of Anonymised Records (2016 POWSCAR), and the Irish National Household Travel Survey (2016 NHTS). Therefore, the ERM is the ideal tool to cordon the LAM from, and to estimate the multi-modal impact of transport schemes within the study area. In addition, it provides the platform to forecast the future trip demand and distribution to/from the area.

3.3 Model Software Platform: SATURN

3.3.1 The model software used to develop the Virginia LAM is the SATURN (Simulation Assignment of Traffic to Urban Road Networks) suite of transportation modelling programs.

3.3.2 SATURN has 6 basic functions:

1) As a combined traffic simulation and assignment model for the analysis of road-investment schemes ranging from traffic management schemes over relatively localised networks (typically of the order of 100 to 200 nodes) through to major infrastructure improvements where models with over 1,000 junctions are not infrequent;

2) As a "conventional" traffic assignment model for the analysis of much larger networks (e.g., up to 6000 links in the standard PC version, 37,500 in the largest);

3) As a simulation model of individual junctions;

4) As a network editor, database and analysis system;

5) As a matrix manipulation package for the production of, for example, trip matrices; and

6) As a trip matrix demand model covering the basic elements of trip distribution, modal split, etc.

3.4 Model Time Periods and User Classes

3.4.1 The standard model time period for traffic simulation and assignment models is one hour and therefore model development and data collection was carried out based on this assumption.

3.4.2 Through a review of survey data, it was noted that the highest traffic flows entering and leaving the area were experienced from 08:00 to 09:00 in the AM, 17:00 to 18:00 in the PM and the average hour between 10:00 to 16:00 for the IP period. Therefore, the LAM was developed, calibrated and validated to represent the following time periods:

- AM Morning peak period: 08:00 to 09:00
- PM Evening peak period: 17:00 to 18:00
- Average Inter peak period: 10:00 to 16:00

3.4.3 The trip demand matrices for these time periods, representing a base year of 2020, were developed for the LAM using extractions from the ERM combined with survey data. The demand matrices are segregated into two vehicle types (or user classes), as follows:

- User Class One - Cars and light Goods Vehicles (LV's). All cars and two axle trucks or other type commercial vehicles are considered LV's; and
- User Class Two - Heavy Goods Vehicles (HV's). This user class is comprised of goods vehicles with 3 or more axles.

3.5 Network Development

3.5.1 The goal in developing the LAM was to create a model that accurately reflects current traffic conditions in the traffic model study area (illustrated in Figure 1-1 previously) for the 2020 base year, and to a sufficient level of detail to allow the appraisal of each option. To achieve this goal, the model must be defined in terms of road network and trip demand representation.

3.5.2 The ERM was utilised as a donor model for generating the initial highway network for the LAM. Additional network and junction detail was then added to Local Area Model Network. The road network, represented in the ERM, is outlined in Figure 3-1 below. The network structure included in this area of the ERM represents the majority of significant roads in the area.

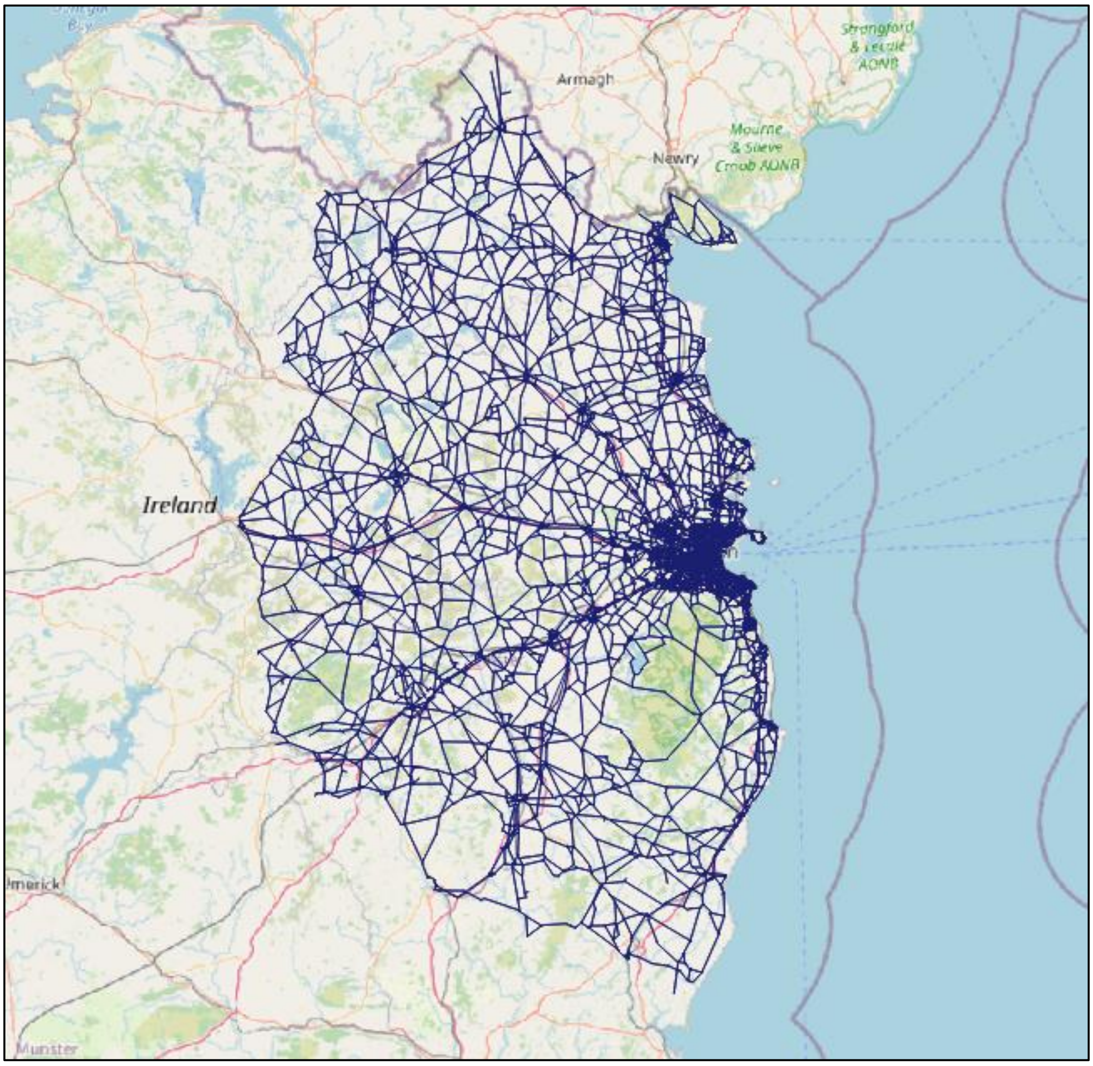


Figure 3-1: ERM Highway Network

3.5.3 The ERM coding of the network within the study area consists of entirely SATURN buffer coding. Buffer coding represents a low detail method of accounting for peripheral networks, Links are modelled using speed-flow relationships, with no junction detail included. Furthermore, buffer coding is not capable of modelling delay or the interaction of turning flows at junctions.

3.5.4 As such, in the development of the LAM, the study area was upgraded from buffer network to a simulated network, enhancing the modelled road network to better represent localised access points for traffic. As part of the regional model development process for the NTA, a review of traffic modelling processes was undertaken, which generated a best practice approach for coding road networks, including:

- Standardised turning saturation flows at junctions;
- Standardised speeds used on different types of road;
- The use of flares for turns at junctions with sufficient space etc.

3.5.5 This best practice approach was utilised to generate the detailed traffic network for the LAM, reviewing existing link detail and adding junction detail. Digital mapping systems such as Google Earth were used to get a high-level view of the network including junction layout details, such as permitted or banned turns, junction priority etc., to ensure it represented, as accurately as possible, the existing road network.

3.5.6 Figure 3.2 illustrates the newly developed road network for the LAM. To ensure full network coverage and route choice, most roads in the study area have been considered, from the national primary routes to more minor regional roads. The short dead-end links in the figure below are "spigots" used to load traffic from the zones onto the network, and reflect the further developed zone network that is discussed in more detail in section 3.6 below.

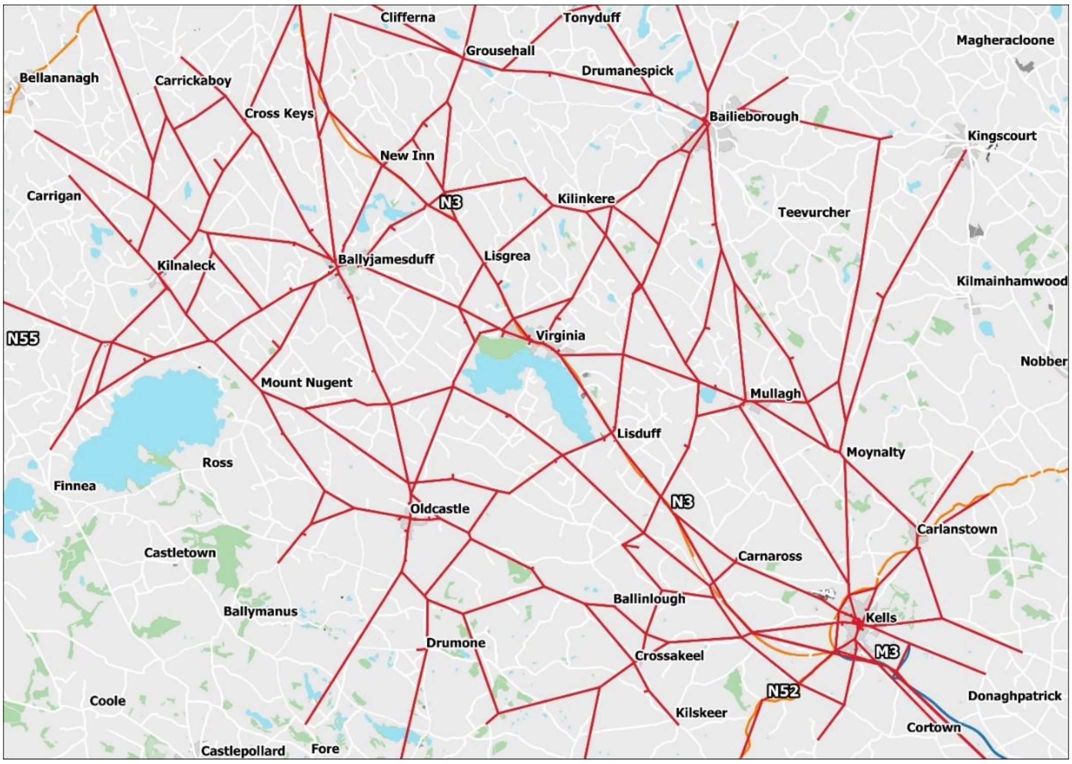


Figure 3-2: LAM Highway Network

3.6 Model Zone System and Prior Matrix Development

Introduction

3.6.1 This section describes the development of the base LAM prior trips matrix with reference to the following aspects:

- Zone system development; and
- Prior matrix development.

Zone System Development

3.6.2 As outlined previously, the ERM was used as a basis for development of the LAM road network. However, as the study area is located outside of the main model area, the ERM zone structure, as shown in Figure 3-3 was subject to additional subdivision in order to allow it to accurately reflect traffic loading along the N3.

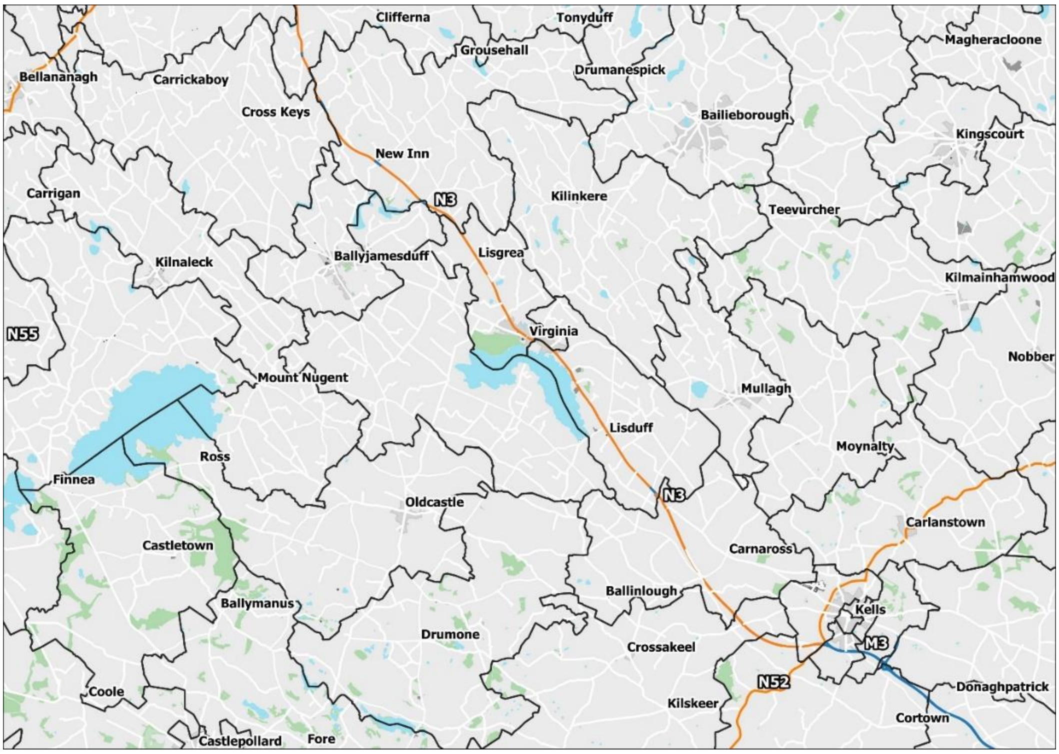


Figure 3-3: ERM Zone System (Study Area)

3.6.3 To provide an accurate representation of traffic loading onto and near the existing N3, a detailed zonal structure was developed for the LAM to reflect key generators and attractors of trips such as:

- Shopping centres / retail car parks / supermarket car parks;
- Key employment locations;
- Townlands; and
- Housing Estates – areas that load onto the network in one specific place.

3.6.4 Figure 3-4 illustrates the zonal system developed for the study area. In total, 105 zones have been created, with 70 internal zones within the study area and 35 external zones representing the roads that enter the area of interest. This level of detail ensures that traffic loads accurately onto both sides of the N3 and the surrounding road network.

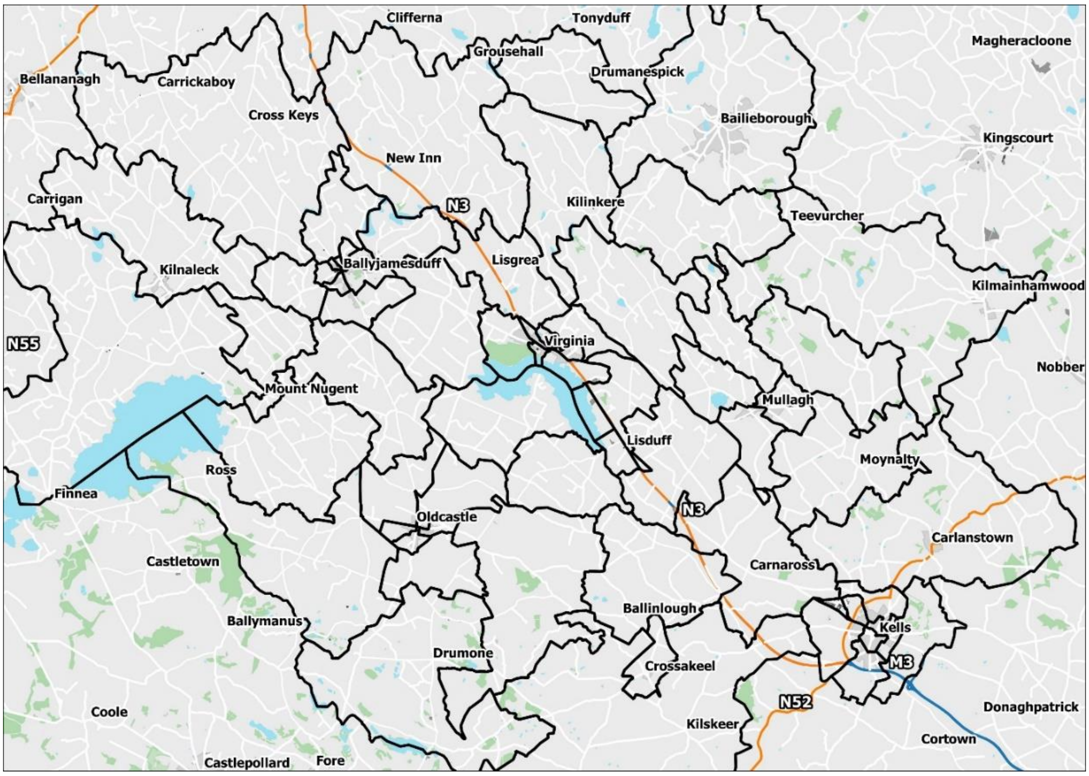


Figure 3-4: Disaggregated N3 Zone System

Prior Matrix Development

3.6.5 As noted previously in Section 3.2, the Full Demand Model carries out mode and trip destination choice for all zones within the ERM. The FDM has been calibrated using Census data, and hence, provides a robust and accurate representation of trip distributions across the model network. In order to generate prior matrices for the study area, a cordon was extracted from a 2019 run of the ERM. The cordon function within SATURN, facilitates the extraction of trip matrices for a subset area of the ERM whilst still maintaining route and destination choice from the full model.

3.6.6 As illustrated in Figure 3-3, the ERM zone system is quite aggregate for the surrounding N3 area, with 22 internal zones covering the area of interest. A bespoke Excel spreadsheet tool was created to disaggregate the cordoned ERM matrices to each of the 70 internal LAM zones. This tool used available data on populations, employment, and education places at Census small area level, to split trips to/from each ERM zone between the more detailed LAM zoning system. This allowed for a consistent split of demand within the study area, whilst maintaining consistency with the ERM matrix.

3.7 Assignment Method

3.7.1 The standard Wardrop Equilibrium using the Frank-Wolfe algorithm has been adopted as the assignment procedures for the highway model, to be consistent with the Eastern Regional Model and other regional models.

3.7.2 Tight highway assignment convergence is important in order to provide a robust appraisal. A highway assignment convergence with a %GAP<0.02% was achieved in the LAM, which considerably exceeds WebTAG guidance (%GAP<0.1%).

3.8 Generalised Cost Parameters

3.8.1 The SATURN assignment procedure builds paths through the network based on the generalised cost formulation. Generalised cost is a linear combination of time and distance, using values of pence per minute (PPM) and pence per kilometre (PPK) to convert distance into generalised minutes. It takes the following form:

Generalised Cost (minutes) = time + distance*PPK/PPM

3.8.2 The values of PPM and PPK within the LAM are based on the guidance on parameter values issued by the Department for Transport (DoT) and set out in the Common Appraisal Framework (CAF) (March 2016, updated October 2020). The table below shows the PPM and PPK used in the base year models for each user class and time period.

Table 3-1: Generalised Cost Parameters

USER CLASS	AM		IP		PM	
	PPM	PPK	PPM	PPK	PPM	PPK
LV	23.75	9.51	23.75	9.51	23.75	9.51
HV	50.85	40.89	50.85	40.89	50.85	40.89

4. MODEL CALIBRATION

4.1 Overview of the Calibration and Validation Process

4.1.1 Once the base year prior matrix is created, calibration is used to improve agreement in the model between observed and modelled traffic characteristics. Generally, the components of the model that may be adjusted on the demand side are trip distribution and trip production and generation levels. This adjustment usually involves trip matrix estimation.

4.1.2 On the supply side (network), modelled junction and link characteristics may be altered if sufficient new information is available to justify changes to the existing network.

4.1.3 The Virginia LAM was calibrated and validated in accordance with Transport Infrastructure Ireland's (TII) *Project Appraisal Guidelines (PAG) for National Roads Unit 5.1 – Construction of Transport Models (October 2016).* This is a widely accepted standard in Ireland that provides robust calibration and validation criteria to which certain types of highway models should adhere. Additionally, the LAM development has followed guidance from the UK's Department for Transport's Transport Analysis Guidance (TAG) unit M3-1, particularly in terms of matrix estimation controls.

4.1.4 The following sections of this chapter detail the calibration process undertaken to ensure that the LAM accurately reflects baseline conditions, including information on:

- Traffic Count Data;
- Calibration Steps;
- Matrix Estimation; and
- Calibration Statistics i.e. GEH and Linear Regression Analysis.

Traffic Count Data

4.1.5 To ensure the robustness of the developed strategic model, a series of traffic counts for the study area have been used to assist in the calibration and validation of base model flows. The following surveys were used in the process:

- Junction Turning Counts (JTC) at 34 locations.
- Automatic Traffic Counts (ATC) at 13 locations.

4.1.6 The JTC and ATC survey locations are illustrated in Figure 2-1. The Journey Time Surveys are discussed in further detail in Chapter 5 describing the model validation process.

4.1.7 Turning counts were taken at key locations and provide detailed movements within a specified junction. The locations of ATC surveys provide a record of traffic at key locations in the study area over an extended period of time (14 days). Incorporating this information enables an accurate representation of traffic flows within the model.

Calibration Steps

4.1.8 As an initial calibration step, all modelled movements with corresponding junction turning counts were examined to determine if the count exceeded modelled capacity. Remedial steps were then taken to permit realistic flows in the model.

4.1.9 Similarly, the capacity and speeds of modelled links were also checked to ensure they were broadly in line with survey information.

4.1.10 As the LAM was coded based on best practice approaches developed during the NTA Regional Model Scoping Process, the network coded was an accurate and up-to date representation of the existing road network. If required however, the following network model parameters were adjusted if there was clear reason for doing so:

- Junction type (Priority, Signalised, Roundabout);
- Road lengths;
- Signal timings;
- Link free flow travel speed;
- The number of approach lanes at each junction arm;
- Traffic lane width per junction approach, and the lane discipline adopted (including prohibited turns);
- Saturation flow through junctions;
- Assumed road capacities;
- Link based flow-delay relationships;
- Any other traffic management measures that may impact on capacity, such as bus lanes, traffic calming, parking controls and cycle-lanes.
- Zone co-ordinates; and
- Zone loading points (connections to the network).

Trip Demand Adjustment (Matrix Estimation)

4.1.11 Following calibration of the network, trip demand is adjusted in line with count data, so that there is an improved agreement between counts and modelled flows. The base prior matrix is fed into a SATURN programme called ME2. ME2 then adjusts origin-destination patterns to produce a trip demand matrix that better replicates traffic counts when assigned to the network. When this replication is satisfactory the matrix is said to be calibrated.

4.1.12 The prior matrix is adjusted only after all options for improving the network are exhausted. Any matrix adjustment must significantly improve the match between observed and modelled flows, and not introduce more trips into a zone than could realistically be expected. Controls are placed on zones to ensure that the trip demand generated is sensible and in line with census population and employment statistics.

4.1.13 The algorithm driving the ME2 estimation process tends to reduce long trips in place of chains of short trips, especially when counts are spread over the entire area, which may not fully reflect reality. Constraints are therefore placed on the adjustment process to protect the number of movements and distribution of the through trips contained within the original car trip matrix. By restricting such long through trips, the matrix adjustment algorithm is forced to create or re-distribute short trips.

4.1.14 Detailed constraints were developed for all zones within the study area to ensure that the ME2 process did not unrealistically alter trips entering/exiting the main areas of assessment. Census Small Area Population Statistics (SAPS) 2016 and land-use data (Geo-directory) were utilised to determine a range of the likely number of trips that would originate, or end, in each zone and these were used as constraints in the matrix estimation process. In Summary:

- **Residential Zones:** The trip generation values from the prior matrix (Cordoned ERM) were utilised as minimum constraints for residential zones. Land use information identified through the creation of the LAM zone system gave a breakdown on the approximate number of housing units in each residential zone.
- **Employment Zones:** Minimum constraints based on employment attractions, within the NTA planning sheet for the ERM cordon run were utilised to encourage employment zones as destinations. Maximum constraints were applied to areas within Virginia to reflect the amount of on-street parking available.
- **Schools:** Minimum constraints were applied to school zones based on the NTA planning sheet. For the PM peak (17:00 - 18:00), constraints were applied to ensure that no trips were attracted to school zones to reflect the fact that all schools would be closed at this time.
- **Heavy Vehicles:** Constraints were applied on all residential and unsuitable zones to ensure that HV traffic was not assigned to inappropriate zones in the LAM. For key HV generators/attractors in the area, a possible range of values were defined based on the surveys carried out in the area.

Calibration Statistics: GEH

4.1.15 The GEH statistic is a measure that considers both absolute and proportional differences in flows. Thus, for high levels of flow a low GEH may only be achieved if the percentage difference in flow is small. For lower flows, a low GEH may be achieved even if the percentage difference is relatively large. GEH is formulated as:

$$\mathrm{GEH} = \sqrt{\frac{(\text{observed} - \text{modelled})^2}{0.5 \times (\text{observed} + \text{modelled})}}$$

4.1.16 The reason for introducing such a statistic is the inability of either the absolute difference or the relative difference to cope over a wide range of flows. For example, an absolute difference of 100 pcu/h may be considered a big difference if the flows are of the order of 100 pcu/h, but would be unimportant for flows in the order of several thousand pcu/h. Equally a 10% error in 100 pcu/h would not be important, whereas a 10% error in, for example, 3000 pcu/h might mean the difference between adding capacity to a road or not.

4.1.17 In general, the GEH parameter is less sensitive to the above statistical biases since a modeller would probably feel that an error of 20 in 100 would be roughly as bad as an error of 90 in 2,000, and both would have a GEH statistic of roughly 2.

4.1.18 As a rule of thumb in comparing assigned volumes with observed flows, a GEH parameter of 5 or less would be an acceptable fit, while GEH parameters greater than 10 would require closer attention.

4.1.19 The UK DMRB Volume 12a guidelines (Traffic Appraisal in Urban Areas) are a widely accepted standard in Ireland (with TII basing their guidelines on this document) that provides extremely robust validation criteria to which certain types of highway models should adhere. This document sets a guideline that 85% of links should have a GEH less than 5 (when measured in vehicles per hour) as shown in Table 4-1 below. In addition, it is commonplace to establish that 90% of assessment links have a GEH of less than 10 and that 100% of validation links have a GEH less than 20.

Table 4-1: Calibration Criteria

Criteria	Acceptability Guideline
GEH < 5 for individual flows	> 85% of cases

4.2 Model Calibration Results

4.2.1 Table 4-2 below summarises the GEH calibration results for the model after the matrix estimation process, for each of the three modelled time periods. The full list of GEH results for each traffic count location are presented in the accompanying calibration dashboards in **Appendix A**.

Table 4-2: Count Validation Statistics (Post-Calibration)

GEH	AM	PM	INTER-PEAK
GEH < 5	95%	94%	95%
GEH < 10	99%	98%	99%
GEH < 20	100%	100%	100%
Overall Average GEH	1.37	1.34	1.17

4.2.2 The figures demonstrate that an excellent calibration has been achieved in the model for the morning, evening and inter peak periods, with overall GEH<5 of 95%, 94% and 95% respectively, which falls well within TII standards.

4.3 Link and Turn Flow Calibration

4.3.1 PAG (Unit 5.1 Table 5.2.2 and 5.2.3) says that both of the following two criteria should be met in 85% of cases:

- Criteria 1: links should have a GEH value of less than 5;
- Criteria 2:
  - where modelled flows are less than 700, the model flow should be within 100 vehicles of the count;
  - where modelled flows are between 700 and 2700 the modelled flows should be within 15% of observed flows; and
  - where modelled flows are greater than 2700 the modelled flows should be within 400 vehicles of the observed flows.

4.3.2 Table 4-3 presents the link count validation for counts used in matrix estimation. The results indicate that the model is calibrated as per the requirements of PAG for link flows. The tables in **Appendix A** present the calibration results for each link.

Table 4-3: % of Links Achieving Calibration Criteria for Counts used in Matrix Estimation

CRITERIA	AM		INTER-PEAK		PM	
	LV	HV	LV	HV	LV	HV
Flow	100%	100%	100%	100%	99%	100%
GEH	95%	98%	96%	99%	94%	98%

4.3.3 Again, these figures demonstrate that an excellent level of calibration has been achieved in the model for the morning, evening and inter peak periods.

4.4 Impact of Matrix Estimation on Trip Length Distribution

4.4.1 A further calibration step recommended by PAG is to compare trip length distributions for the prior and post calibrated matrices to ensure they have not been distorted to any great extent by the matrix estimation process. ME2 can sometimes generate increased short distance trips to match count information, thus distorting the profile of trip making on the network. PAG suggests that the coincidence ratio[1] should be used to compare trip length distributions before and after estimation, with a desirable range between 0.7 and 1.0.

4.4.2 Table 4-4 below outlines the coincidence ratios for each of the calibrated time periods developed.

Table 4-4: Trip Length Analysis - Coincidence Ratios

MEASURE OF FIT	AM	PM	INTER PEAK
Coincidence Ratio	0.87	0.82	0.89

4.4.3 The coincidence ratios suggest that, while there has been some changes in trip lengths, the changes made during matrix estimation are within acceptable limits.

4.4.4 The graphs below graphically present the change in trip length distribution for each model period as a result of matrix estimation. These figures show that there have been some changes to the trip length distributions, with a slight pattern of changes shown across the time periods. The changes overall are not large and therefore it is considered that Matrix Estimation has not overly distorted the trip length distribution of the prior matrix.

[1] The coincidence ratio is a calculation used to examine the how well the total area under different distributions coincide, with a value of 1 representing an identical distribution.

Figure 4-1: AM Peak Trip Length Distribution

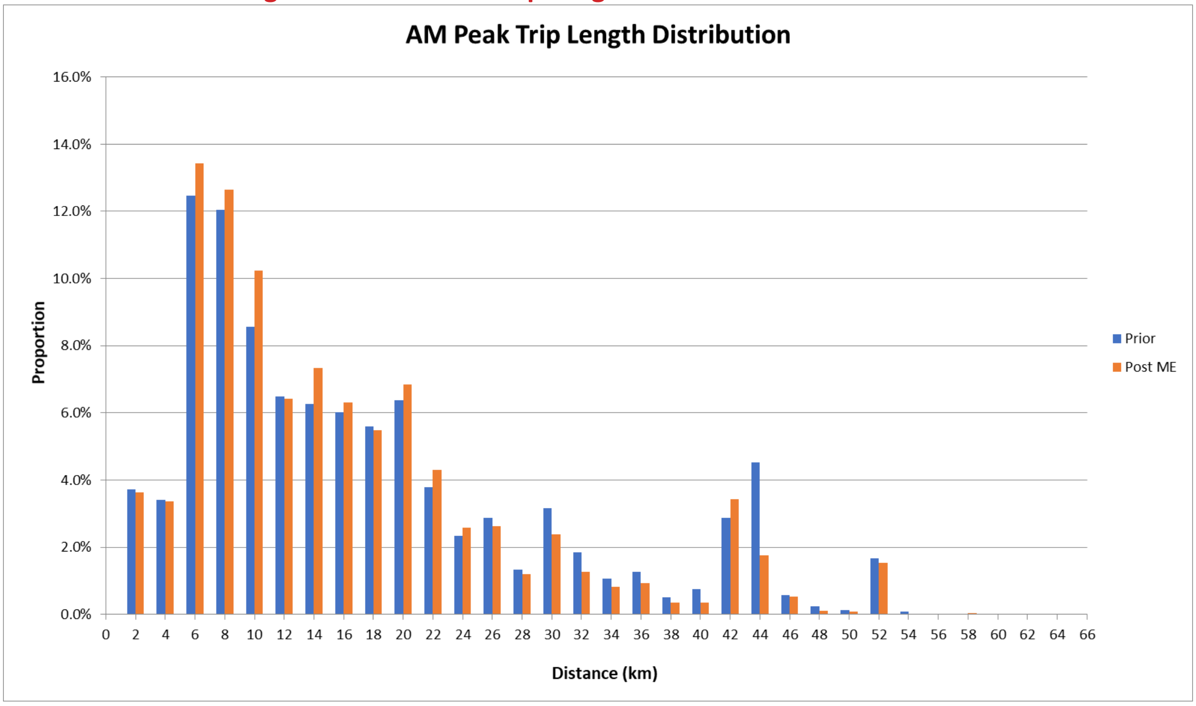


Figure 4-2: PM Peak Trip Length Distribution

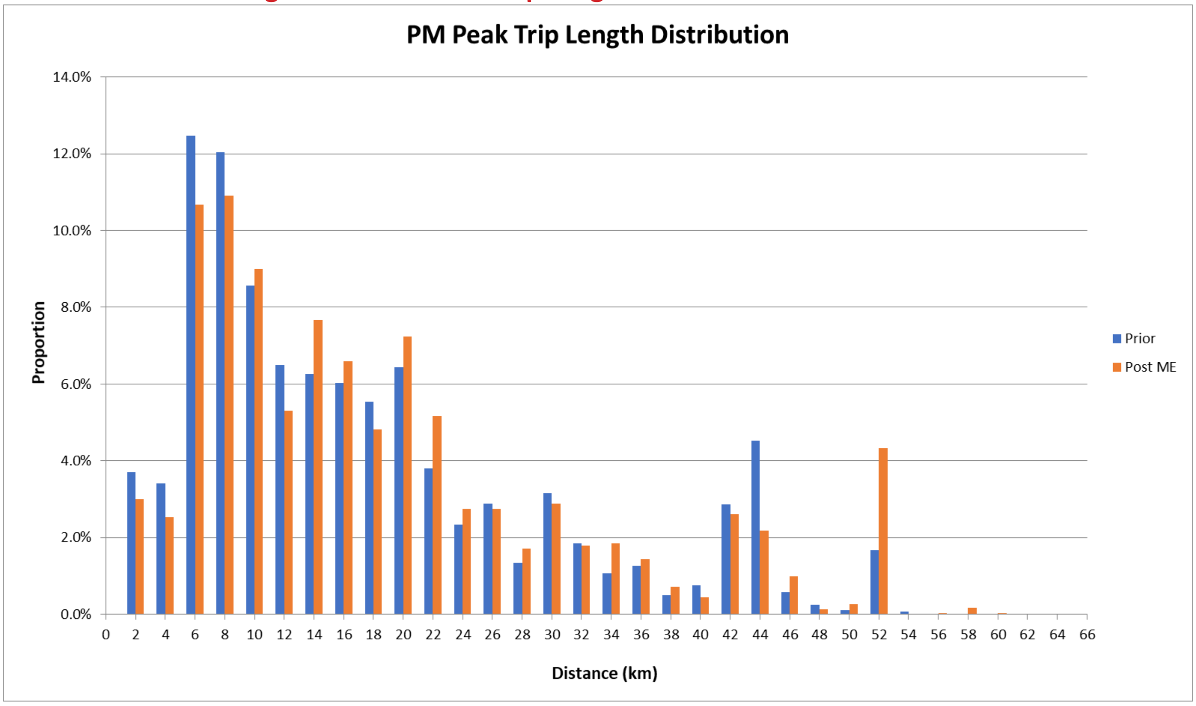
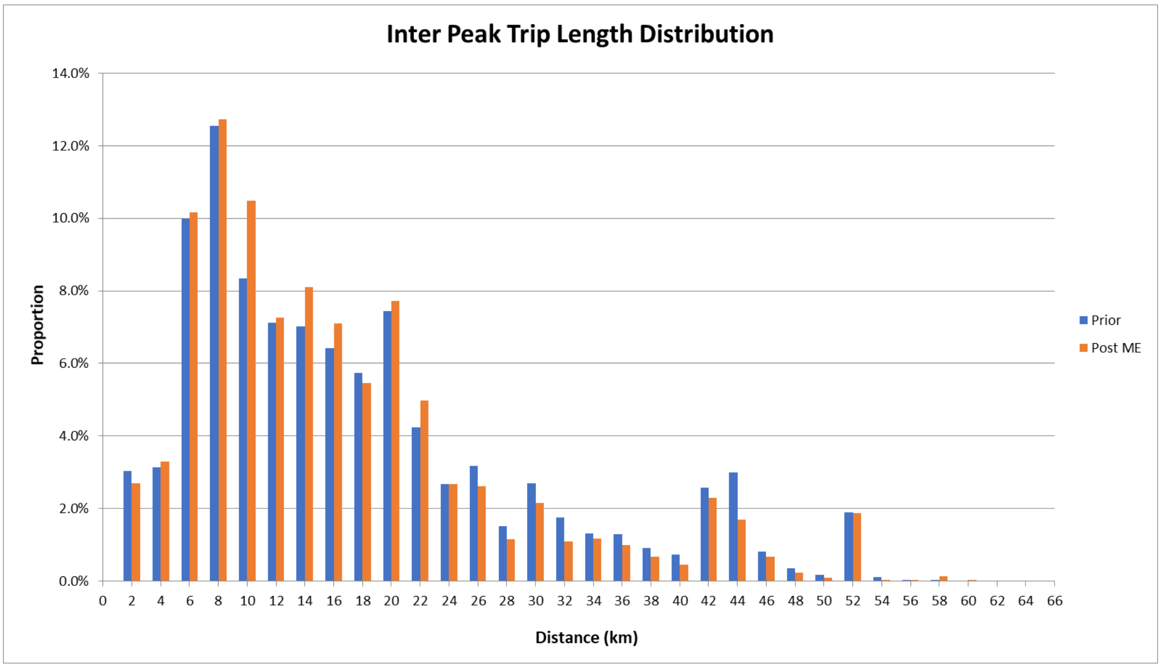


Figure 4-3: Inter Peak Trip Length Distribution



5. MODEL VALIDATION

5.1 Introduction

5.1.1 The validation of the model uses additional comparative measures against which the robustness of the calibrated model may be judged. For the LAM, a combination of modelled flows to midweek ATC averages and modelled to observed journey times were used to validate the model.

5.2 Traffic Survey Data

5.2.1 A set of counts were excluded from the counts used in matrix estimation so they could be used to carry out an independent check on the model to see how well the model flows match the observed counts. The counts reserved for independent validation are the Automatic Traffic Counts (ATCs) discussed previously in Chapter 2. The location of these ATCs is shown in the figure below.

5.2.2 Table 5-1 shows the link count validation for the independent counts excluded from matrix estimation for the AM, Inter Peak and PM peak Hours respectively.

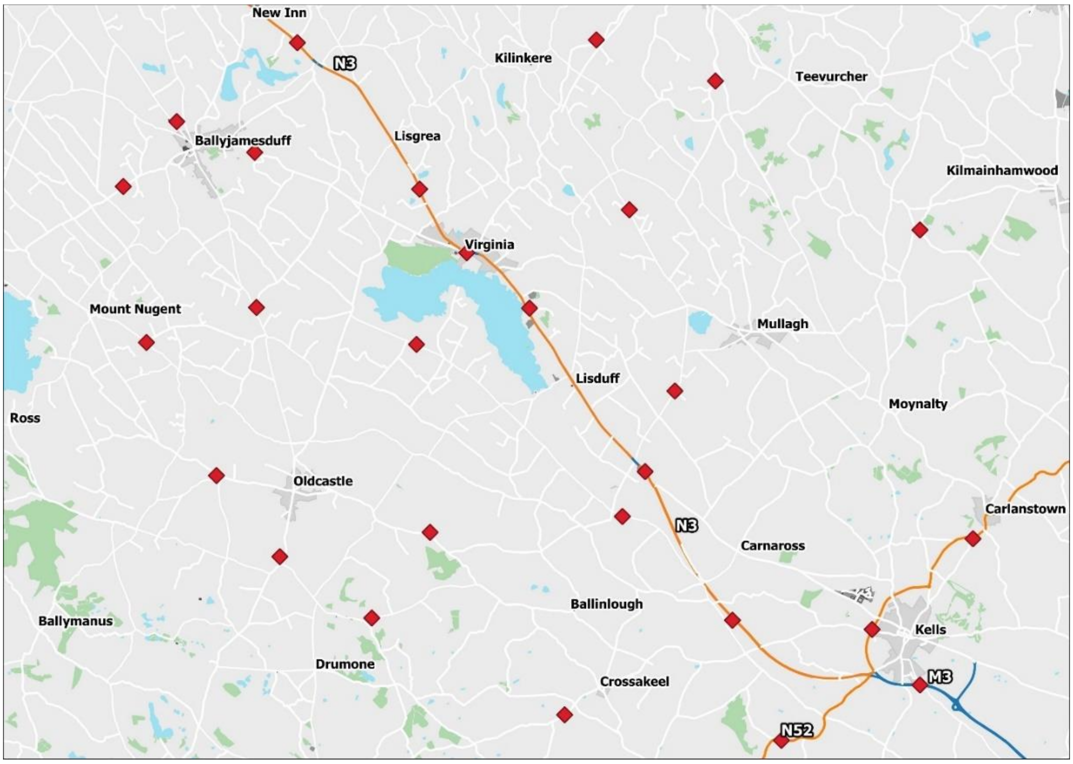


Figure 5-1: ATC Validation Counts

Table 5-1: ATC Validation

GEH	AM	PM	INTER-PEAK
GEH < 5	90%	85%	93%
GEH < 10	100%	100%	100%
GEH < 20	100%	100%	100%
Overall Average GEH	2.4	2.3	2.1

5.2.3 The figures demonstrate that an excellent validation has been achieved in the model for the morning, evening and inter peak periods, with overall GEH<5 of 90%, 85% and 93% respectively, which falls well within TII standards.

5.4 Journey Time Validation

5.4.1 As outlined previously in Chapter 2, Journey Time Surveys were carried out within the study area. The journey time routes used for model validation purposes are shown in the figures below:

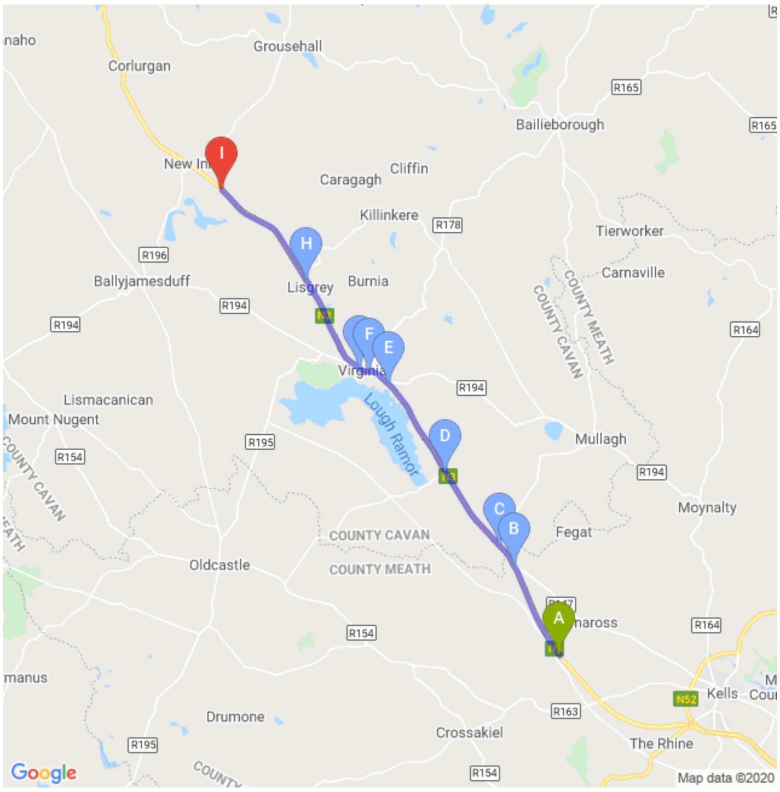


Figure 5-2: N3 Journey Time Route 1

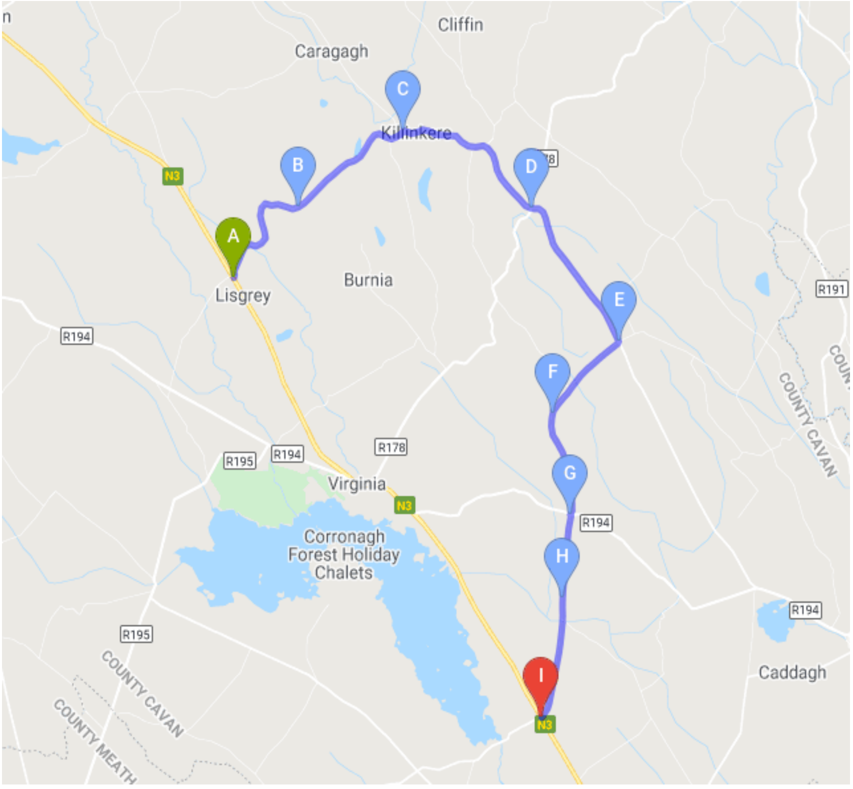


Figure 5-3: Journey Time Route 2

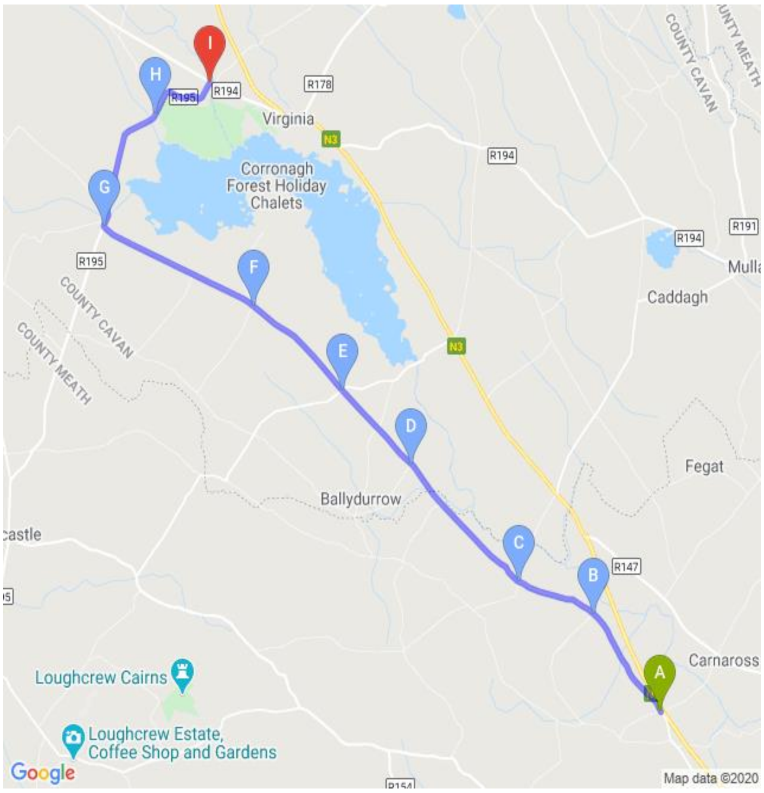


Figure 5-4: Journey Time Route 3

5.4.2 PAG (Unit 5.1 Table 5.1.5) advises that modelled journey times should be within 15% of the observed time (or 60 seconds if higher) in more than 85% of routes. Table 5-2 below outlines the overall results for the cumulative route totals (in both directions). The results show an excellent match to TII guidelines, with cumulative route totals and all of the individual sections satisfying the PAG criteria for each time period. A detailed breakdown is provided for each time period in the subsequent section.

Table 5-2: Journey Time Validation Statistics

PAG CRITERIA	AM	PM	INTER PEAK
Cumulative Routes	100%	100%	100%
Individual Sections	100%	100%	100%
Route Totals	100%	100%	100%
Pass	✓	✓	✓

AM Journey Time Validation

5.4.3 Table 5-3 below summarises the observed journey times against the modelled times for each of the journey time routes, and sections, outlined in Table 5-2 above for the AM peak period. Figure 5-5 to Figure 5-10 illustrate the correlation between observed and modelled journey times along the entire route in both directions.

Table 5-3: AM Journey Time Validation Totals

ROUTE	OBSERVED (SECS)	MODELLED (SECS)	DIFF (%)	PASS
Route 1 (NB along the N3)	1116	1079	-3%	✓
Route 1 (SB along the N3)	1156	1153	0%	✓
Route 2 NB	1040	1142	10%	✓
Route 2 SB	1004	1139	13%	✓
Route 3 NB	1202	1259	5%	✓
Route 3 SB	1187	1196	1%	✓

Figure 5-5: Route 1 N-bound AM Peak Journey Time Validation

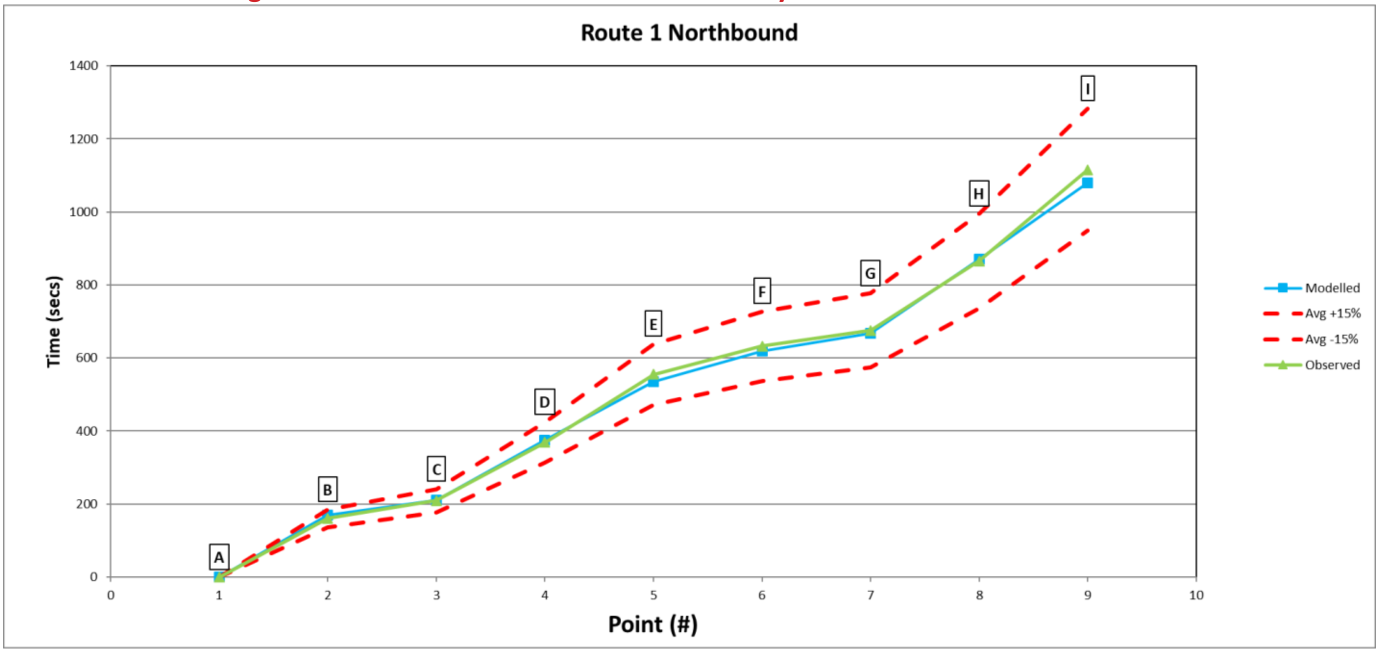


Figure 5-6: Route 1 S-bound AM Peak Journey Time Validation

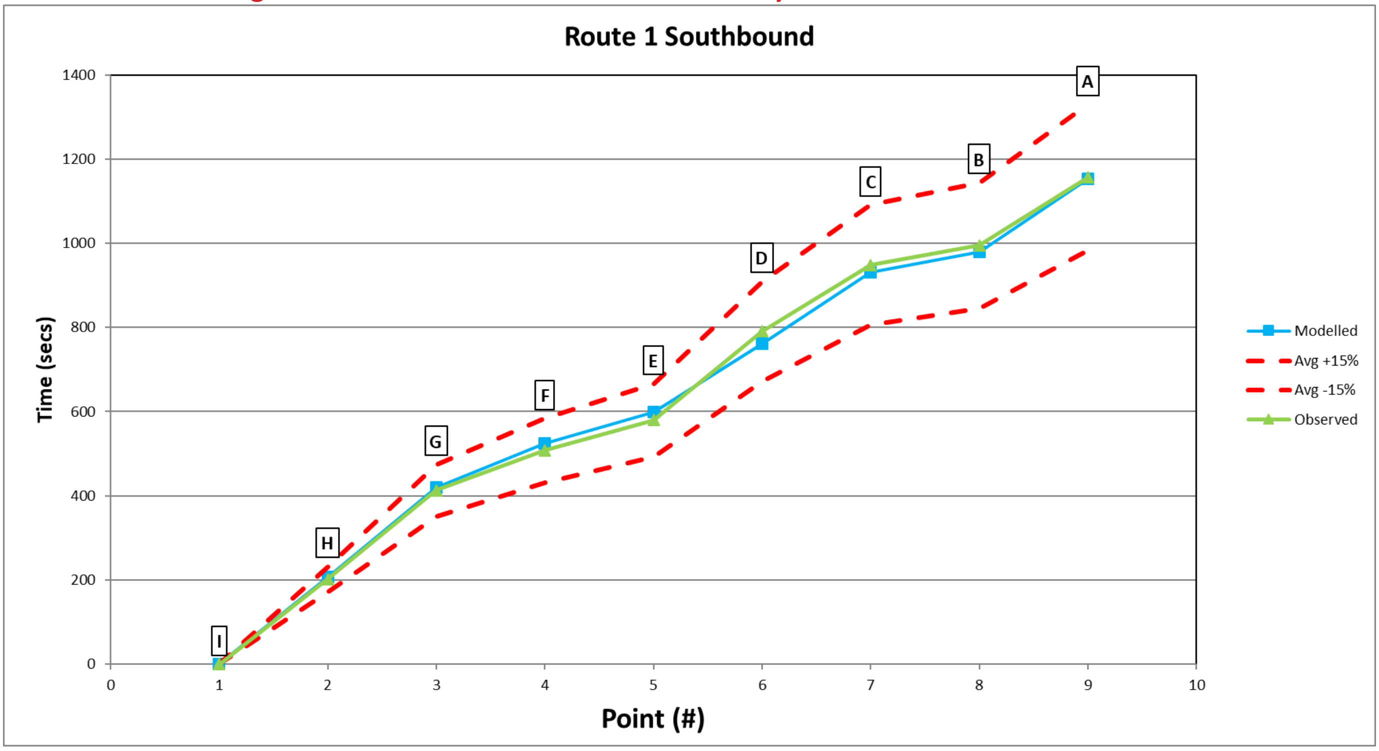


Figure 5-7: Route 2 N-bound AM Peak Journey Time Validation

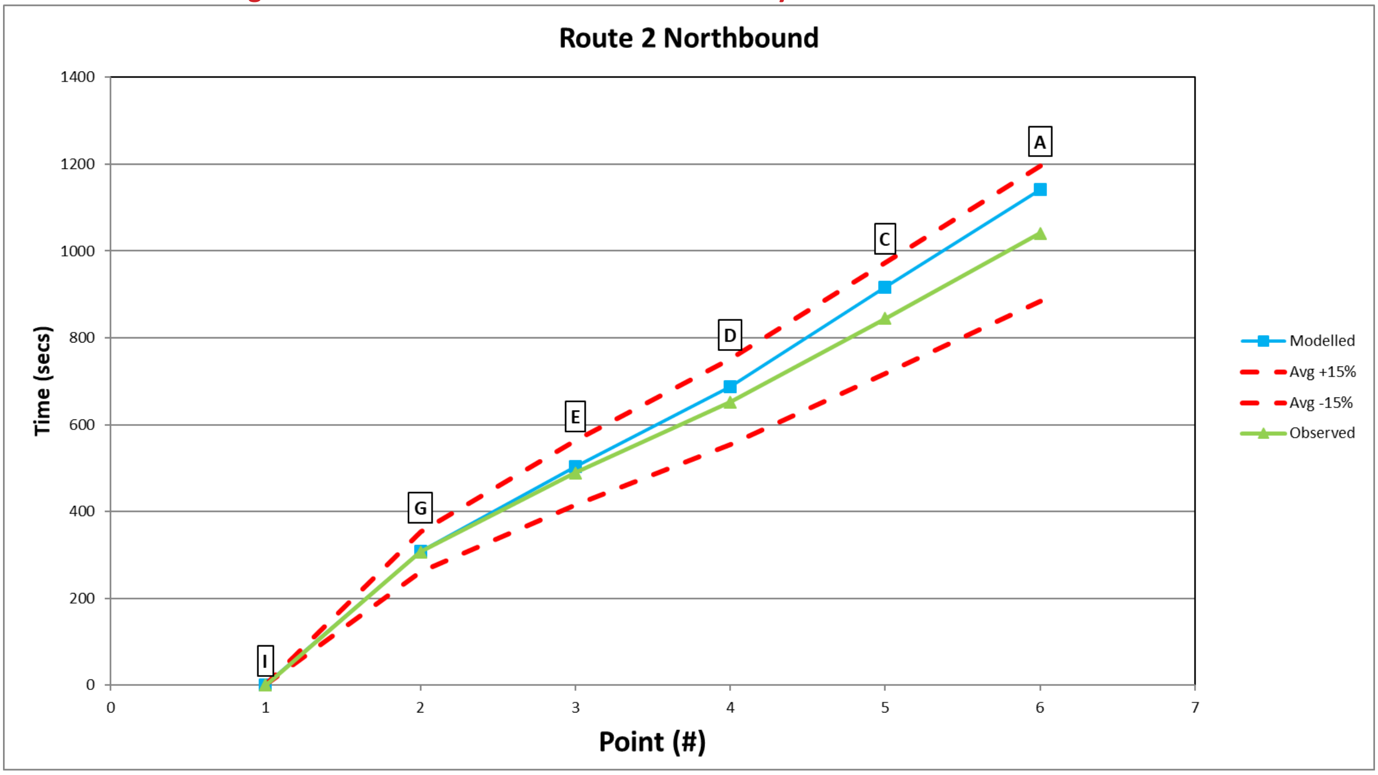


Figure 5-8: Route 2 S-bound AM Peak Journey Time Validation

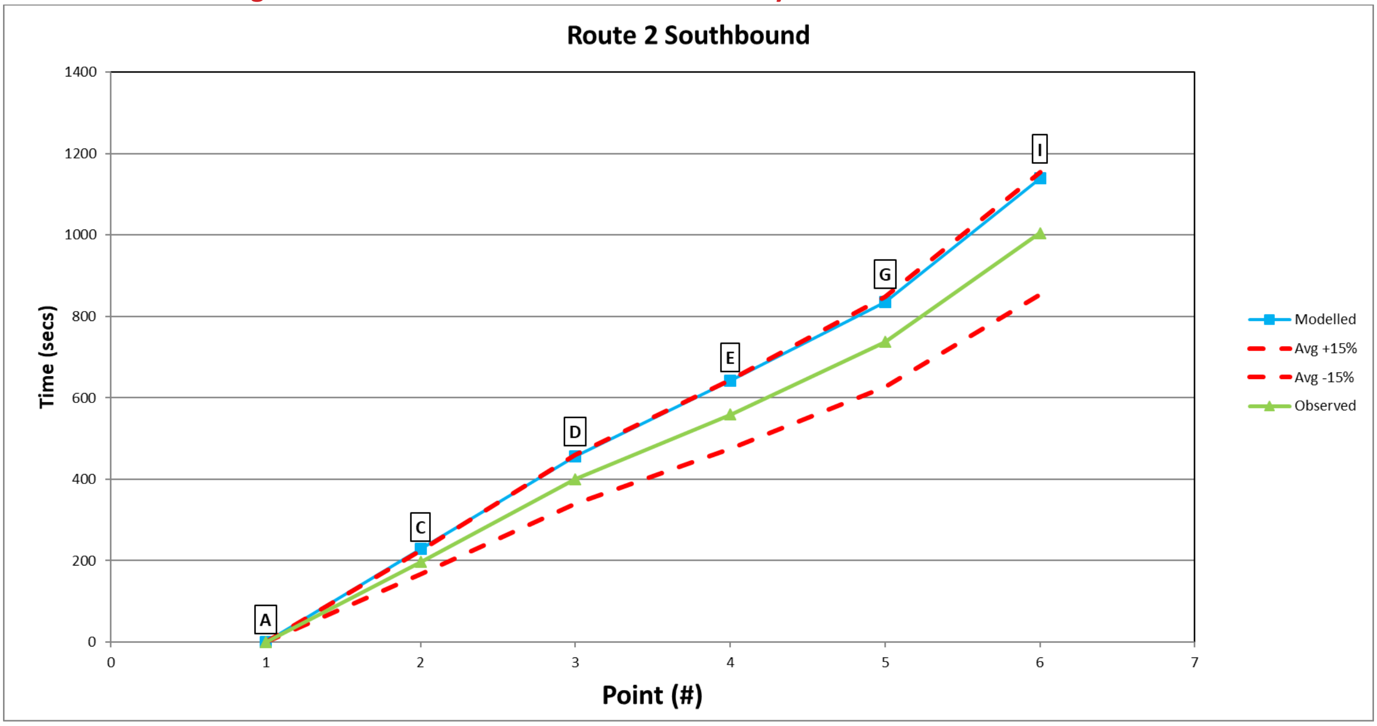


Figure 5-9: Route 3 N-bound AM Peak Journey Time Validation

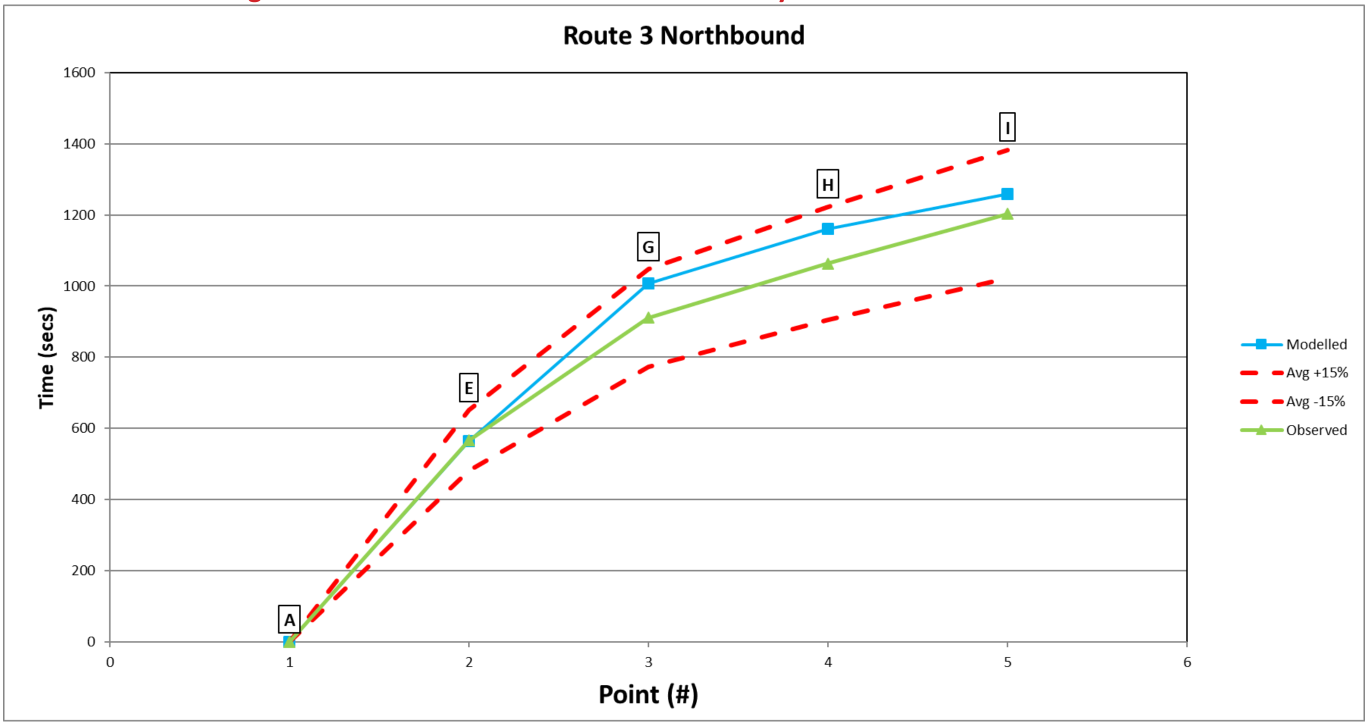
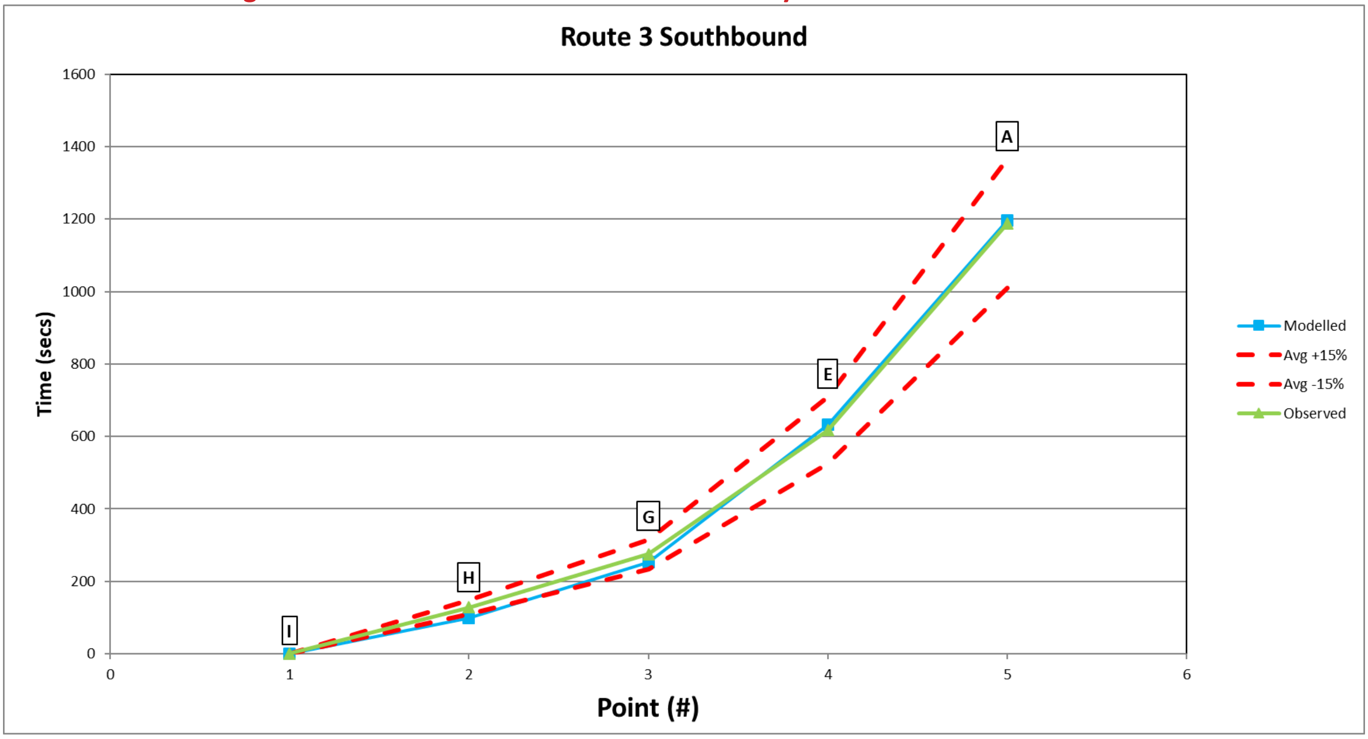


Figure 5-10: Route 3 S-bound AM Peak Journey Time Validation



5.4.4 The results outlined above indicate that the modelled journey times in the AM peak satisfy the UK DMRB and TII guidelines. The results indicate an excellent match with all routes falling within the stated criteria.

PM Journey Time Validation

5.4.5 Table 5-4 below, summarises the observed journey times against the modelled times for each of the journey time routes, and sections, outlined in Table 5-2 for the PM peak period. Figure 5-11 to Figure 5-16 illustrate the correlation between observed and modelled journey times along the entire route in both directions.

Table 5-4: PM Journey Time Validation Totals

ROUTE	OBSERVED (SECS)	MODELLED (SECS)	DIFF (%)	PASS
Route 1 (NB along the N3)	1170	1158	-1%	✓
Route 1 (SB along the N3)	1083	1123	4%	✓
Route 2 NB	1020	1141	12%	✓
Route 2 SB	1005	1140	13%	✓
Route 3 NB	1243	1262	2%	✓
Route 3 SB	1286	1193	-7%	✓

Figure 5-11: Route 1 N-bound PM Peak Journey Time Validation

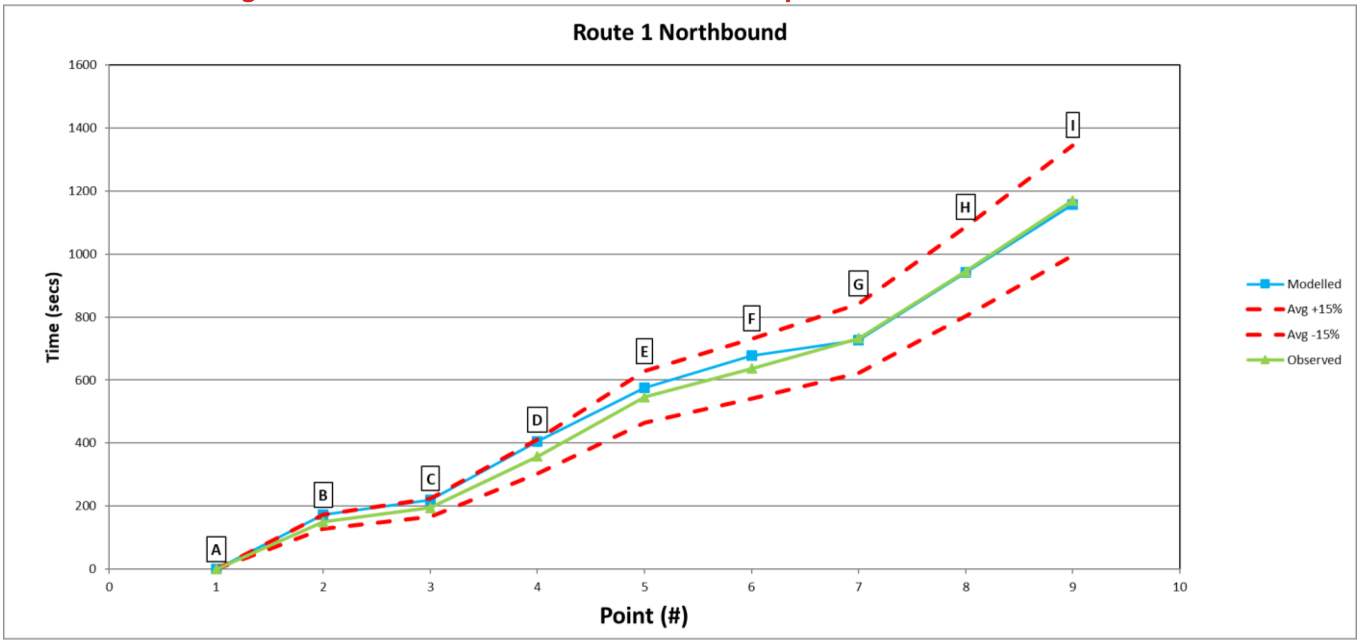


Figure 5-12: Route 1 S-bound PM Peak Journey Time Validation

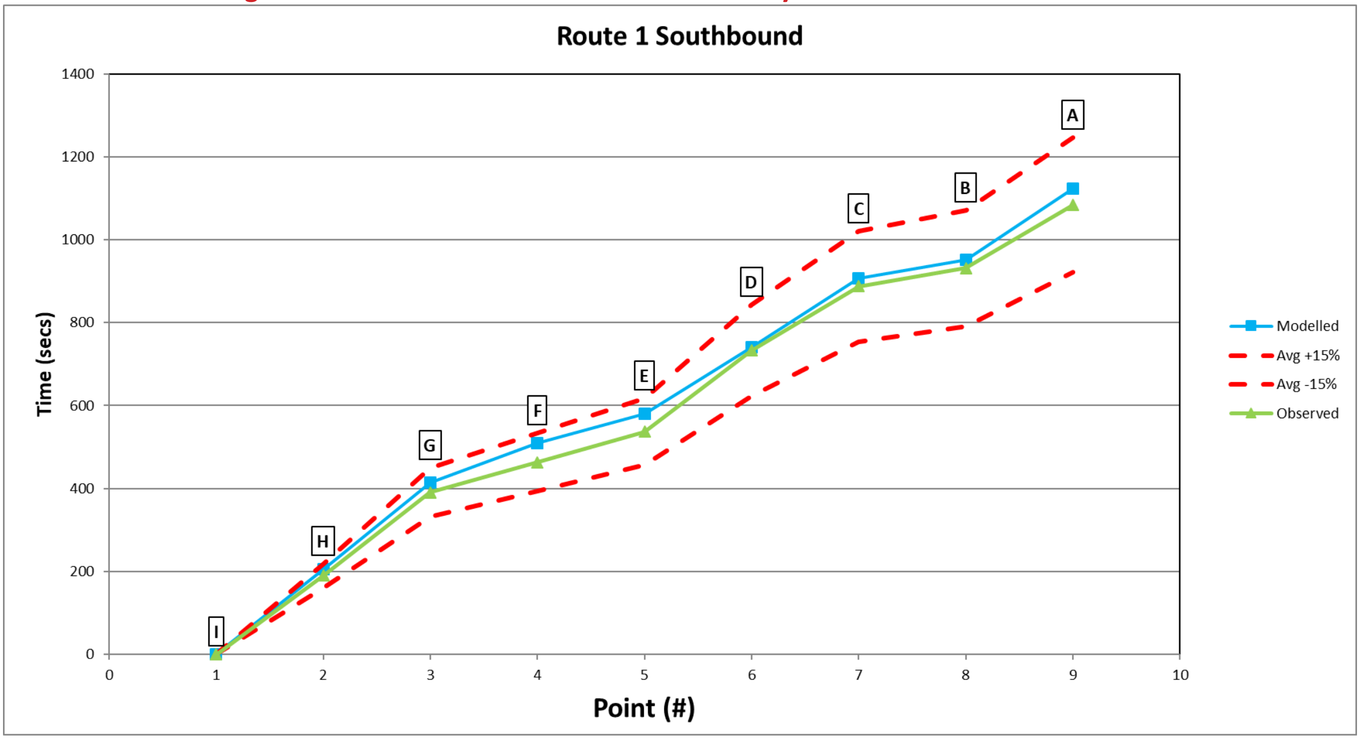


Figure 5-13: Route 2 N-bound PM Peak Journey Time Validation

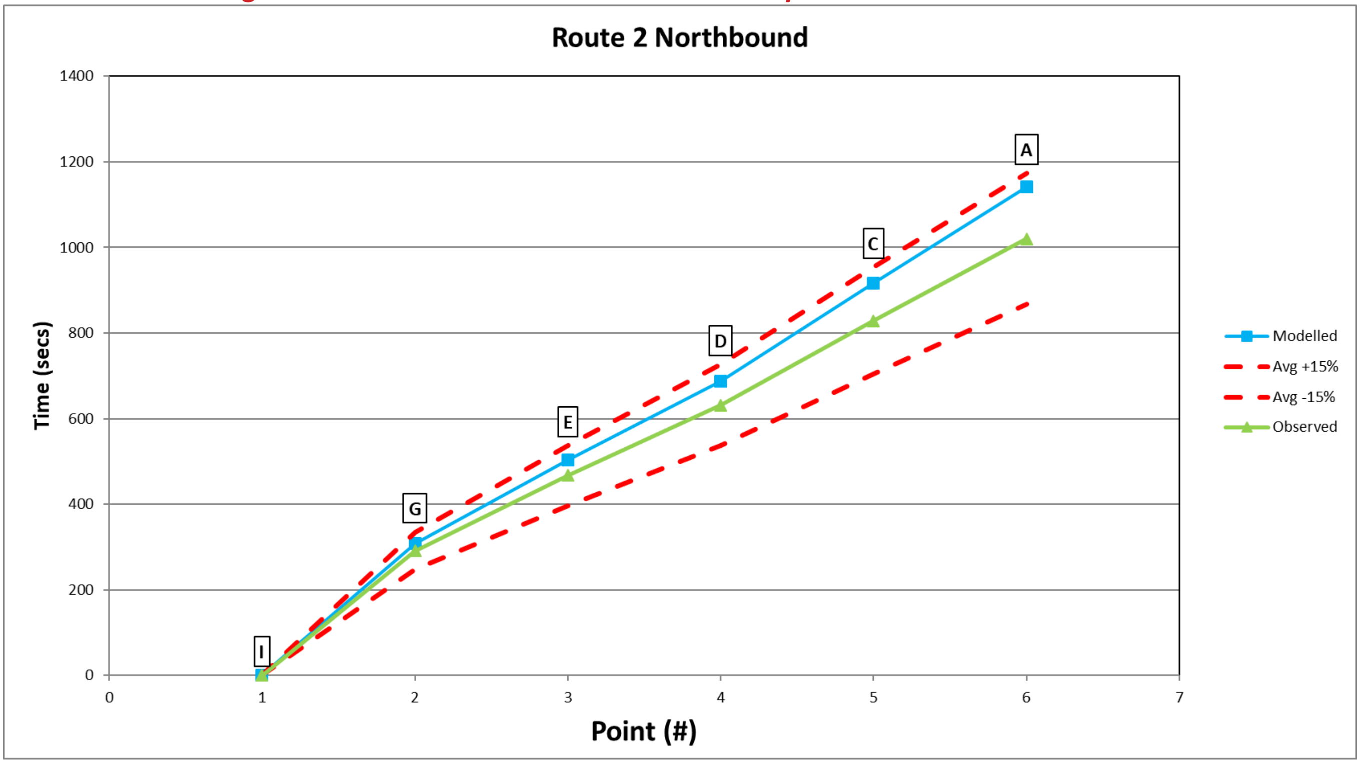


Figure 5-14: Route 2 S-bound PM Peak Journey Time Validation

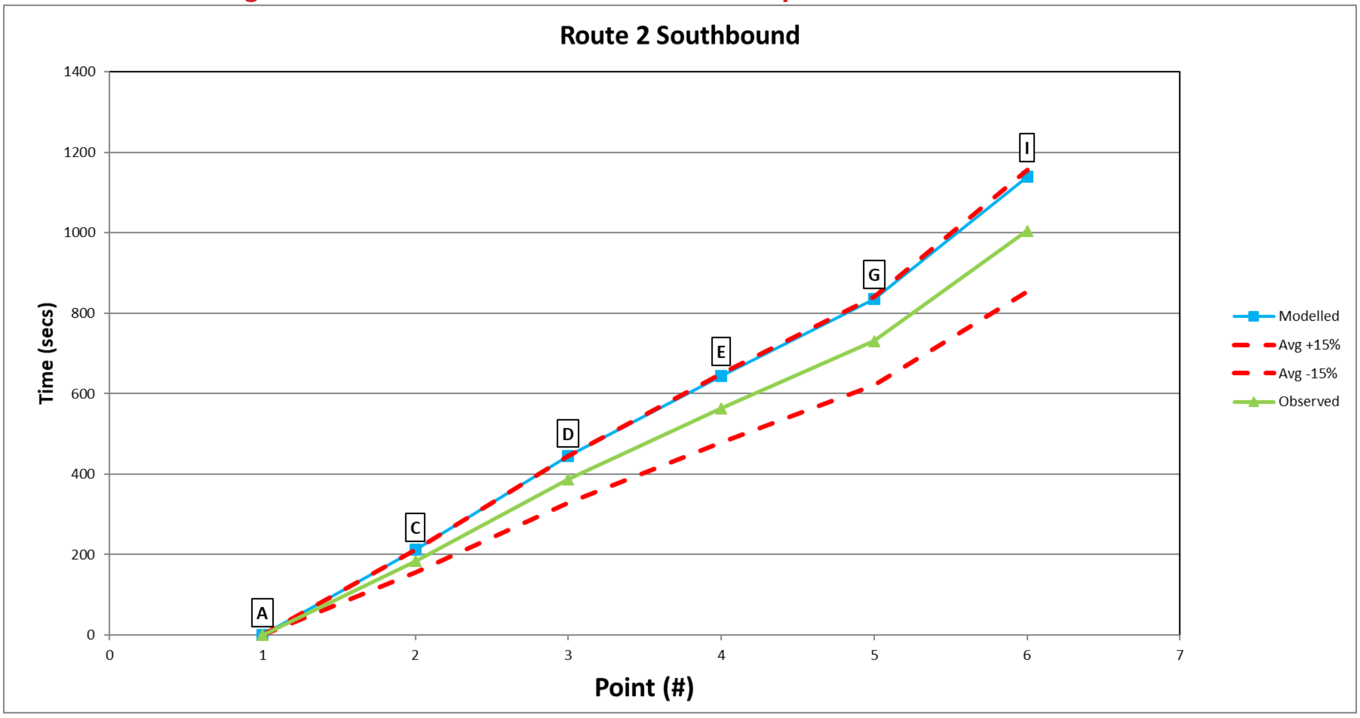


Figure 5-15: Route 3 N-bound PM Peak Journey Time Validation

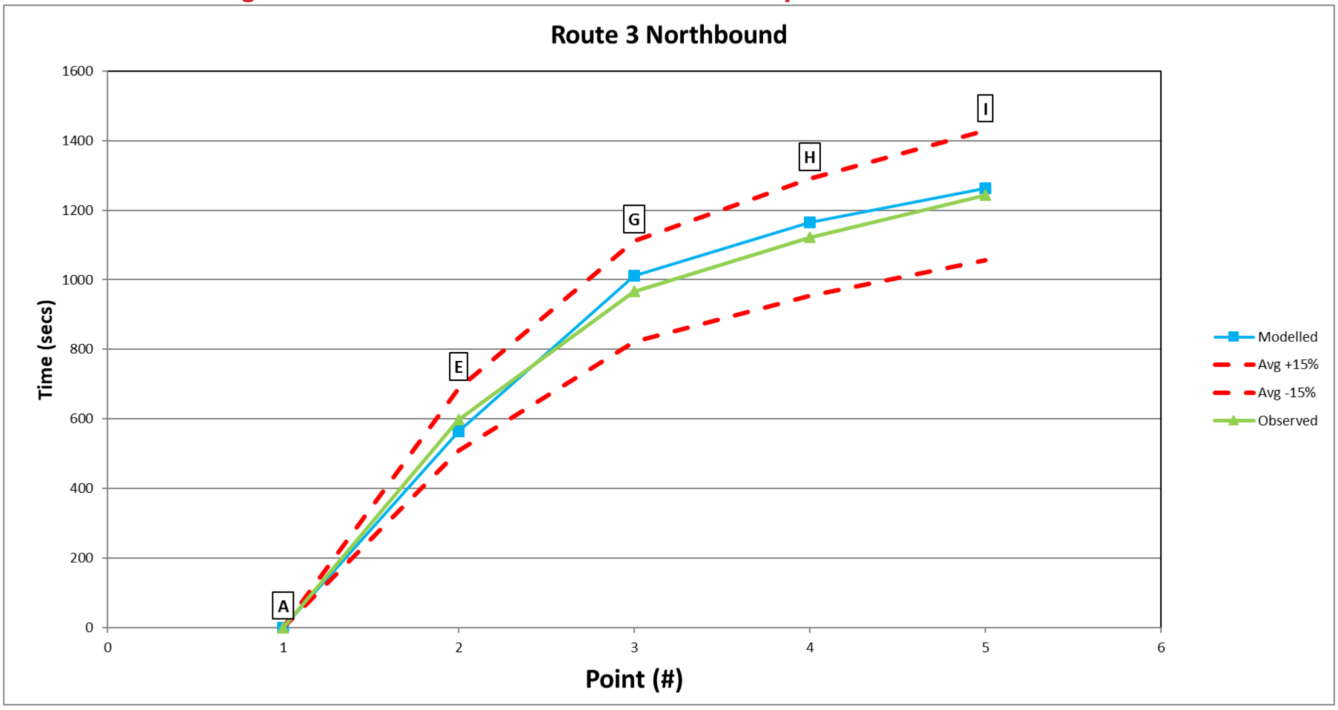
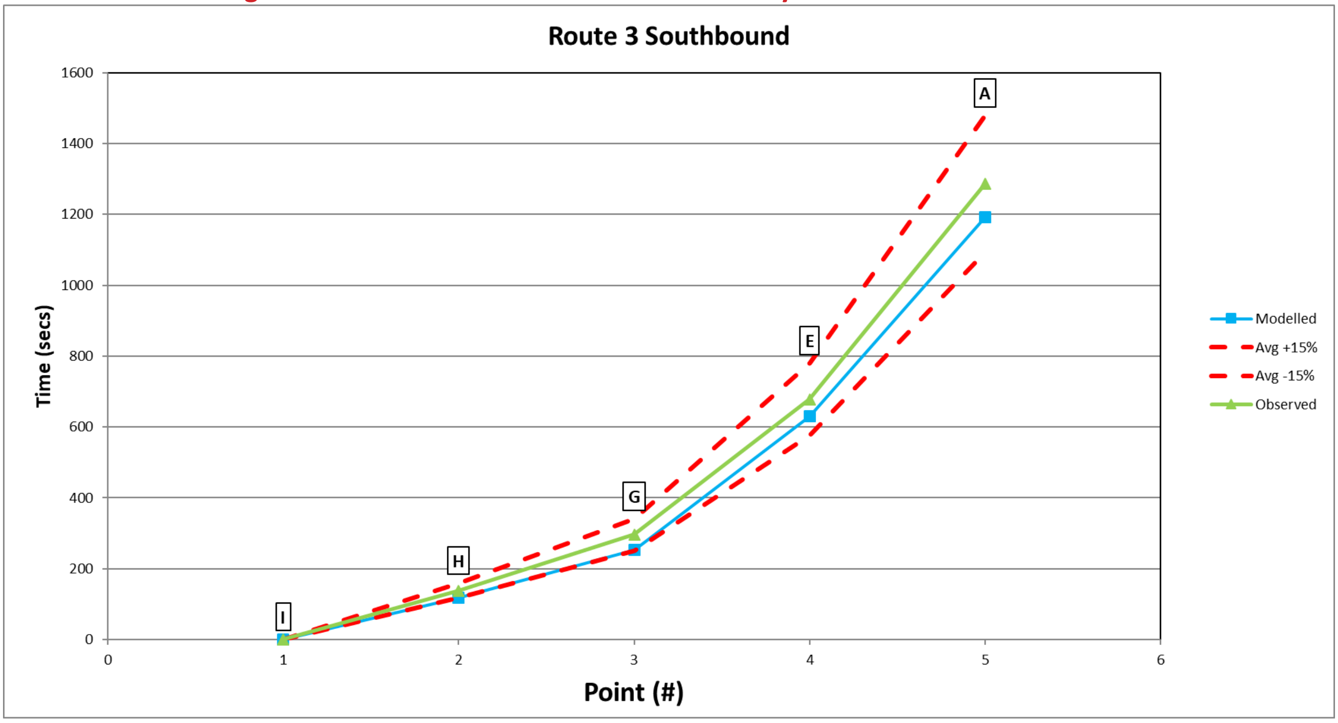


Figure 5-16: Route 3 S-bound PM Peak Journey Time Validation



5.4.6 The results outlined above indicate that the modelled journey times in the Inter peak satisfy the UK DMRB and TII guidelines. The results indicate an excellent match with all routes falling within the stated criteria.

Inter Peak Journey Time Validation

5.4.7 Table 5-5 below summarise the observed journey times against the modelled times for each of the journey time routes, and sections, outlined in Table 5-2 above for the Inter peak period. Figure 5-17 to Figure 5-22 illustrate the correlation between observed and modelled journey times along the entire route in both directions.

Table 5-5: Inter Peak Journey Time Validation Totals

ROUTE	OBSERVED (SECS)	MODELLED (SECS)	DIFF (%)	PASS
Route 1 (NB along the N3)	1176	1074	-9%	✓
Route 1 (SB along the N3)	1109	1106	0%	✓
Route 2 NB	1069	1140	7%	✓
Route 2 SB	1079	1138	5%	✓
Route 3 NB	1230	1258	2%	✓
Route 3 SB	1195	1192	0%	✓

Figure 5-17: Route 1 N-bound Inter Peak Journey Time Validation

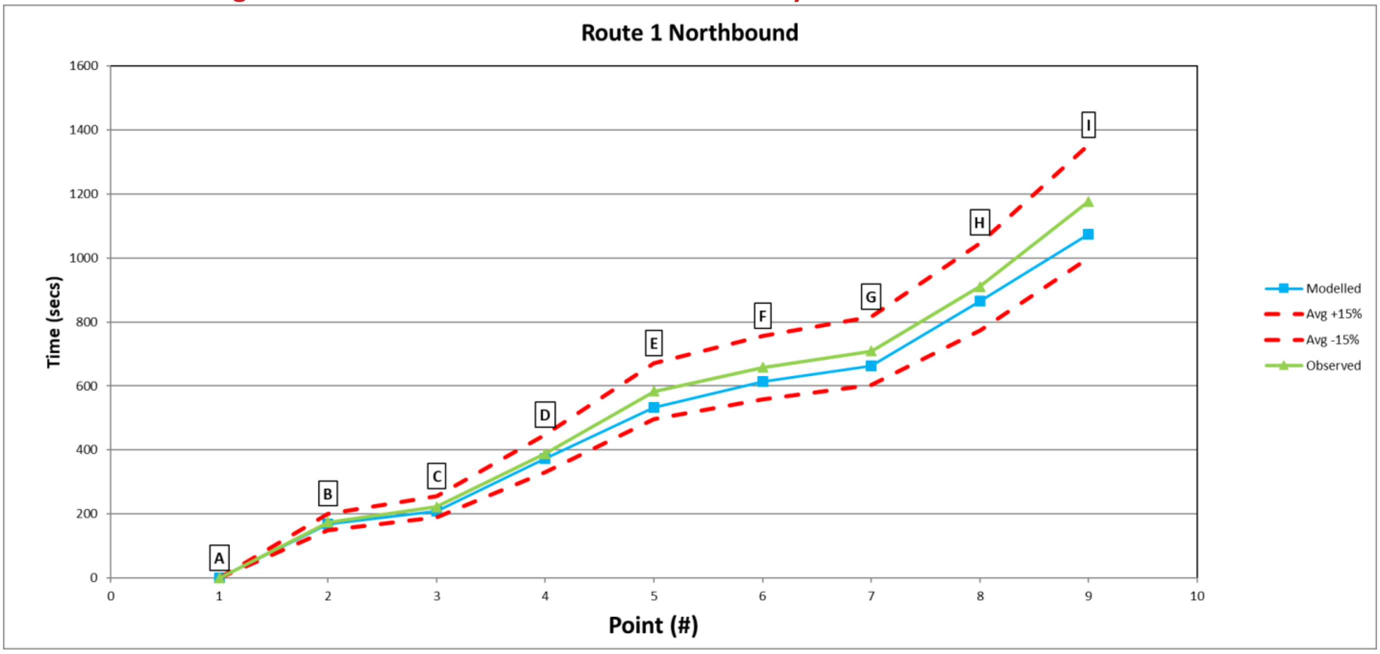


Figure 5-18: Route 1 S-bound Inter Peak Journey Time Validation

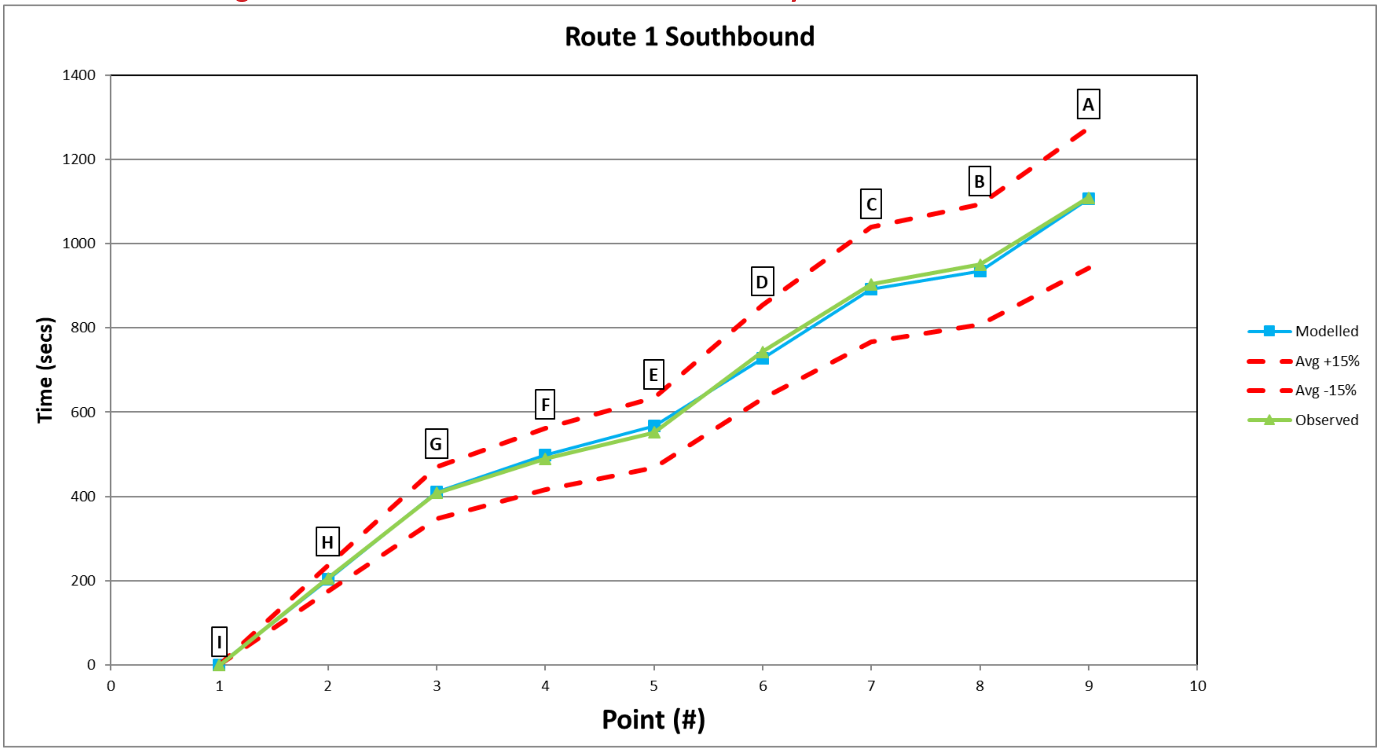


Figure 5-19: Route 2 N-bound Inter Peak Journey Time Validation

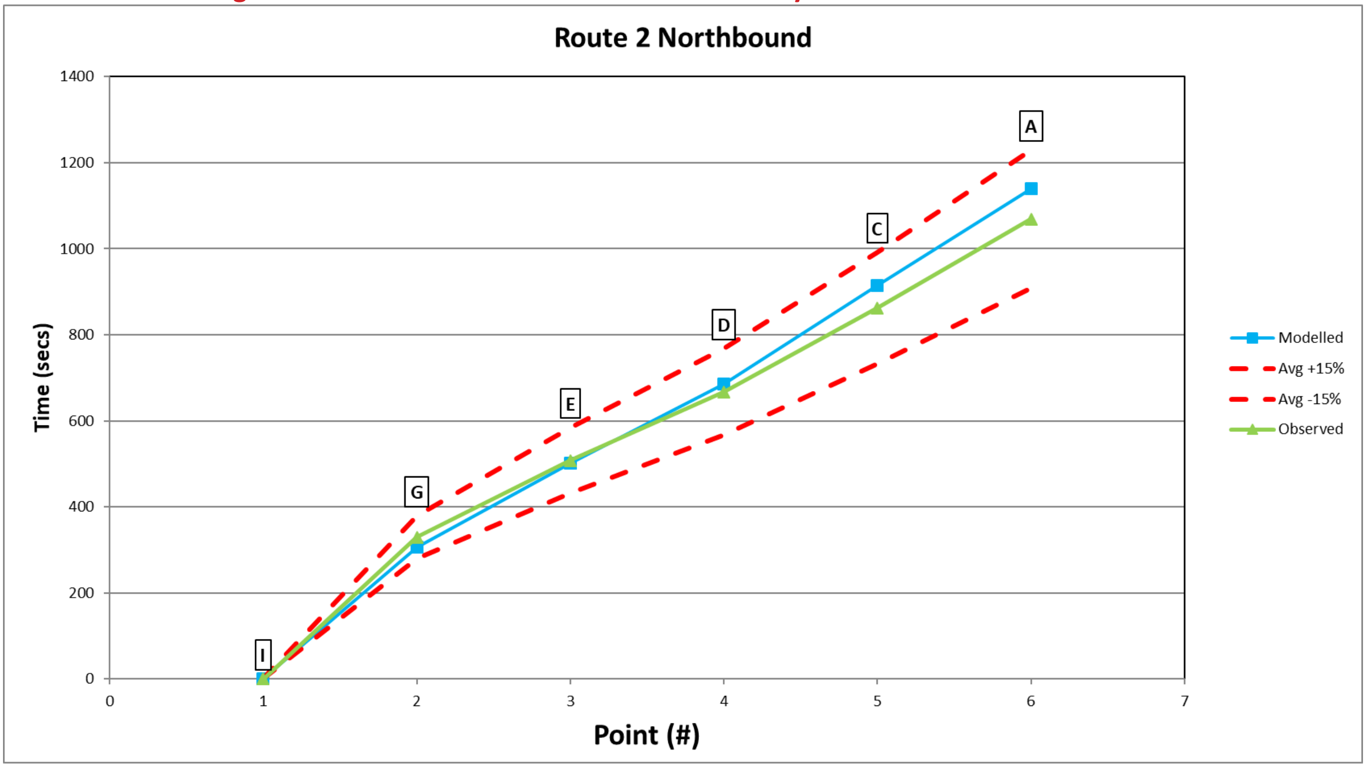


Figure 5-20: Route 2 S-bound Inter Peak Journey Time Validation

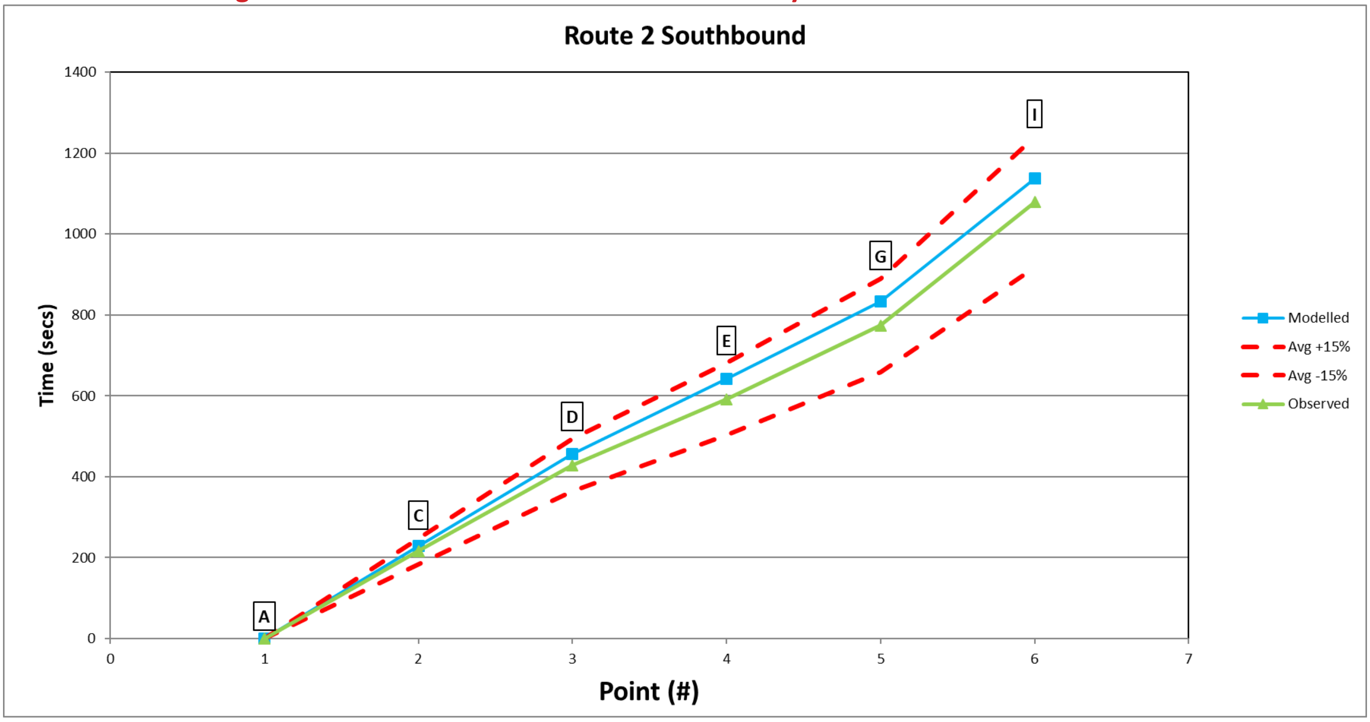


Figure 5-21: Route 3 N-bound Inter Peak Journey Time Validation

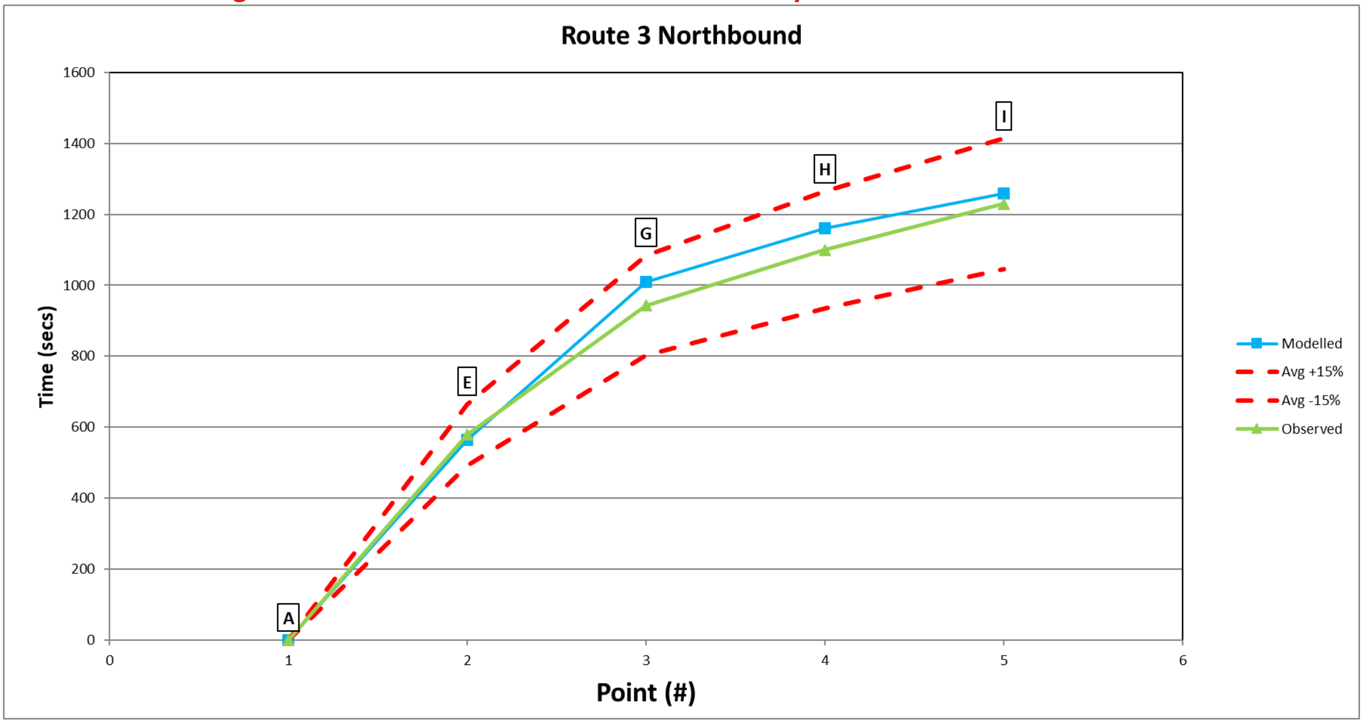
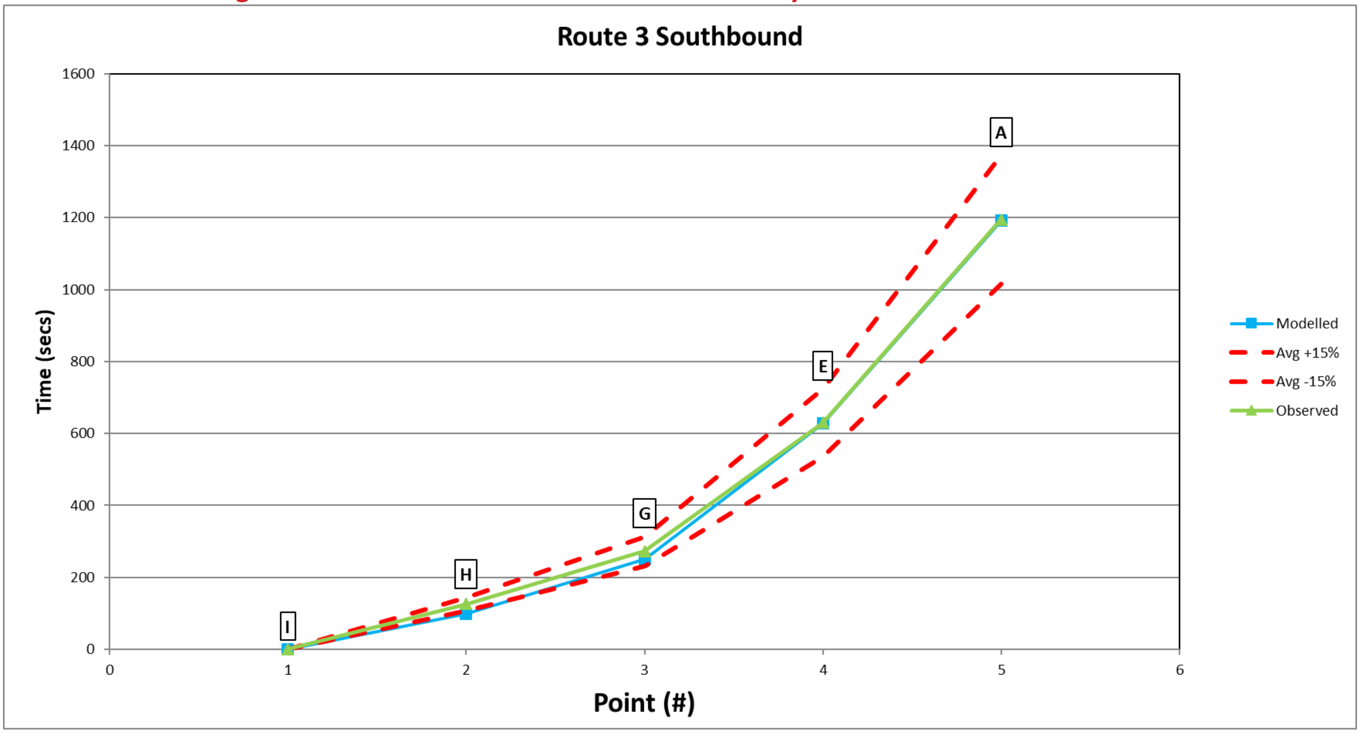


Figure 5-22: Route 3 S-bound Inter Peak Journey Time Validation



5.4.8 The results outlined above indicate that the modelled journey times in the Inter peak satisfy the UK DMRB and TII guidelines. The results indicate an excellent match with all routes falling within the stated criteria.

5.5 Calibration and Validation Summary

5.5.1 The previous two chapters provide an overview of the calibration and validation of the Virginia local area traffic model which has been developed to assess the proposed route options for the N3 Virginia Bypass. In summary:

- The NTAs ERM was used as a basis for development of the Virginia Local Area Model with additional network and zonal detail added to more accurately represent localised traffic movements;
- The model has been calibrated and validated in-line with TII Project Appraisal Guidelines and meets all specified criteria for all modelled time periods
- The LAM is fit for purpose, and represents base year traffic conditions well, as demonstrated statistically through calibration and validation.
- While the traffic surveys were undertaken during a period where the country was under Covid-19 travel restrictions, the LAM stills provides a robust basis for assessing the proposed route alignment options as:
  - The model realistically represents journey times;
  - The study area is covered by a large number of calibration counts;
  - Trip length distributions have not been significantly altered during the Matrix Estimation processes.

6. FUTURE YEAR MODEL DEVELOPMENT

6.1 Introduction

6.1.1 This section sets out the development of the future year ERM & Virginia LAM models for the scheme opening year (2028) and design year (2043). These forecast years will be used for assessing the performance of the Scheme and for input into the design process.

6.2 Future Year Network Development

6.2.1 The future year networks include the different alignment options to be tested (outlined in Chapter 1). The future year networks developed are:

- 2028 Opening Year; and
- 2043 Design Year.

Do-Minimum Networks

6.2.2 The Do-minimum scenario is a reference case against which each of the options will be assessed. In general, the Do-Minimum Scenario consists of the existing road network plus any planned or committed schemes for the area.

6.2.3 Included as part of the Do Minimum scenario for this modelling assessment are the following Traffic Management proposals which are committed for the Town of Virginia. These measures aim to make the town safer and more attractive for vulnerable road users:

- Recently implemented 80 Kph speed limits between Maghera and Virginia and on the north side of Virginia to Cornaslieve;
- Reconfigured signal timings in the town to facilitate longer pedestrian / cyclist crossing times, to be completed prior to the end of the street enhancement works which are currently under construction; and
- Upgrading the Main Street and change of R194 Ballyjamesduff Road junction to a roundabout junction, currently under construction:
    - Including modelling a 30 kph speed limit along the N3 through Virginia town to simulate slower traffic speeds as a result of the four additional zebra crossings and new roundabout on the N3, currently under construction.

Do-Something Networks

6.2.4 The same proposals included in the Do Minimum scenario have also been brought forward into the Do Something scenarios. These will be modelled in conjunction with each of the Do-Something Options to be assessed.

6.2.5 A description (including a figure) of each of these Do-Something options is outlined in Section 1.5 of this Report.

6.3 Future Year Travel Demand Estimation

NTA vs TII Traffic Forecasts

6.3.1 At the time of modelling, the decision was made to use the National Transport Authority's Eastern Regional Model (ERM) to inform traffic growth in the study area rather than using TII's National Transport Model (NTpM). This decision was based on the following combination of reasons –

- The ERM is a strategic multi-modal transport model representing travel by all the primary surface modes – including, walking and cycling (active modes), and travel by bus, rail, tram, car, light goods and heavy goods vehicles;
- The Cavan County Development Plan 2022 – 2028 wasn't available at the time to inform the distribution of new traffic growth in the study area;
- The ERM's zoning system is more disaggregated in our study area compared with TII's National Transport Model (NTpM), as shown below in Figure 6-1;
- The NTA's planning team develop land use forecasts by Census Small Area which is the smallest geographical boundary available and these forecasts inform the level of traffic growth in each model zone. As such, it was the best source of data we had at the time to inform the distribution of traffic growth around Virginia; and
- The NTA traffic growth forecasts were also more conservative than the equivalent TII forecasts. As such, they were deemed suitable to use at the comparative assessment stage. That comparative analysis of forecasts is shown below.

ERM vs NTpM Model Zone Comparison

6.3.2 Both variable demand models (ERM and NTpM) have their own zone systems which any growth in demand will be based upon and thus the zoning systems of each are also compared here for the project study area.

6.3.3 As shown in the figure below, the town of Virginia and the section of the N3 between Lisgrea and the Derver roundabout (at the intersection of the N3 and R147 south of Virginia town) which covers the length of the proposed scheme is covered by one NTpM zone. For comparative purposes, the ERM has five zones for the same NTpM zone - 3 zones that are wholly contained in the the single large NTpM zone and 2 partially contained zones. This makes the ERM slightly more detailed in the project study area and makes the task of distributing any growth in traffic easier given the smaller zone boundaries.

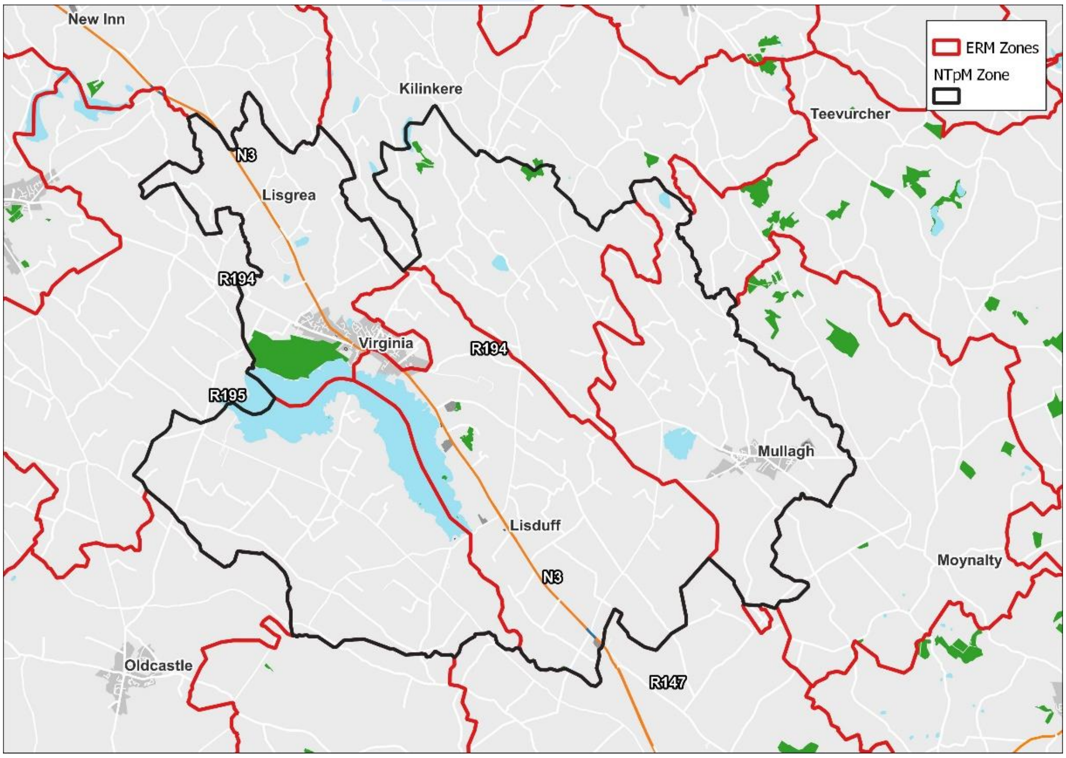


Figure 6-1: Model Zone Comparison

ERM vs NTpM Comparison of Traffic Forecasts for Key Locations in Study Area

6.3.4 For the comparison of growth rates (up to the design year of 2043), the following key locations have been compared –

- The external zone which represents the entry/exit point of the N3 (to the north of Virginia, towards Cavan town);
- The external zones which represent the entry/exit points of the M3 (to the south of Kells);
- The NTpM zone boundary which contains the town of Virginia (the same referenced in the previous section and Figure 1);

6.3.5 But in order to compare the level of traffic growth on the N3 (north of Virginia) and the M3 (South of Virginia) i.e. external zones in our study area, a extraction of both the ERM and the NTpM was taken which matches our study area. Given both models cover a wide area which is far greater than our study area, an extraction must be taken from both models to ascertain the growth in traffic which would be entering our study area. By doing this, we can directly compare the level of traffic on both the N3 and M3.

6.3.6 These 3 locations as shown in the figure below have been used given they represent the key inbound and outbound movements into the study area (via the N3 to the north and the M3 to the south) and for the area along the N3 which contains the town of Virginia itself. For context, figure 2 below represents the road links extraction and associated external zones for the N3 and M3 which was taken from the NTpM, which matches our study area.

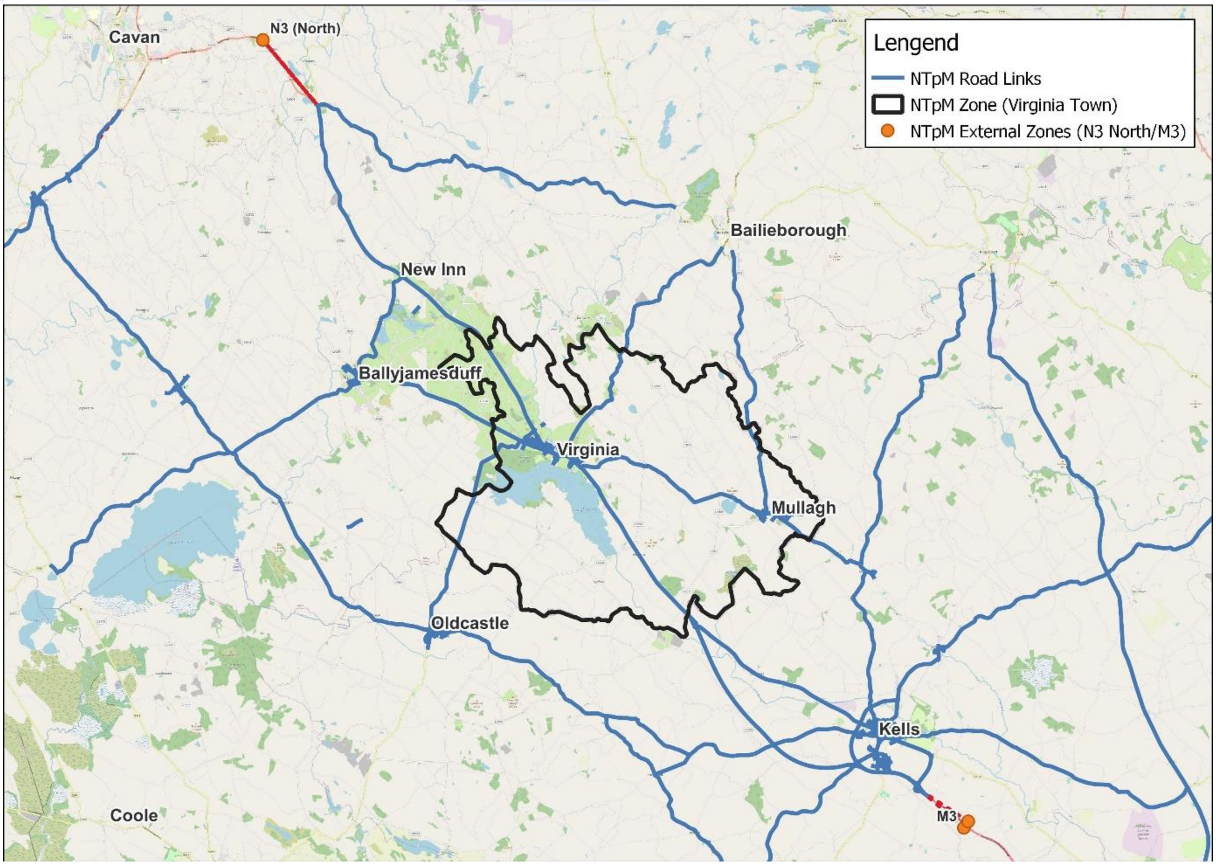


Figure 6-2: Key inbound and outbound movements into the study area

6.3.7 The tables below show the comparison of growth rates for both light vehicles (cars, LGVs) and heavy vehicles (various goods vehicles) and the values are also presented for origin and destination traffic separately too. The absolute differences are shown below and any instance where the NTpM rates are higher are shown in **red** while any instance where the ERM rates are higher are shown in **green**.

6.3.8 The analysis shows that in almost all instances (18/24), the NTpM rates are higher especially on the N3 and the M3 which would have the highest traffic volumes in the study area. So for instance in the AM, we would see an additional 120 vehicles travelling southbound on the N3 towards Virginia (equally split between light and heavy vehicles).

6.3.9 There are only two instances where the ERM has a higher percentage growth rate for light vehicles and only three instances where it has a higher percentage growth for heavy vehicles.

ZONE DESCRIPTION	NTPM RATES				ERM RATES				DIFFERENCE (ABSOLUTE %)			
	AM		PM		AM		PM		AM		PM	
	ORIGIN	DEST	ORIGIN	DEST	ORIGIN	DEST	ORIGIN	DEST	ORIGIN	DEST	ORIGIN	DEST
N3 (North of Virginia)	1.43	1.20	1.20	1.43	1.24	1.15	1.11	1.24	19%	5%	8%	19%
M3 (South of Kells)	1.54	1.43	1.43	1.54	1.17	1.55	1.43	1.19	37%	-12%	0%	35%
Zone which contains Virginia town	1.25	1.17	1.17	1.25	1.17	1.16	1.18	1.18	8%	1%	-2%	7%

Table 6-1: Light Vehicle Growth Comparison (%)

ZONE DESCRIPTION	NTPM RATES				ERM RATES				DIFFERENCE (ABSOLUTE %)			
	AM		PM		AM		PM		AM		PM	
	ORIGIN	DEST	ORIGIN	DEST	ORIGIN	DEST	ORIGIN	DEST	ORIGIN	DEST	ORIGIN	DEST
N3 (North of Virginia)	1.62	1.49	1.49	1.62	1.37	1.40	1.43	1.41	25%	10%	6%	20%
M3 (South of Kells)	1.98	1.97	1.97	1.98	1.37	1.37	1.39	1.44	61%	60%	58%	54%
Zone which contains Virginia town	1.48	1.47	1.47	1.48	1.31	1.60	1.59	1.51	16%	-14%	-12%	-4%

Table 6-2: Heavy Vehicle Growth Comparison (%)

ERM Overview

6.3.10 The ERM Future year travel demand is based on forecasts of population, employment and education data as defined by the National Transport Authority at the Census Small Area (CSA) level. The National Demand Forecasting Model converts this forecast planning data to trip forecasts (in total productions and attractions per zone) for input to the Eastern Regional Model. The travel demand for the assessment years for this project (2028, 2043) have been derived by linear interpolation of the NTA's, 2043, NPF Scenario.

6.3.11 Annualised external growth rates have been calculated by cordoning the modelled study area from the future year (2043) ERM model. Internal growth rates have been based on the ERM zonal growth rates. This internal growth was proportioned between the disaggregated LAM zones based on base year proportions or in accordance with the county development plan and information from the planning department of Cavan County Council, where appropriate.

Future Year Matrix Development

6.3.12 As discussed above, the forecast year matrices have been based on growth between the base and future year cordons from the Eastern Regional Model. These cordon models include demand from NPF planning data forecasts as per the NTA's planning team. Upon producing these cordon models, the demand was disaggregated to our LAM zones (105 in total), which resulted in a set of trip end growth factors compared to the base year cordons. These growth factors were applied to the row and column totals of the existing base year matrices (which is calibrated and validated to a local level) to give future year trip ends. Trip Ends were factored to the average of the row-total-sum and column-total-sum, and then a Furnessing process was applied to factor the base year matrices to the future year trip ends.

6.4 Goods Vehicle Growth

6.4.1 For the NTA's Regional Models, and therefore the Virginia LAM, Goods vehicle growth is assumed to increase broadly in line with economic growth forecasts. CSO Gross Domestic Product (GDP) forecasts have been used to derive a growth factor for HGV traffic for each of the Future Years Assessed.

6.5 Vehicle Operating Costs

6.5.1 Vehicle Operating Costs (VOCs) were assumed to remain constant in real terms through time, as recommended in the TII PAG.

6.6 Future Year Matrix Totals

6.6.1 A comparison of the peak hour trip matrix totals for the Base Year, 2028 Opening Year and 2043 Design Year scenarios are outlined in the tables below, in terms of PCU's (passenger car units).

Table 6-3: Matrix Totals 2028 Opening Year

TIME PERIOD	UNIT	2020	2028
AM	PCUs	7,913	9,179
IP	PCUs	5,619	6,420
PM	PCUs	8,565	9,745

Table 6-4: Matrix Totals 2043 Design Year

TIME PERIOD	UNIT	2020	2043
AM	PCUs	7,913	10,299
IP	PCUs	5,619	7,356
PM	PCUs	8,565	10,938

6.7 Future Year Matrix Analysis

6.7.1 The TII PAG require a quantitative assessment of the impact of the traffic forecasting process to be undertaken to ensure that the process of applying traffic growth factors does not unduly distort the trip matrix. These checks include assessing the following criteria:

- Trip Length Distribution;
- Trip End Growth; and
- Zone to Zone Growth.

Trip Length Distribution

6.7.2 The graphs below show the change in trip length distribution between the 2020 Base and 2043 Design Year for car trips in the morning peak hour, inter-peak hour and evening peak hour respectively. These results show a very similar distribution of trip lengths between the base year and design year across all periods.

Figure 6-3: Change in Trip Length Distribution (Light Vehicles) – AM Peak

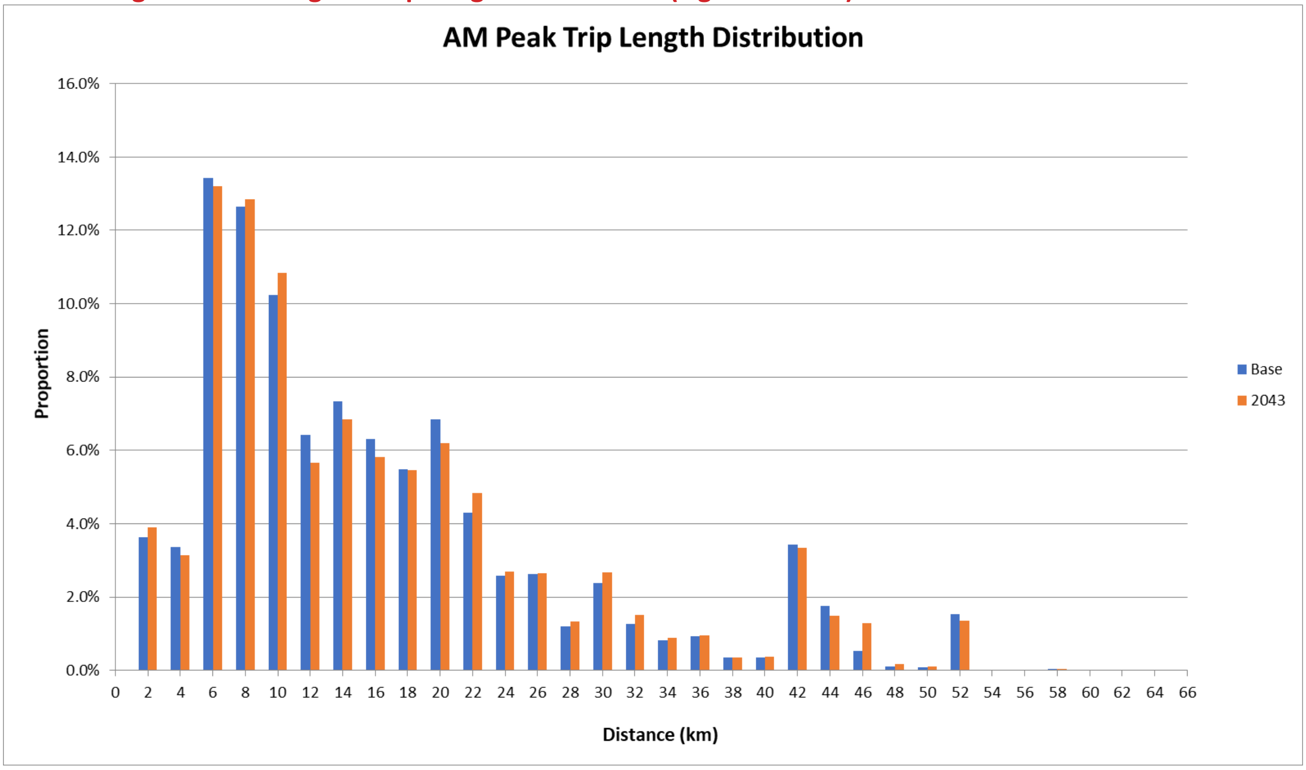


Figure 6-4: Change in Trip Length Distribution (Light Vehicles) – Inter Peak

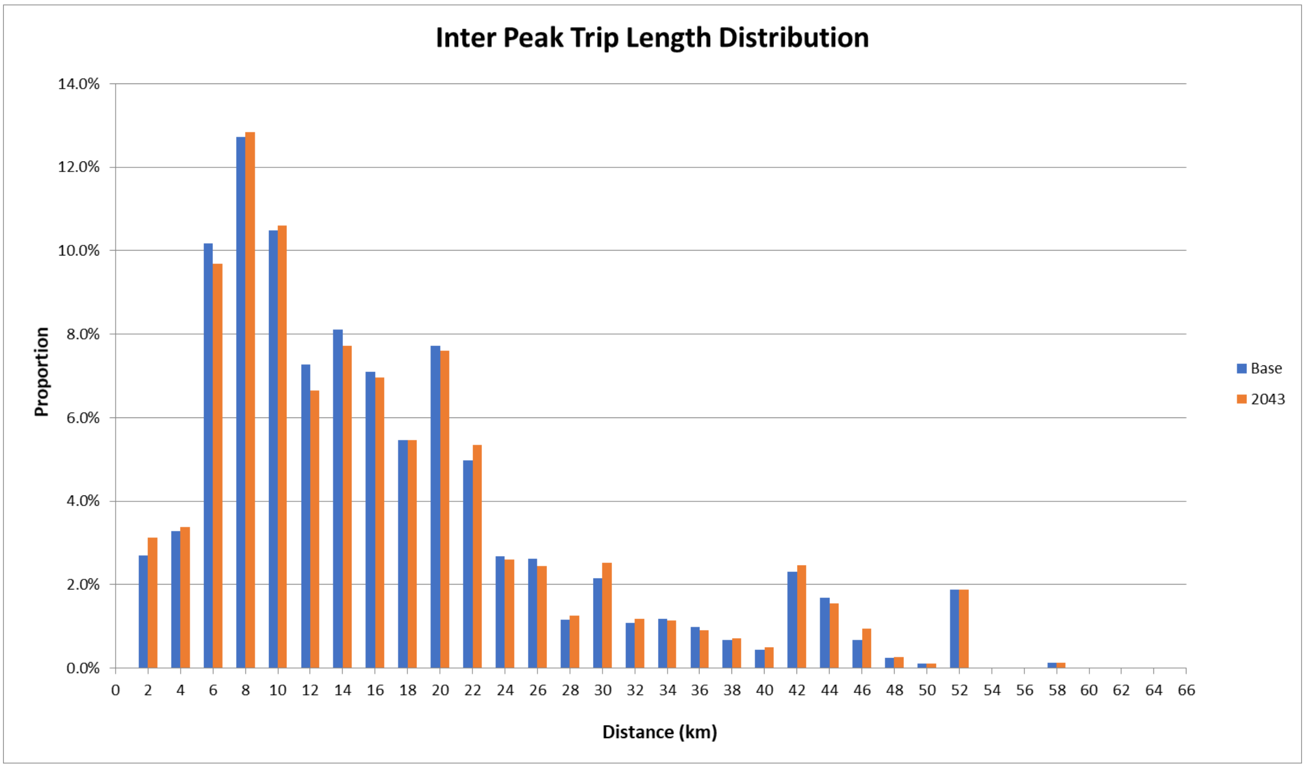
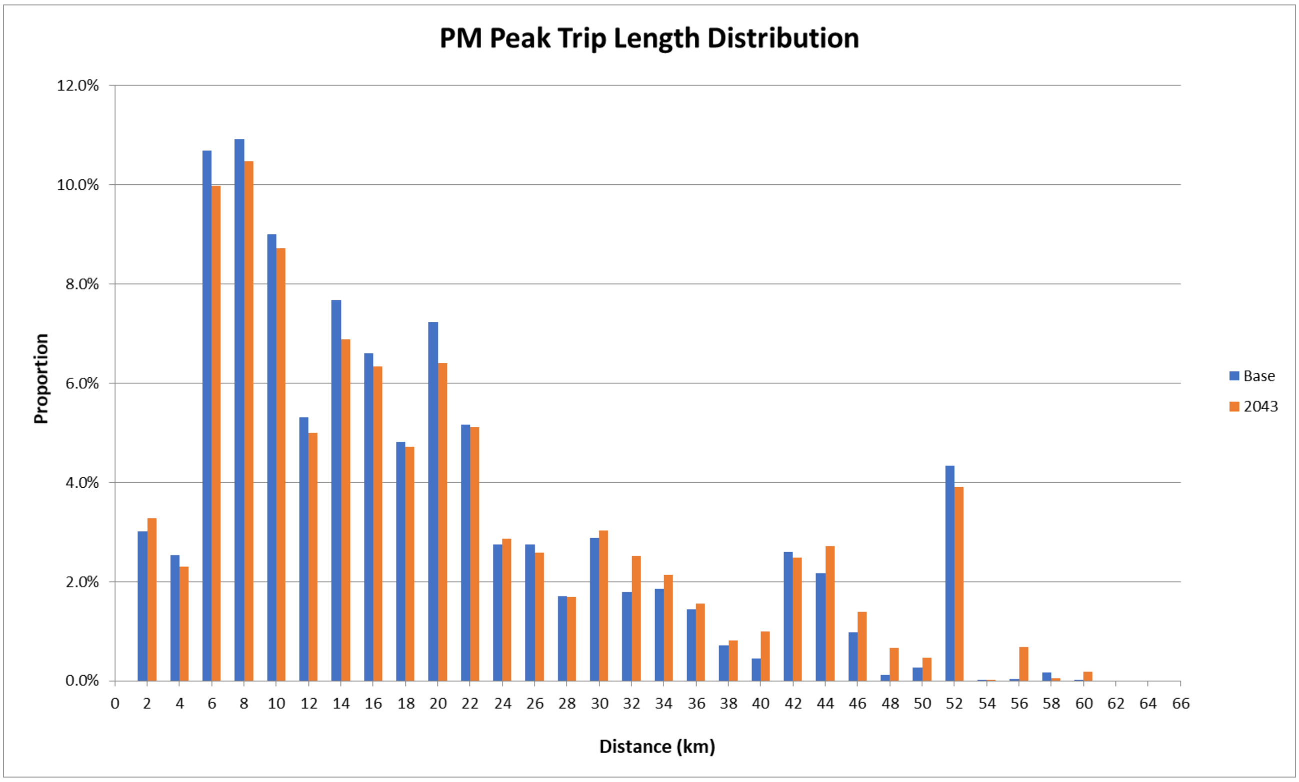


Figure 6-5: Change in Trip Length Distribution (Light Vehicles) – PM Peak



Trip End Growth

6.7.3 An assessment of the Trip End Growth (TEG) between the Base and Design Year demand in the three time periods was undertaken to assess if there were any significant changes i.e. GEH > 10, in demand at trip end level when compared to the overall growth between the Base and Design Year demand.

6.7.4 The assessment indicated that the percentage increase between several trip ends in the Base and Design Year demand was considerable in terms of percentage growth, however, that the actual increase in the number of trips was only minor. In order to assess the true magnitude of TEG, the GEH statistic was applied to the Base and Design Year trip ends in order to take account of not only the difference between the Base and Design Year demand, but also the magnitude of the difference.

6.7.5 Figure 6-6 - Figure 6-11 illustrate the GEH (>10) between the Base and Design Year demand in the AM, IP and PM Peak respectively. The PAG guidance on the GEH statistic indicates that any GEH statistic above 10 warrants further investigation. In general the figures show a very small number of origin and destination zones with a GEH statistic above 10 in all time periods.

6.7.6 A review was undertaken to assess the origin and destination trips end growth whereby a GEH of 10 or more was calculated. In summary these instances were:

- AM - 2 origin (for Lights) zones that represent the Kells Business Park on the R147 and an external zone that marks the entry point for the N52
- AM – 3 destination (for Lights) zones that represent a part of Kells town, an area in the village of Mullagh and an external zone that marks the exit point for the M3
- AM – 6 origin (for HGV) zones that all represent external zones at the edge of the model
- AM – 4 origin (for HGV) zones that all represent external zones at the edge of the model
- IP - 1 origin (for Lights) zone that represents an external zone that marks the entry point for the N52
- IP – 2 destination (for Lights) zones that represents the Kells Business Park on the R147 and an external zone that marks the entry point for the N52
- IP – 4 origin (for HGV) zones that all represent external zones at the edge of the model
- IP – 3 origin (for HGV) zones that all represent external zones at the edge of the model
- PM - 6 origin (for Lights) zones that represent the Glanbia site on the N3, the Kells Business Park on the R147, another part of Kells town, an area in Oldcastle, and two external zones that marks the entry point for the M3 and the R147 through Kells
- PM – 9 destination (for Lights) zones that represent two areas in the village of Mullagh, an area around Knocktemple, two areas in Ballyjamesduff, an area in Oldcastle and three external zones at the edge of the model
- PM – 2 origin (for HGV) zones that all represent external zones at the edge of the model
- PM – 2 origin (for HGV) zones that all represent external zones at the edge of the model

6.7.7 As expected the review indicated that several of the zones with a GEH over 10 were external movements passing through the model. While the remaining internal zones were either areas which had very low values in the base year (and thus even a small amount of growth in traffic results in a GEH >10) or where growth is planned as per NPF land use forecasts derived by the NTA's planning team.

Figure 6-6: AM Light Vehicle Trip End Growth (2020 to 2043)

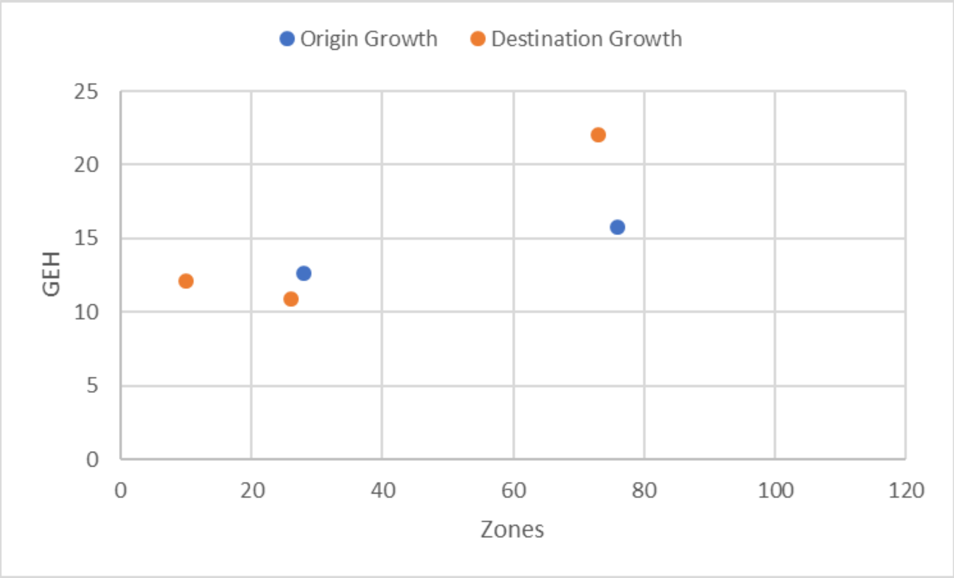


Figure 6-7: AM HGV Trip End Growth (2020 to 2043)

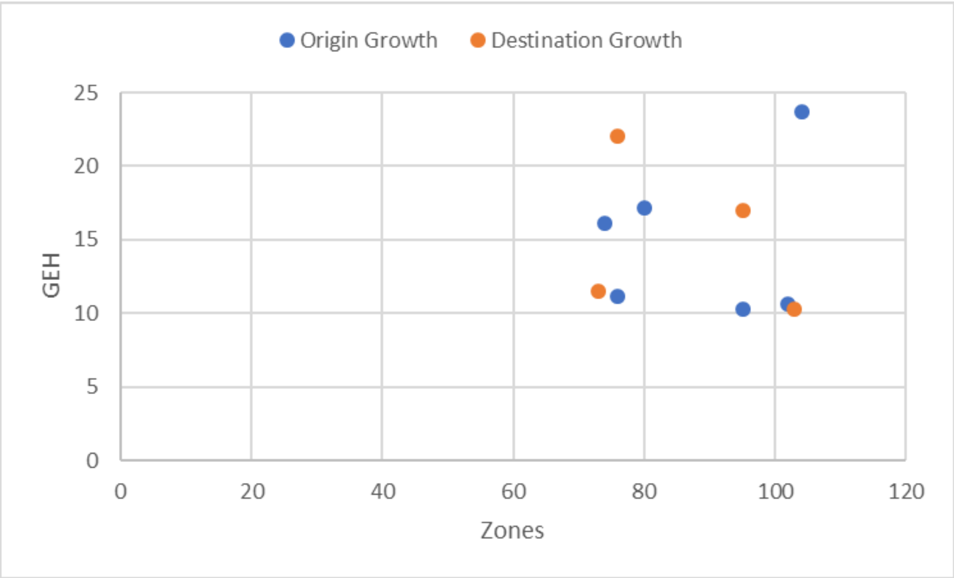


Figure 6-8: IP Light Vehicle Trip End Growth (2020 to 2043)

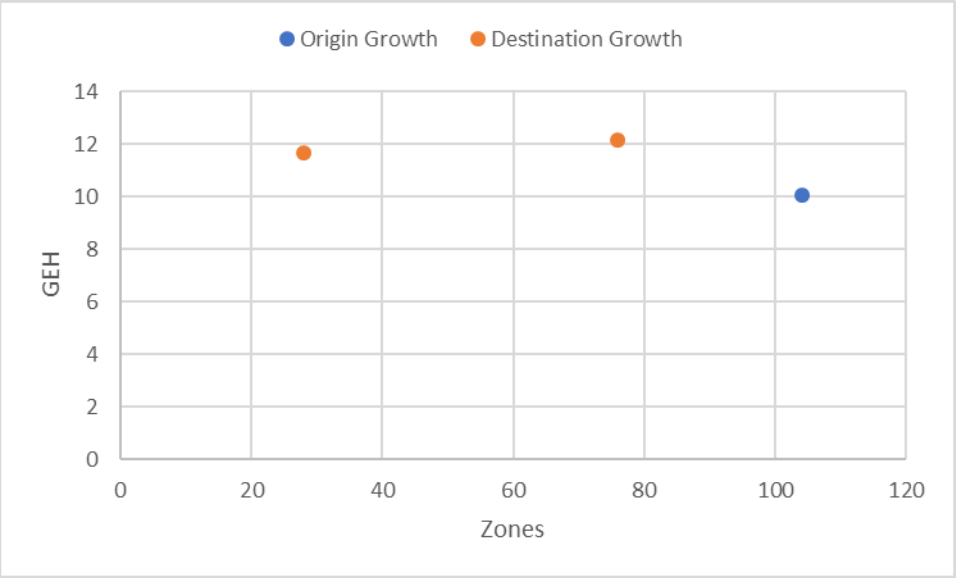


Figure 6-9: IP HGV Trip End Growth (2020 to 2043)

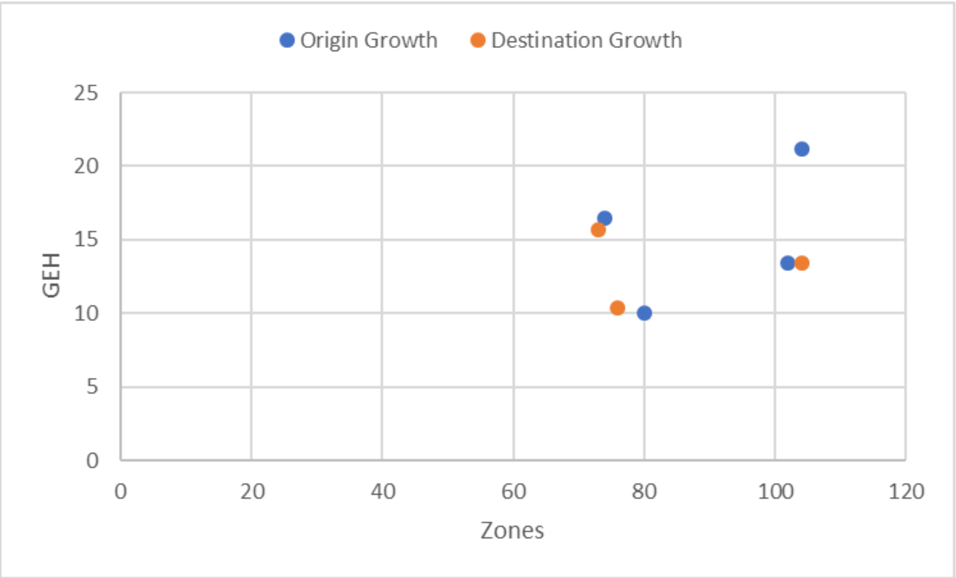


Figure 6-10: PM Light Vehicle Trip End Growth (2020 to 2043)

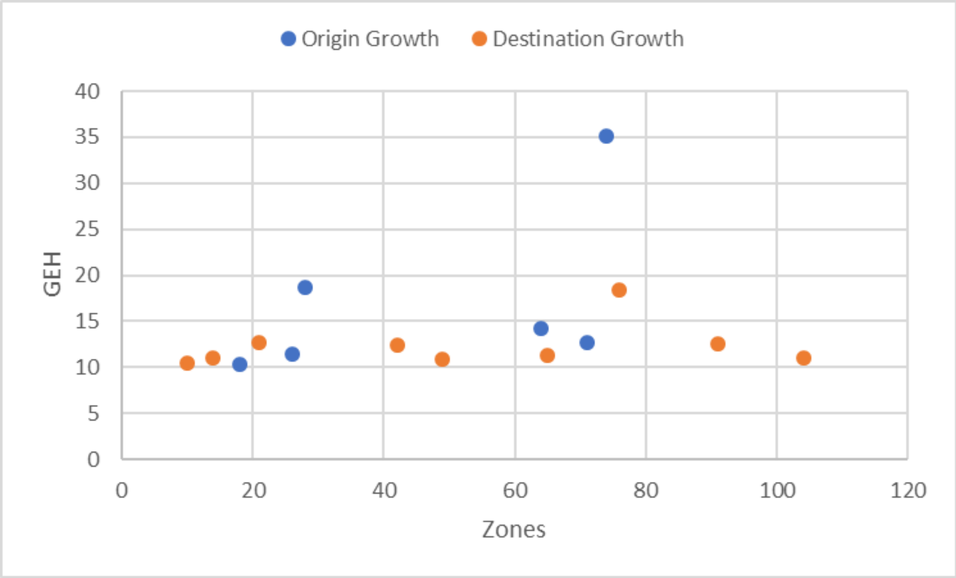
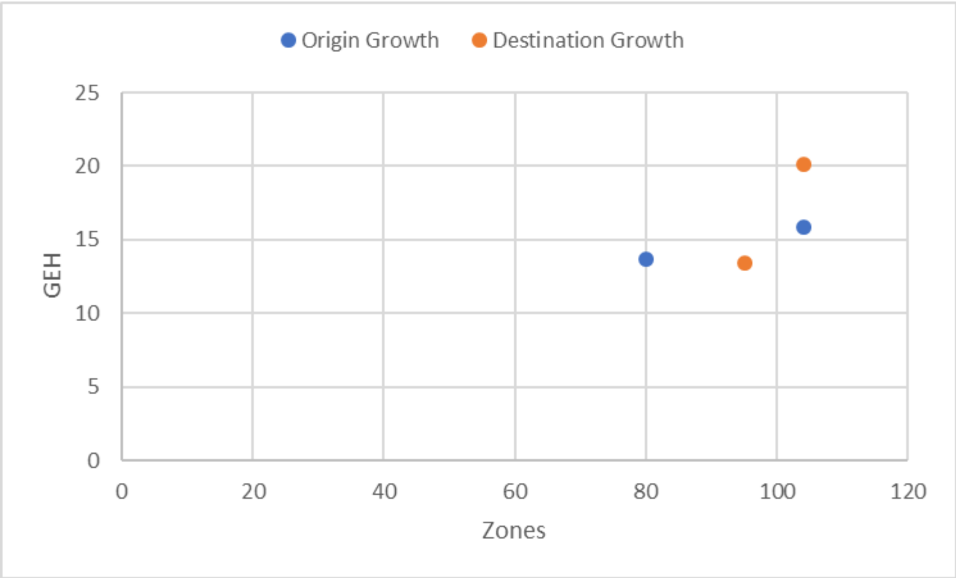


Figure 6-11: PM HGV Trip End Growth (2020 to 2043)



Zone to Zone Growth

6.7.8 The same procedure for TEG was also undertaken for zone to zone growth. The GEH statistic for each origin-destination pair was assessed to show any significant outliers or issues in the AM, IP and PM Peak demand.

6.7.9 The GEH statistic on a zone to zone basis for each period is shown in Figure 6-12 to Figure 6-17. The figures show that there are no GEH statistics greater than 10 for light vehicle movements in all three time periods. There are 3 movements in the AM and 1 in both the Inter peak and PM for HGVs which have a GEH >10. These all represent external to external movements which pass through the model.

Figure 6-12: AM Light Vehicle Zone to Zone Growth (Base year to Design year)

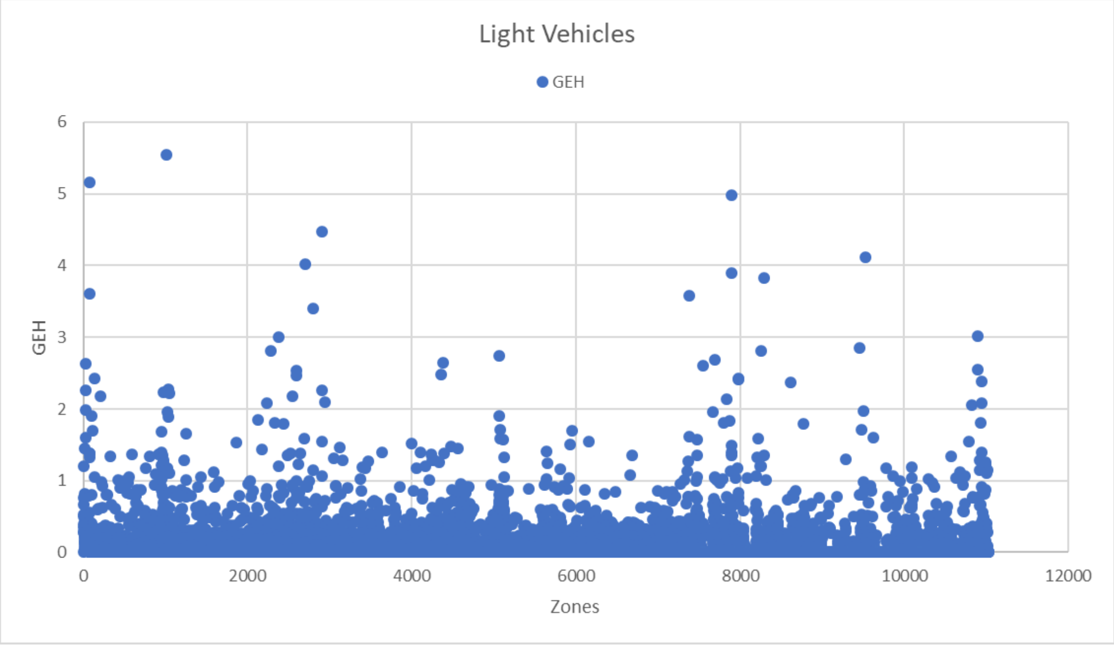


Figure 6-13: AM Heavy Vehicle Zone to Zone Growth (Base year to Design year)

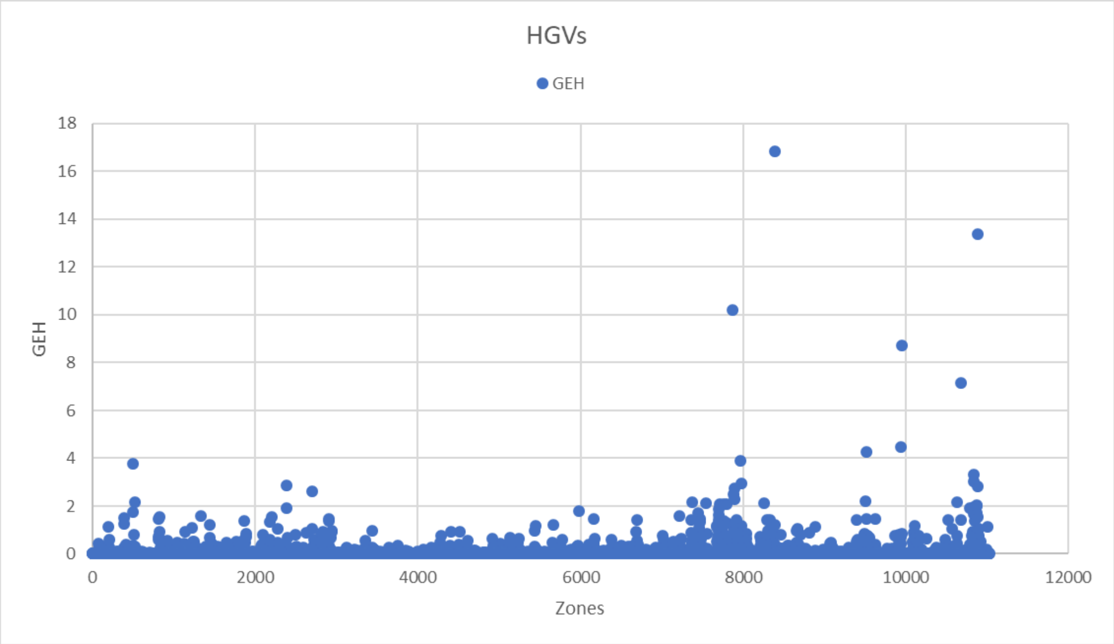


Figure 6-14: IP Light Vehicle Zone to Zone Growth (Base year to Design year)

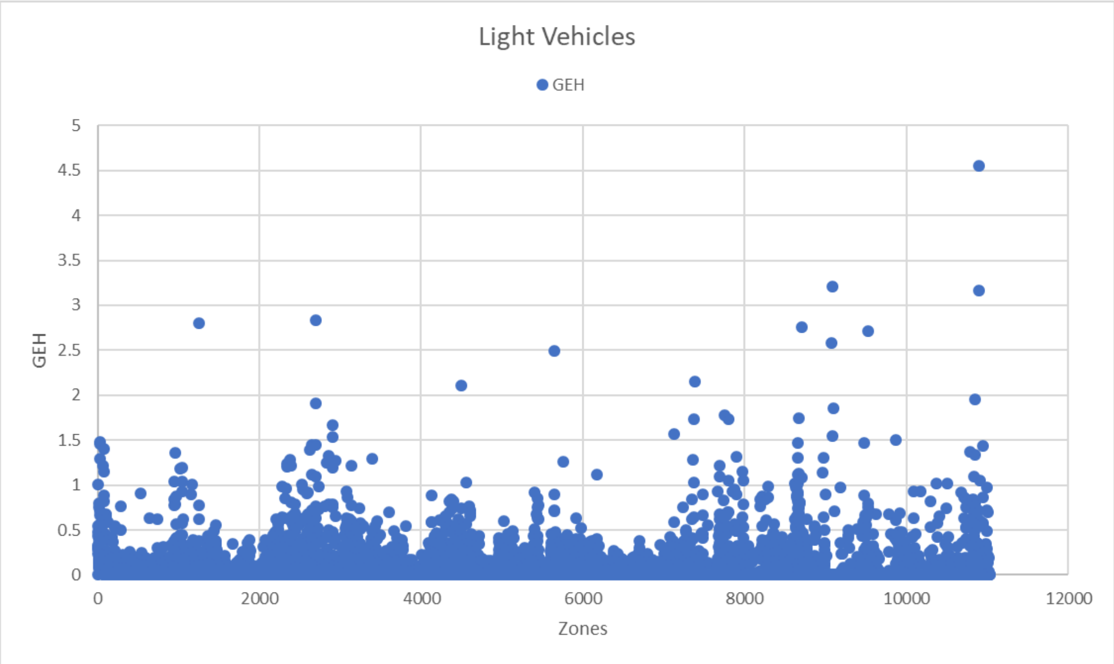


Figure 6-15: IP Heavy Vehicle Zone to Zone Growth (Base year to Design year)

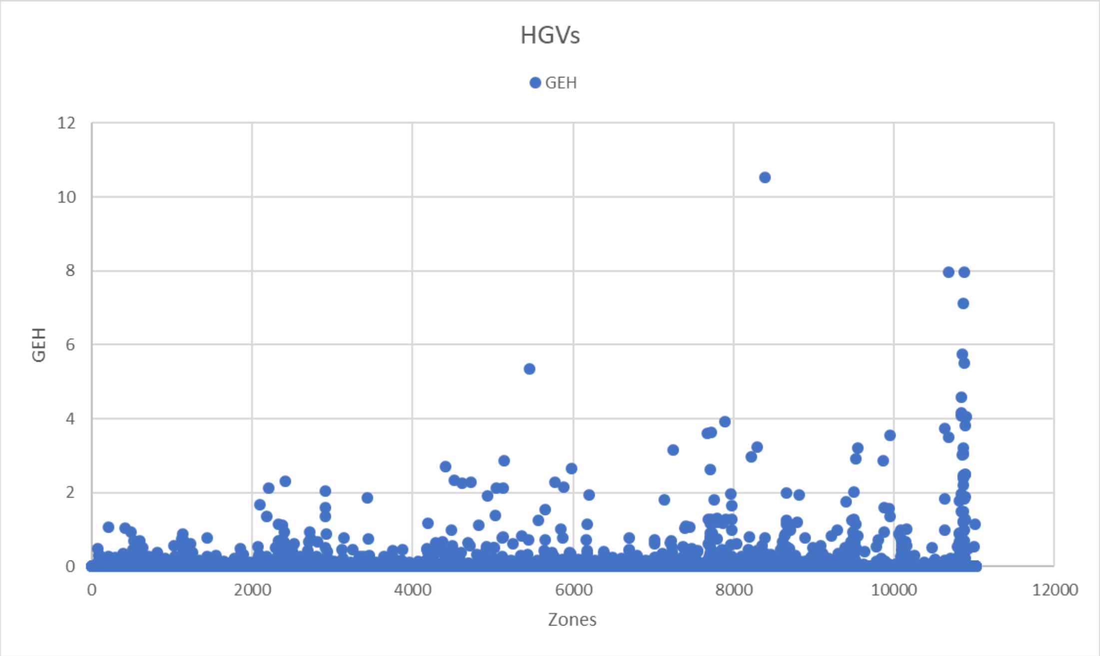


Figure 6-16: PM Light Vehicle Zone to Zone Growth (Base year to Design year)

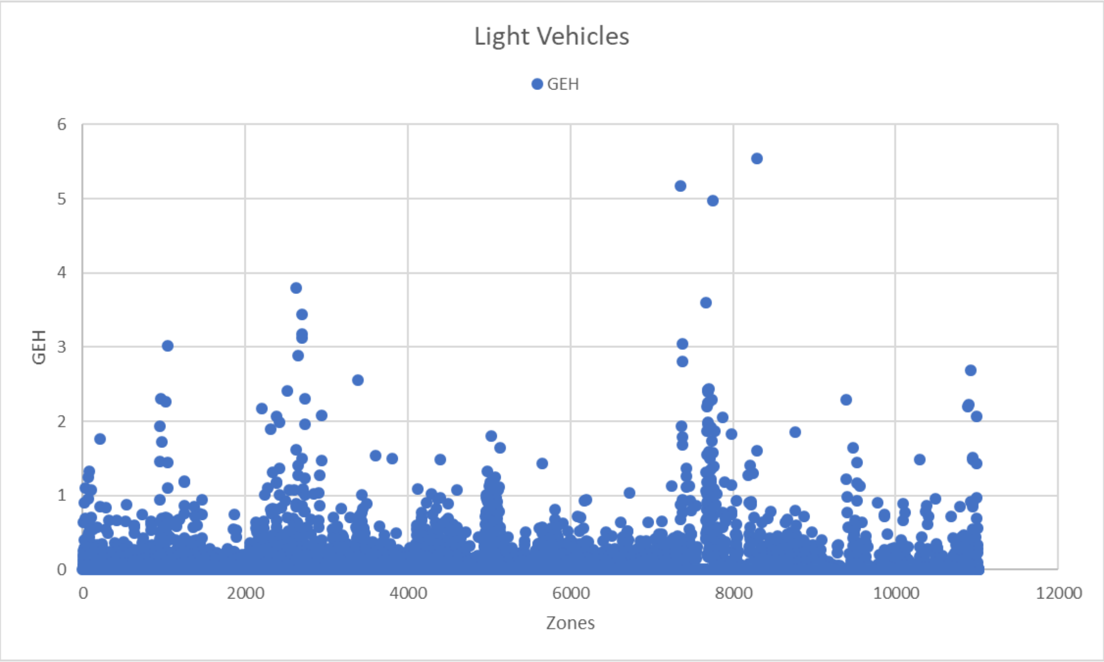
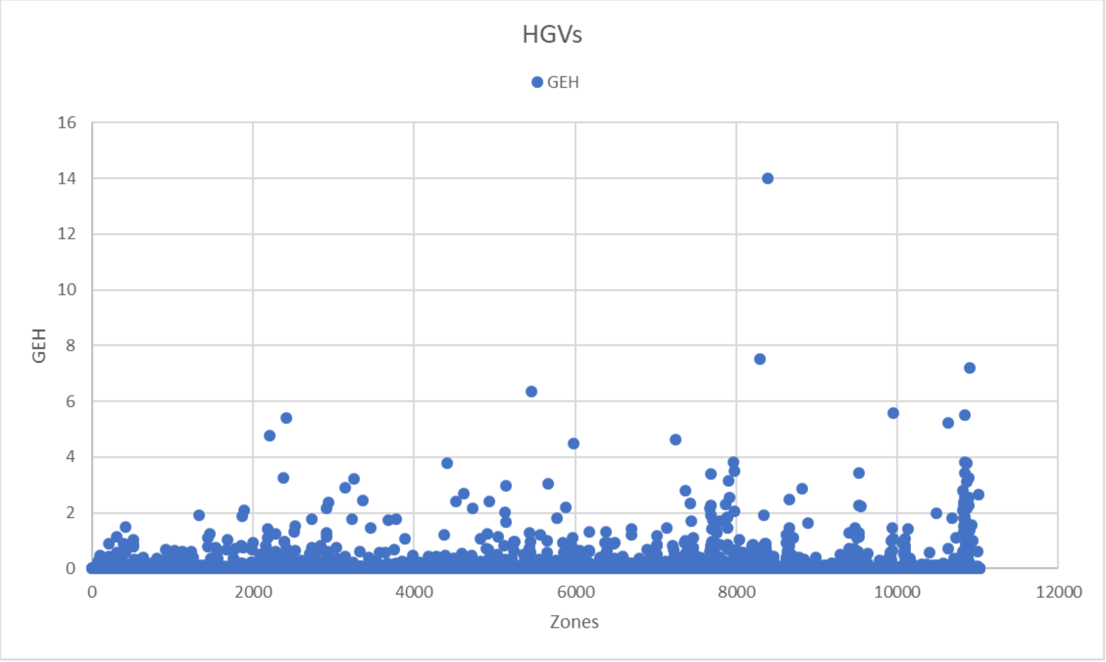


Figure 6-17: PM Heavy Vehicle Zone to Zone Growth (Base year to Design year)



7. ANALYSIS OF OPTIONS

7.1 Introduction

7.1.1 This section provides a summary of the performance of each option assessed, based on the following key performance indicators:

- Network Performance Indicators
- Journey Times
- Reduction of Traffic on Main Street in Virginia
- AADT Flows

7.2 Description of Forecast Scenarios

Do-Minimum Scenarios

7.2.1 The Do-minimum scenario is a reference case against which each of the options will be assessed. In general, the Do-Minimum Scenario consists of the existing road network plus any planned or committed schemes for the area.

7.2.2 Included as part of both the Do Minimum scenario for this modelling assessment are the following Traffic Management proposals. These measures are either committed for the town, or are in advanced stages of delivery and aim to make the town safer and more attractive for vulnerable road users:

- Recently implemented 80 Kph speed limits between Maghera and Virginia and on the north side of Virginia to Cornaslieve;
- Reconfigured signal timings in the town to facilitate longer pedestrian / cyclist crossing times, to be completed prior to the end of the street enhancement works which are currently under construction.
- Upgrading the Main Street and change of R194 Ballyjamesduff Road junction to a roundabout junction, currently under construction:
  - Including modelling a 30 kph speed limit along the N3 through Virginia town to simulate slower traffic speeds as a result of the four additional zebra crossings and new roundabout on the N3, currently under construction.

Do-Something Scenarios

7.2.3 A description (including a figure) of each of the Do-Something options can be found in Section 1.5 of this Report.

7.4 Network Performance Indicators

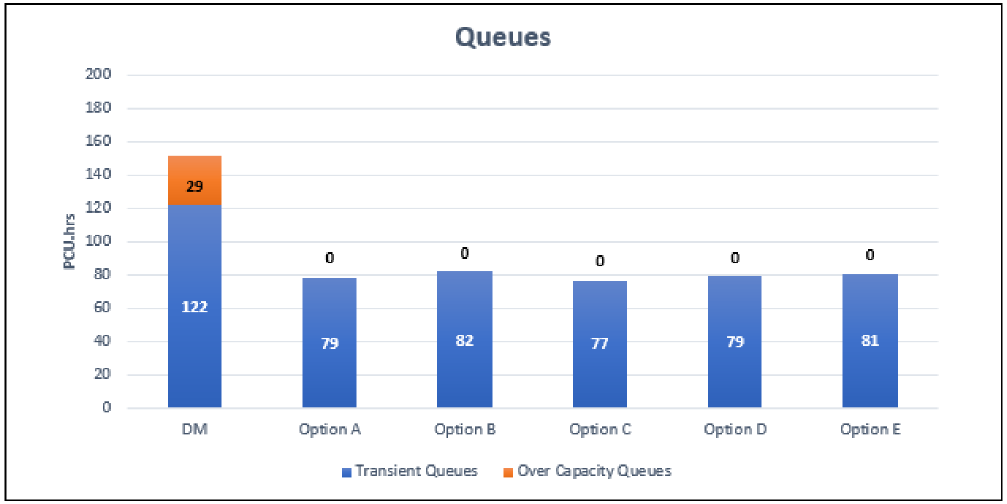
7.4.1 The tables and figures below present a summary of the network performance statistics for the scenarios modelled for the 2043 Design Year in the AM, Inter-peak and PM peak. The following network statistics are presented for each scenario:

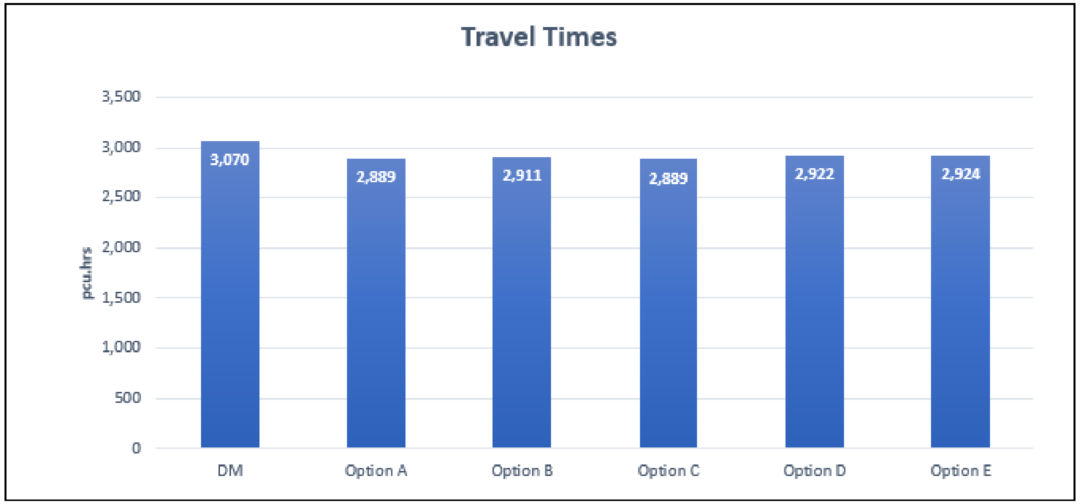
- **Transient Queues**: represents time spent in queues at junctions which are not over capacity, for example, at a signalised junction where the queue is able to clear during a single cycle. This is presented in total pcu.hours which is essentially the volume of vehicles on the network multiplied by the time spent in transient queues.
- **Over-capacity queues**: occur where the volume of turning movements exceed junction capacity, such that a permanent queue builds – for example at a signalised junction where a queue is unable to clear in a single cycle. Similar to transient queues, over-capacity queues are presented in total pcu.hours
- **Total Travel Time**: represents the total travel time for all vehicles on the network in the modelled period measured in pcu.hours.
- **Total Travel Distance**: represents the total distance travelled by vehicles on the road network in the modelled period measured in pcu.kms
- **Average Speed**: represents the average speed of all vehicles travelling on the network within the modelled time period measured in kph.

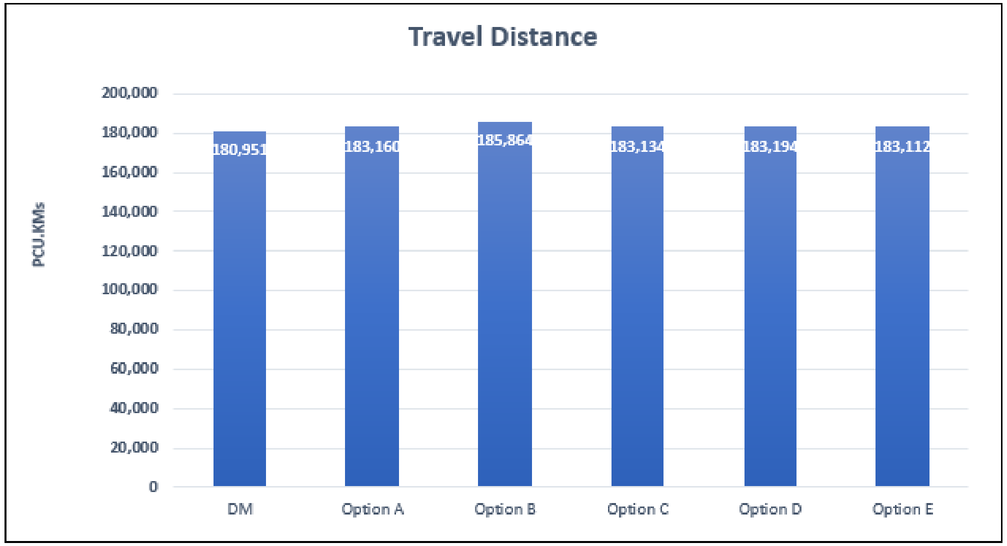
Table 7-1: Network Performance Indicators (AM Peak – 2043 Design Year)

	DO MIN	OPT A	OPT B	OPT C	OPT D	OPT E
Transient Queues (pcu.hrs)	122	79	82	77	79	81
Over Capacity Queues (pcu.hrs)	29	0	0	0	0	0
Total Travel Times (pcu.hrs)	3,070	2,889	2,911	2,889	2,922	2,924
Total Travel Times (pcu.kms)	180,951	183,160	185,864	183,134	183,194	183,112
Average Speed (km/hr)	59	63	64	63	63	63

7.4.2 An analysis of the AM peak network performance statistics indicates that, in general, all options perform similarly to each other when the impact on the entire network is considered. All options provide a relatively similar drop in overall network delay (i.e. queues) when compared against the Do Minimum scenario. They also all achieve a similar average speed increase (3 – 4 kph increase) and a similar total travel time reduction (5 – 6% decrease). All options also experience a marginal increase in the total distance travelled in the model compared to the Do-minimum Scenario, this is to be expected given the alignment of each option is longer than the existing N3.


Queues
PCU.hrs
200
180
160
140
120
100
80
60
40
20
0
29
122
0
79
0
82
0
77
0
79
0
81
DM
Option A
Option B
Option C
Option D
Option E
Transient Queues
Over Capacity Queues


Travel Times
pcu.hrs
3,500
3,000
2,500
2,000
1,500
1,000
500
0
3,070
2,889
2,911
2,889
2,922
2,924
DM
Option A
Option B
Option C
Option D
Option E


Travel Distance
PCU.KMs
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
180,951
183,160
185,864
183,134
183,194
183,112
DM
Option A
Option B
Option C
Option D
Option E

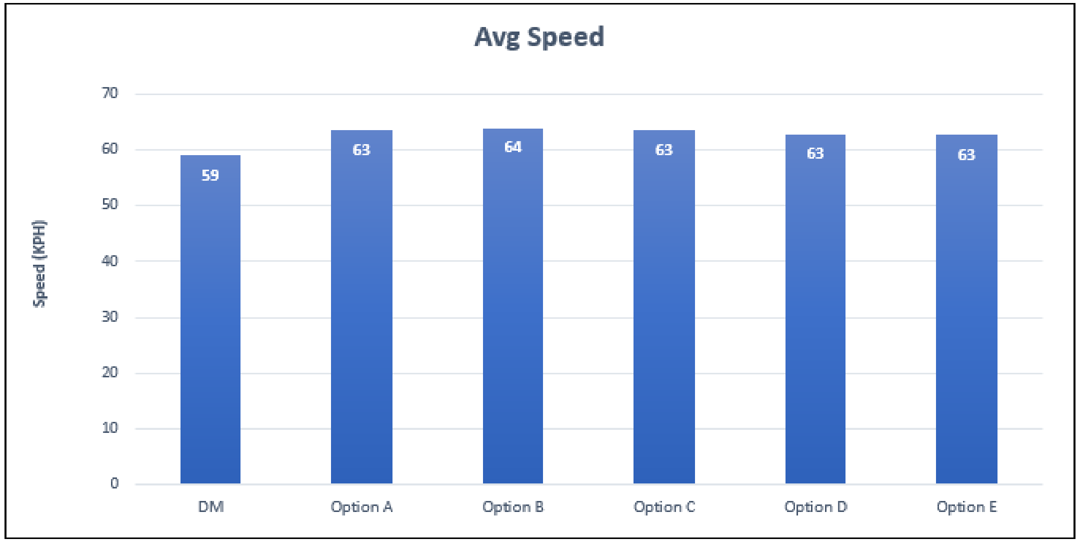
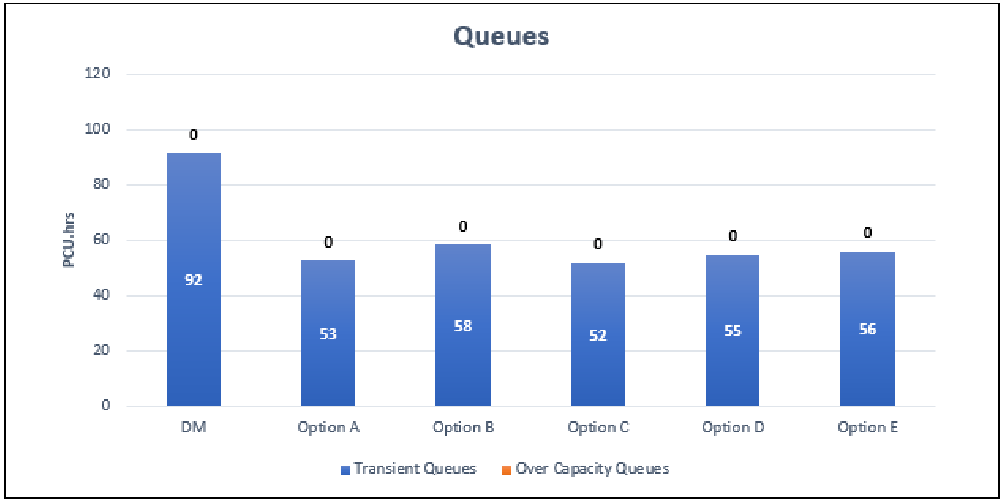
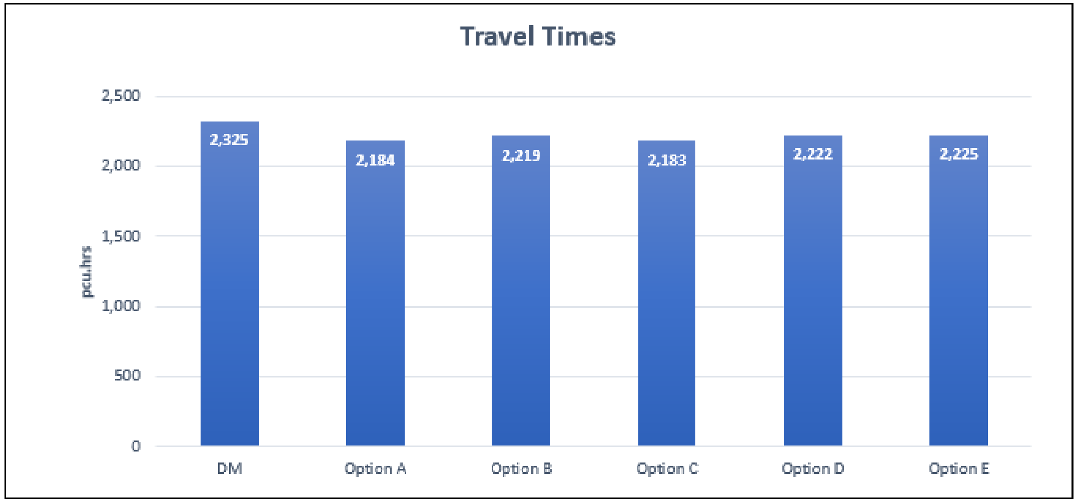

Avg Speed
Speed (KPH)
70
60
50
40
30
20
10
0
59
63
64
63
63
63
DM
Option A
Option B
Option C
Option D
Option E

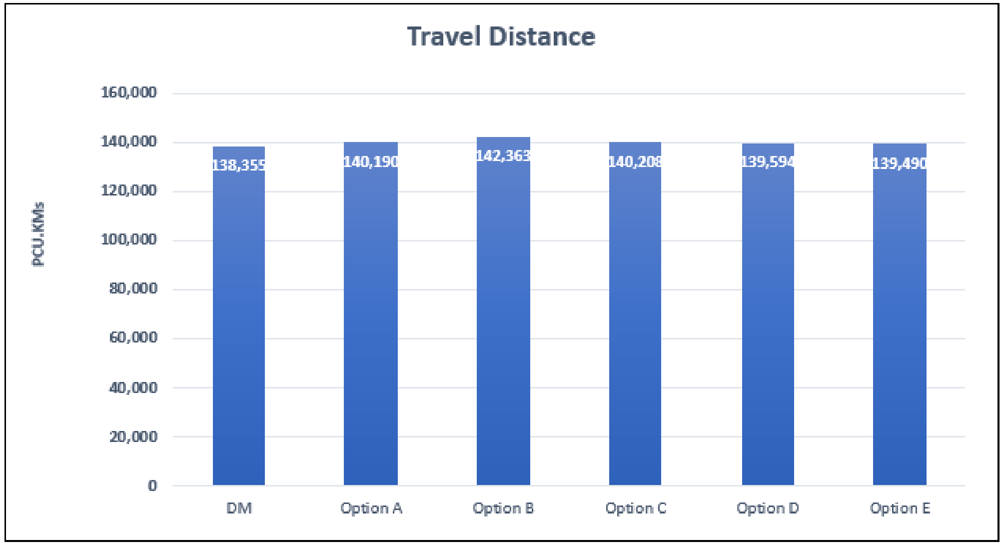
Table 7-2: Network Performance Indicators (Inter Peak – 2043 Design Year)

	DO MIN	OPT A	OPT B	OPT C	OPT D	OPT E
Transient Queues (pcu.hrs)	92	53	58	52	55	56
Over Capacity Queues (pcu.hrs)	0	0	0	0	0	0
Total Travel Times (pcu.hrs)	2,325	2,184	2,219	2,183	2,222	2,225
Total Travel Times (pcu.kms)	138,355	140,190	142,363	140,208	139,594	139,490
Average Speed (km/hr)	60	64	64	64	63	63

7.4.3 An analysis of the Inter peak network performance statistics again indicates that in general all options perform similarly to each other when the entire network is considered. All options provide a relatively similar drop in overall network delay (i.e. queues) when compared against the Do Minimum scenario. They also all achieve a similar average speed increase (3 – 4 kph increase) and a similar total travel time reduction (4 – 6% decrease). All options also experience a marginal increase in the total distance travelled in the model compared to the DM, this is to be expected given the alignment of each option is longer than the existing N3.


Queues
120
100
80
60
40
20
0
PCU.hrs
0
92
0
53
0
58
0
52
0
55
0
56
DM
Option A
Option B
Option C
Option D
Option E
Transient Queues
Over Capacity Queues


Travel Times
2,500
2,000
1,500
1,000
500
0
pcu.hrs
2,325
2,184
2,219
2,183
2,222
2,225
DM
Option A
Option B
Option C
Option D
Option E


Travel Distance
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
PCU.KMs
138,355
140,190
142,363
140,208
139,594
139,490
DM
Option A
Option B
Option C
Option D
Option E

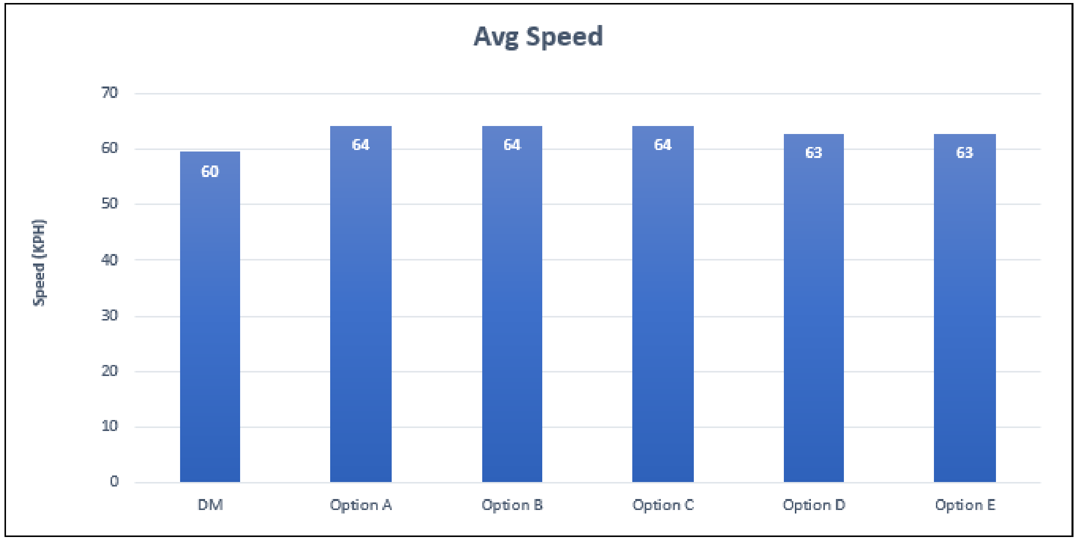
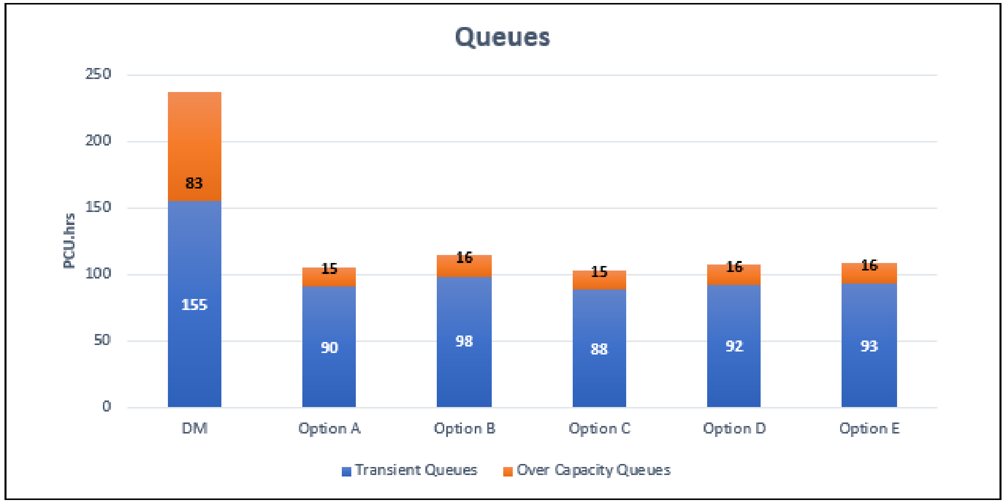
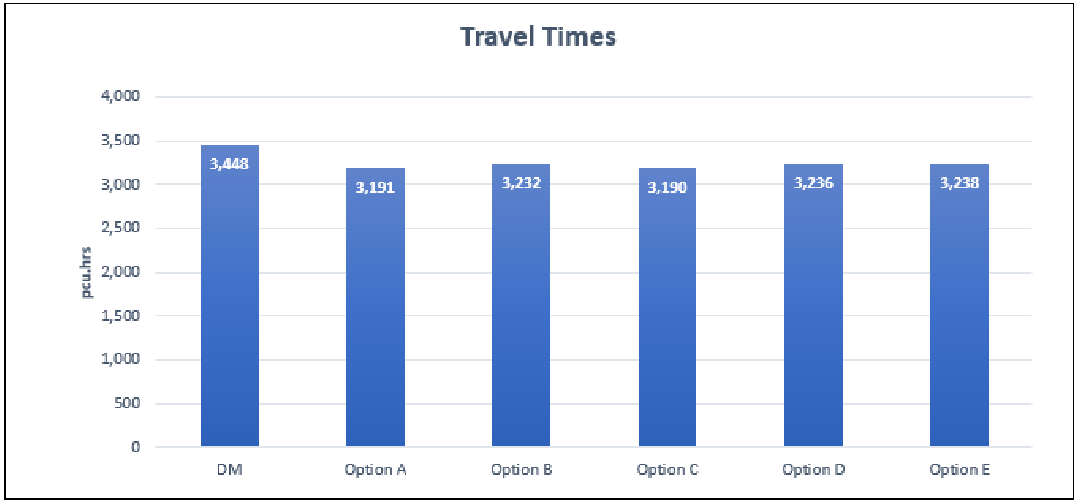

Avg Speed
70
60
50
40
30
20
10
0
Speed (KPH)
60
64
64
64
63
63
DM
Option A
Option B
Option C
Option D
Option E

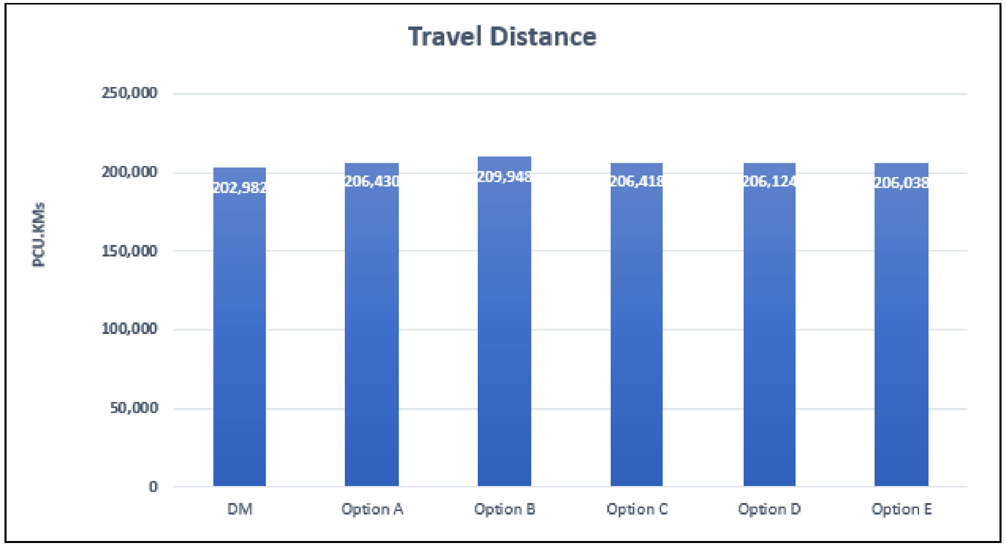
Table 7-3: Network Performance Indicators (PM Peak – 2043 Design Year)

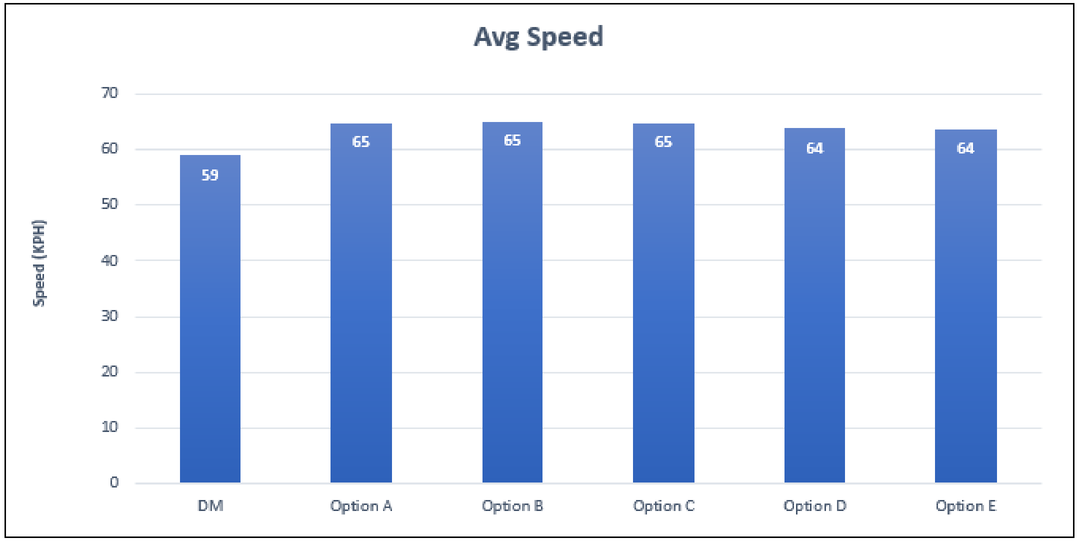
	DO MIN	OPT A	OPT B	OPT C	OPT D	OPT E
Transient Queues (pcu.hrs)	155	90	98	88	92	93
Over Capacity Queues (pcu.hrs)	83	15	16	15	16	16
Total Travel Times (pcu.hrs)	3,448	3,191	3,232	3,190	3,236	3,238
Total Travel Times (pcu.kms)	202,982	206,430	209,948	206,418	206,124	206,038
Average Speed (km/hr)	59	65	65	65	64	64

7.4.4 Again, similar to the analysis of the other two time periods, the PM peak network performance statistics indicate that in general all options perform similarly to each other when the entire network is considered. All options provide a relatively similar drop in overall network delay (i.e. queues) when compared against the Do Minimum scenario. They also all achieve a similar average speed increase (5 – 6 kph increase) and a similar total travel time reduction (6 – 7% decrease). Also all options also experience a marginal increase in the total distance travelled in the model compared to the DM, this is to be expected given the alignment of each option is longer than the existing N3.


Queues
250
200
150
100
50
0
PCU.hrs
83
155
15
90
16
98
15
88
16
92
16
93
DM
Option A
Option B
Option C
Option D
Option E
Transient Queues
Over Capacity Queues


Travel Times
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
pcu.hrs
3,448
3,191
3,232
3,190
3,236
3,238
DM
Option A
Option B
Option C
Option D
Option E


Travel Distance
250,000
200,000
150,000
100,000
50,000
0
PCU.KMs
202,982
206,430
209,948
206,418
206,124
206,038
DM
Option A
Option B
Option C
Option D
Option E


Avg Speed
70
60
50
40
30
20
10
0
Speed (KPH)
59
65
65
65
64
64
DM
Option A
Option B
Option C
Option D
Option E

7.5 Journey Times

7.5.1 A journey time analysis has been undertaken for all options and is summarised in the tables below for the two main routes in and out of Virginia town for all time periods. In the Do-minimum scenario the journey times shown below are along the existing N3 while the journey times for each option are taken along each new road.

7.5.2 In the AM period, we see that all options result in very similar journey times with Options A, C, D and E all producing similar end to end journey times. While Option B is the worst performing in terms of journey times, which is to be expected given that it is the longest and thus vehicles have further to travel.

7.5.3 In the southbound direction, Options A, C, D and E see reductions of between 37% – 38% compared to the Do Minimum time which is a saving of approx. 10 minutes. Meanwhile Option B sees a 30% reductions in the southbound journey time which is the equivalent of approx. 8 minutes.

7.5.4 In the northbound direction, Options A, C, D and E see reductions of between 27% – 28% compared to the Do Minimum time which is a saving of approx. 6 minutes. Meanwhile Option B sees a 19% reductions in the southbound journey time which is the equivalent of approx. 4 minutes.

Table 7-4: Journey Time Comparison (AM Peak – 2043 Design Year)

ROUTE	JOURNEY TIME (MINS)						DIFF (%)				
	DO MIN	OPT A	OPT B	OPT C	OPT D	OPT E	OPT A	OPT B	OPT C	OPT D	OPT E
N3 Northbound	23.5	16.9	19.0	16.8	17.1	17.1	-28%	-19%	-28%	-27%	-27%
N3 Southbound	27.4	17.0	19.2	16.9	17.2	17.2	-38%	-30%	-38%	-37%	-37%

7.5.5 In the Inter Peak period, all options result in similar journey times with Options A, C, D and E all producing similar end to end journey times. Again option B is the worst performing in terms of journey times given that it is the longest and thus vehicles have further to travel.

7.5.6 In the southbound direction, Options A, C, D and E see reductions of between 28% – 29% compared to the Do Minimum time which is a saving of approx. 6 minutes. Meanwhile Option B sees a 19% reductions in the southbound journey time which is the equivalent of approximately 4 minutes.

7.5.7 In the northbound direction, Options A, C, D and E see reductions of between 27% – 28% compared to the Do Minimum time which is a saving of approx. 6 minutes. Meanwhile Option B sees a 19% reductions in the southbound journey time which is the equivalent of approximately 4 minutes.

Table 7-5: Journey Time Comparison (Inter Peak – 2043 Design Year)

ROUTE	JOURNEY TIME (MINS)						DIFF (%)				
	DO MIN	OPT A	OPT B	OPT C	OPT D	OPT E	OPT A	OPT B	OPT C	OPT D	OPT E
N3 Northbound	23.4	16.8	19.0	16.8	17.0	17.1	-28%	-19%	-28%	-27%	-27%
N3 Southbound	23.5	16.8	19.1	16.7	17.0	17.0	-29%	-19%	-29%	-28%	-28%

7.5.8 Similarly to the other time periods, in the PM period, Options A, C, D and E all result in similar end to end journey times and Option B is the worst performing in terms of journey times.

7.5.9 In the northbound direction, Options A, C, D and E see reductions of between 45% – 46% compared to the Do Minimum time which is a saving of approx. 13 minutes. Meanwhile Option B sees a 39% reductions in the southbound journey time which is the equivalent of approx. 11 minutes.

7.5.10 In the southbound direction, Options A, C, D and E see reductions of between 29% – 30% compared to the Do Minimum time which is a saving of approx. 7 minutes. Meanwhile Option B sees a 20% reductions in the southbound journey time which is the equivalent of approx. 5 minutes.

Table 7-6: Journey Time Comparison (PM Peak – 2043 Design Year)

ROUTE	JOURNEY TIME (MINS)						DIFF (%)				
	DO MIN	OPT A	OPT B	OPT C	OPT D	OPT E	OPT A	OPT B	OPT C	OPT D	OPT E
N3 Northbound	31.7	17.2	19.4	17.2	17.5	17.5	-46%	-39%	-46%	-45%	-45%
N3 Southbound	24.0	16.8	19.1	16.8	17.0	17.1	-30%	-20%	-30%	-29%	-29%

7.6 Reduction of Traffic Volumes in Virginia Town Centre

7.6.1 Currently Virginia experiences considerable congestion within its Town Centre. Successive county plans have noted the need for a bypass which would help alleviate this congestion and provide an improved environment and more accessibility for vulnerable road users within Virginia. Therefore, an analysis has been undertaken to assess the reduction in traffic through Virginia town following the inclusion of each option. The results are presented in the following tables for all traffic travelling through the town during the AM and PM peak hours and the average inter-peak hour.

7.6.2 The results show that both Option A and C are the best performing options in terms of removing the most traffic in Virginia town across all time periods with a 74% reduction in the AM, a 79% reduction in the inter peak and 72% reduction in the PM peak hour. Options B, D and E all produce very similar results (50 – 52% in the AM, 49 – 54% in the inter peak and 45 – 50% in the PM.

Table 7-7: Reduction in Traffic (AM Peak – 2043 Design Year)

	TOTALS (PCUS)						DIFF (%)				
TYPE	DO MIN	OPT A	OPT B	OPT C	OPT D	OPT E	OPT A	OPT B	OPT C	OPT D	OPT E
Total Traffic	1,717	441	830	442	831	852	-74%	-52%	-74%	-52%	-50%

Table 7-8: Reduction in Traffic (IP Peak – 2043 Design Year)

	TOTALS (PCUS)						DIFF (%)				
TYPE	DO MIN	OPT A	OPT B	OPT C	OPT D	OPT E	OPT A	OPT B	OPT C	OPT D	OPT E
Total Traffic	1,659	347	763	345	835	838	-79%	-54%	-79%	-50%	-49%

Table 7-9: Reduction in Traffic (PM Peak – 2043 Design Year)

	TOTALS (PCUS)						DIFF (%)				
TYPE	DO MIN	OPT A	OPT B	OPT C	OPT D	OPT E	OPT A	OPT B	OPT C	OPT D	OPT E
Total Traffic	1,930	532	960	534	1,044	1,057	-72%	-50%	-72%	-46%	-45%

7.7 Annual Average Daily Traffic (AADT)

7.7.1 To estimate the annual average daily traffic (AADT) using Peak Hour Model outputs, factors were developed that allowed extrapolation of peak hour traffic flows to AADT.

7.7.2 PAG suggests using the Permanent Counter method to estimate AADT, however TII permanent counters are located some distance from the Study Area. The Localised Period Count method was therefore preferable and has been applied using the ATC count locations throughout the area. This method combines localised count data with nearby TII permanent counters in order to estimate AADTs.

7.7.3 PAG recommends a daily flow profile is generated for the weekday for which the short period traffic counts have been collated. In this case the short period data will be peak hour model outputs. The peak hour models have been developed to represent the "average weekday", therefore, a daily profile for the average weekday was generated using two weeks of ATC data.

7.7.4 Data from the ATCs (and TII Permanent Counters) was then classified into Peak (comprising AM Peak and/or PM Peak) and Inter Peak periods. In performing this task, the following bands were used.

- AM Peak Period: The period from 06:00 to 10:00
- PM Peak Period: The period from 16:00 to 20:00
- Inter Peak Period: The period from 20:00 to 06:00 and 10:00 to 16:00

7.7.5 To estimate the flow for a defined period (e.g. the AM peak) from the short period count, the procedure is as follows:

$$AM_x = \left(\frac{Q_x}{Q_{PTC}}\right) \times AM_{PTC}$$

Where:

- AM_x = Annual Average AM Peak (06:00 – 10:00) traffic flow at location x
- AM_{PTC} = Annual Average AM Peak (06:00 – 10:00) traffic flow at Permanent Traffic Counter
- Q_x = Short Period AM Peak traffic flow
- Q_{PTC} = Short Period AM Peak traffic flow at Permanent Counter, This should relate to same Short Period as Q_x

7.7.6 The same process is applied to the IP and PM peaks and the result for all periods (AM, PM and IP) is aggregated to give a value of AADT as follows:

$$AADT_x = (AM_x) + (IP_x) + (PM_x)$$

7.7.7 The above calculations were performed for the ATC surveys illustrated in Figure 2.1, providing AADT values for each of these locations. Similarly, this analysis provided a relationship between the short period count (i.e. Modelled Peak Hour) and the Peak Period (06:00-10:00) at each site and for each time period (AM_x, IP_x, PM_x). A regression analysis was then preformed at the ATC locations to calculate the appropriate expansion factor to be applied to model flows to estimate future year AADTs. The table below shows the expansion factors calculated by time period and user class.

Table 7-10: AADT Expansion Factors

TIME PERIOD	LV	HV
AM	2.54	2.93
IP	6.00	6.00
PM	2.69	2.96

7.8 Option AADTs

7.8.1 The forecast AADT flows for each option are presented in the tables and figures in the following section of this report.

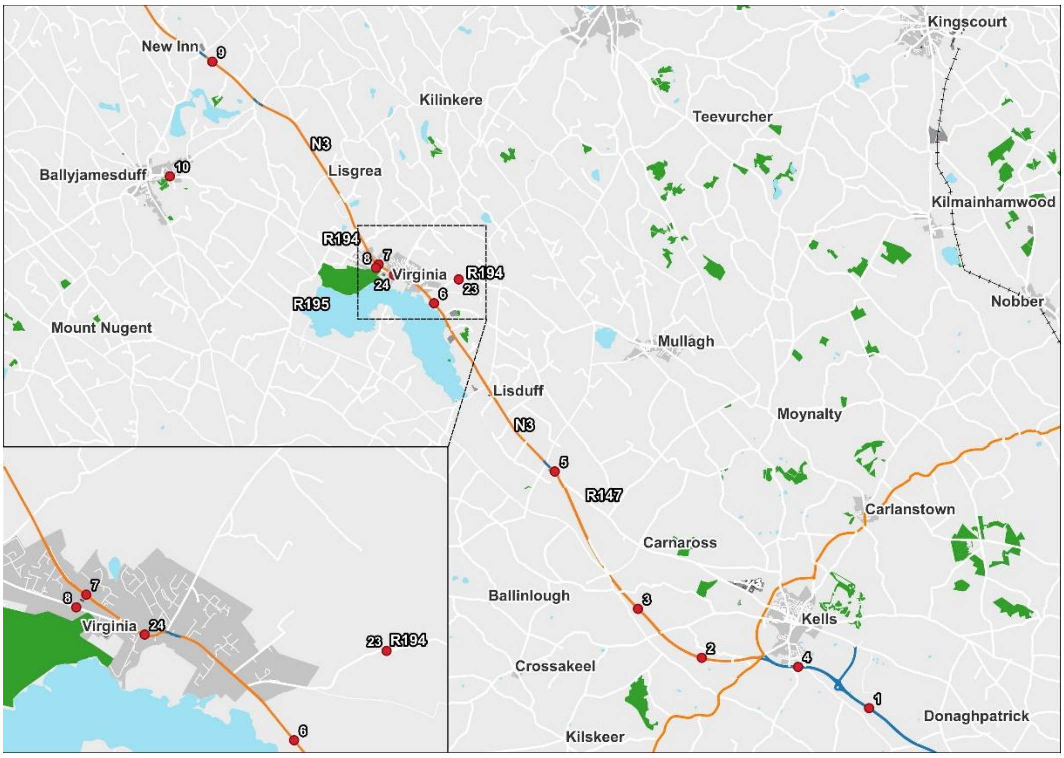


Figure 7-1: Do Minimum– AADT Site Locations

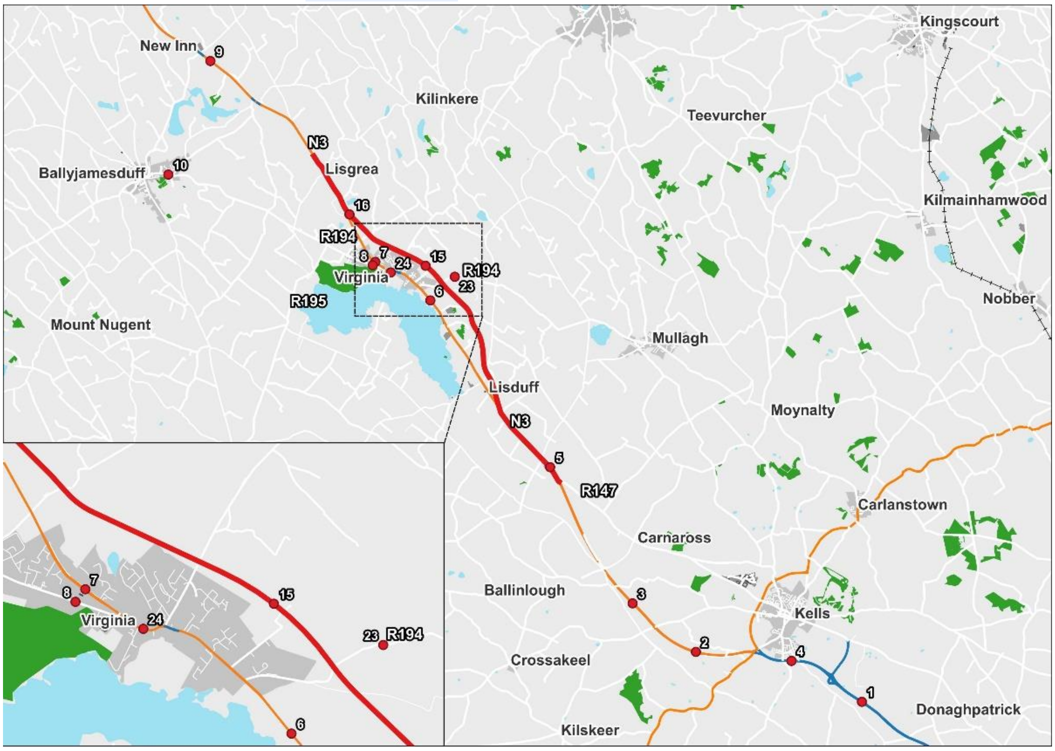


Figure 7-2: Option A – AADT Site Locations

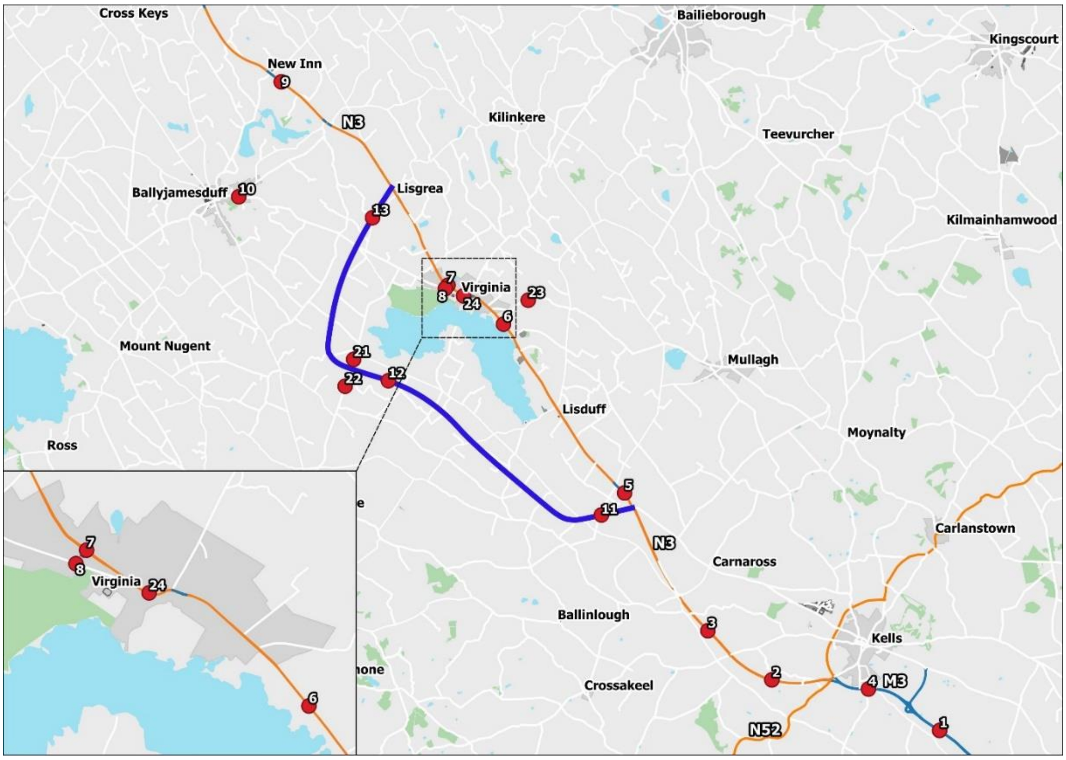


Figure 7-3: Option B – AADT Site Locations

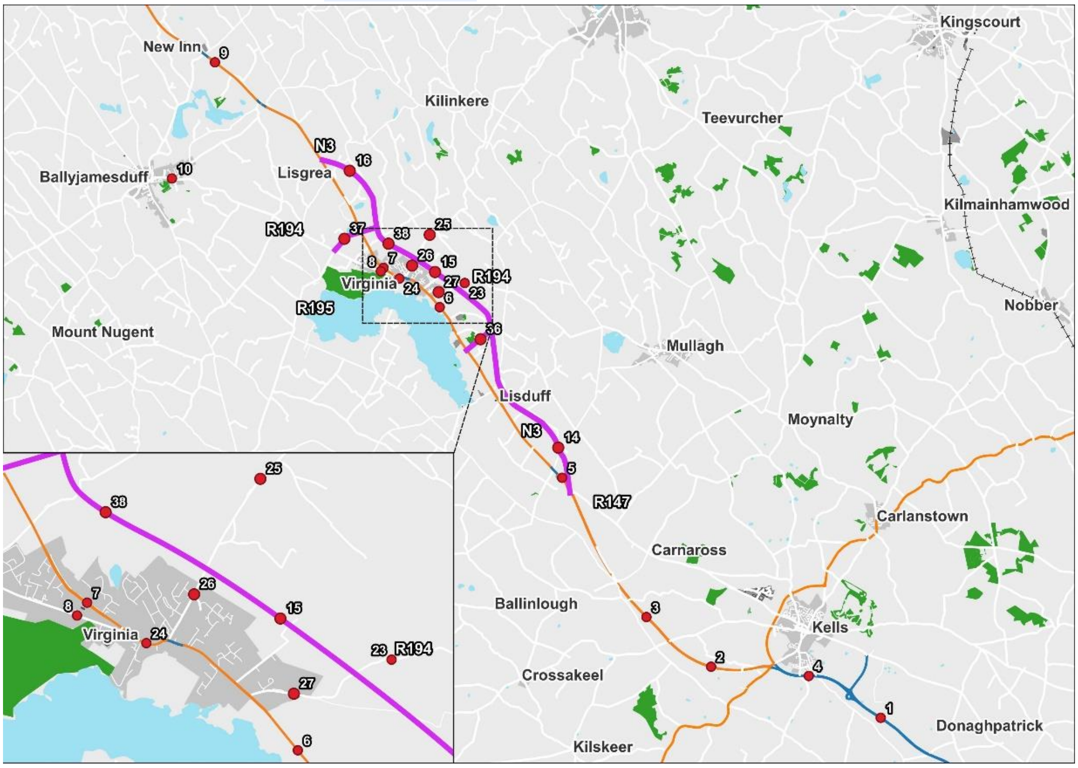


Figure 7-4: Option C – AADT Site Locations

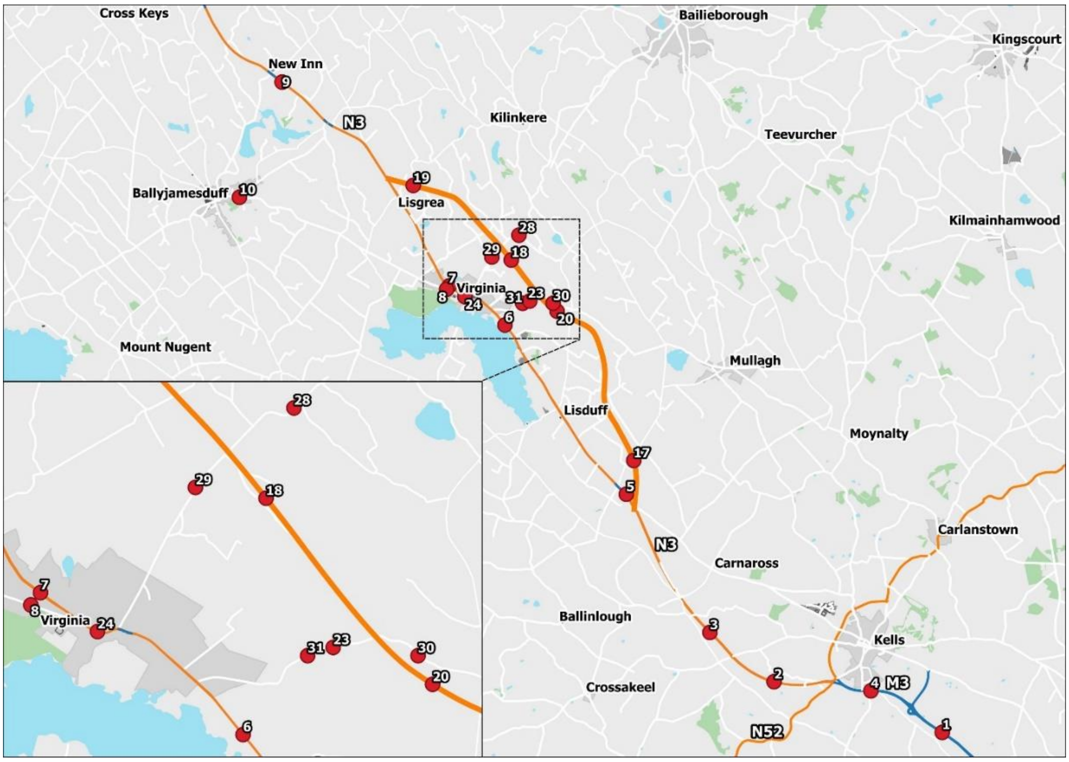


Figure 7-5: Option D – AADT Site Locations

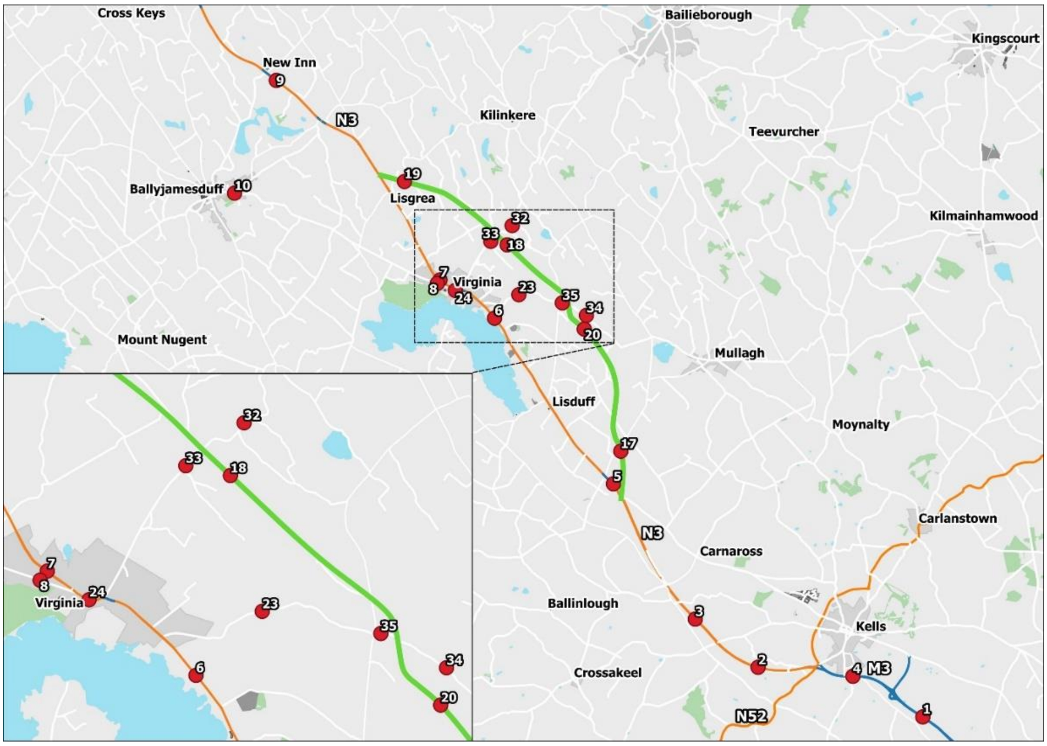


Figure 7-6: Option E – AADT Site Locations

Table 7-11: 2043 AADT Values

AADT POINT	DO MINIMUM		OPTION A		OPTION B		OPTION C		OPTION D		OPTION E	
	TOTAL AADT	% HGV	TOTAL AADT	% HGV	TOTAL AADT	% HGV	TOTAL AADT	% HGV	TOTAL AADT	% HGV	TOTAL AADT	% HGV
1	13,900	13%	13,932	13%	13,932	13%	13,933	13%	13,932	13%	13,932	13%
2	12,189	14%	12,423	14%	12,214	14%	12,433	14%	12,420	14%	12,413	14%
3	9,155	16%	9,943	15%	9,777	13%	9,928	15%	9,660	16%	9,665	16%
4	13,724	14%	13,713	14%	13,730	14%	13,711	14%	13,679	14%	13,683	14%
5	11,792	16%	13,399	19%	4,796	7%	3,364	15%	5,036	14%	5,210	14%
6	10,339	14%	1,031	12%	3,127	8%	940	11%	3,680	9%	3,747	9%
7	9,622	14%	1,063	4%	3,593	2%	1,064	4%	1,660	3%	2,274	3%
8	5,043	13%	1,732	3%	3,731	5%	1,735	3%	5,895	12%	5,589	12%
9	8,859	15%	8,833	15%	8,870	15%	8,833	15%	9,562	15%	9,871	14%
10	5,468	11%	6,334	11%	7,104	11%	6,335	11%	5,314	11%	5,018	11%
11	-	-	-	-	9,171	21%	-	-	-	-	-	-
12	-	-	-	-	10,600	24%	-	-	-	-	-	-
13	-	-	-	-	8,796	22%	-	-	-	-	-	-
14	-	-	-	-	-	-	10,029	21%	-	-	-	-
15	-	-	11,448	18%	-	-	11,529	18%	-	-	-	-

AADT POINT	DO MINIMUM		OPTION A		OPTION B		OPTION C		OPTION D		OPTION E	
	TOTAL AADT	% HGV	TOTAL AADT	% HGV	TOTAL AADT	% HGV	TOTAL AADT	% HGV	TOTAL AADT	% HGV	TOTAL AADT	% HGV
16	-	-	8,391	16%	-	-	8,378	16%	-	-	-	-
17	-	-	-	-	-	-	-	-	7,423	17%	7,233	17%
18	-	-	-	-	-	-	-	-	9,054	16%	8,222	17%
19	-	-	-	-	-	-	-	-	9,344	15%	9,115	15%
20	-	-	-	-	-	-	-	-	7,423	17%	7,233	17%
21	-	-	-	-	2,184	5%	-	-	-	-	-	-
22	-	-	-	-	4,026	20%	-	-	-	-	-	-
23	1,850	33%	1,050	3%	1,267	13%	1,047	3%	2,118	24%	1,315	37%
24	13,463	15%	2,152	4%	5,976	4%	2,157	4%	6,215	12%	6,519	12%
25	-	-	-	-	-	-	-	-	-	-	-	-
26	-	-	-	-	-	-	-	-	-	-	-	-
27	-	-	-	-	-	-	-	-	-	-	-	-
28	-	-	-	-	-	-	-	-	1,779	8%	-	-
29	-	-	-	-	-	-	-	-	2,347	4%	-	-
30	-	-	-	-	-	-	-	-	2,427	26%	-	-

AADT POINT	DO MINIMUM		OPTION A		OPTION B		OPTION C		OPTION D		OPTION E	
	TOTAL AADT	% HGV	TOTAL AADT	% HGV	TOTAL AADT	% HGV	TOTAL AADT	% HGV	TOTAL AADT	% HGV	TOTAL AADT	% HGV
31	-	-	-	-	-	-	-	-	2,118	24%	-	-
32	-	-	-	-	-	-	-	-	-	-	1,842	7%
33	-	-	-	-	-	-	-	-	-	-	1,960	5%
34	-	-	-	-	-	-	-	-	-	-	2,082	30%
35	-	-	-	-	-	-	-	-	-	-	1,709	28%
36	-	-	-	-	-	-	1,500	4%	-	-	-	-
37	-	-	-	-	-	-	6,567	21%	-	-	-	-
38	-	-	-	-	-	-	14,051	15%	-	-	-	-

8. EMERGING PREFERRED OPTION

ROUTE OPTION	ECONOMY	SAFETY	ENVIRONMENT	ACCESSIBILITY	INTEGRATION	PHYSICAL ACTIVITY	OVERALL
Option A	Preferred	Intermediate	Least Preferred	Intermediate	Preferred	Preferred	Intermediate
Option B	Intermediate	Intermediate	Least Preferred	Intermediate	Preferred	Intermediate	Least Preferred
Option C	Preferred	Preferred	Least Preferred	Intermediate	Preferred	Preferred	Intermediate
Option Cv1	Intermediate	Intermediate	Least Preferred	Intermediate	Preferred	Intermediate	Least Preferred
Option Cv2	Preferred	Preferred	Least Preferred	Intermediate	Preferred	Preferred	Preferred
Option D	Intermediate	Intermediate	Intermediate	Intermediate	Preferred	Intermediate	Intermediate
Option Dv1	Intermediate	Intermediate	Intermediate	Intermediate	Preferred	Intermediate	Intermediate
Option E	Intermediate	Intermediate	Least Preferred	Intermediate	Preferred	Intermediate	Least Preferred
Option Ev1	Intermediate	Intermediate	Least Preferred	Intermediate	Preferred	Intermediate	Least Preferred
Option Ev2	Intermediate	Intermediate	Preferred	Intermediate	Preferred	Intermediate	Intermediate

8.1.1 A comprehensive appraisal of the Options detailed in the preceding chapters has been carried out using the multiple criteria process outlined by the Department of Transport in their report 'Guidelines on a Common Appraisal Framework for Transport Projects and Programmes (March 2016, updated March 2021)'. This is in line with the approach of the Project Appraisal Guidelines and considers each option under the following criteria:

- Economy;
- Safety;
- Environment;
- Accessibility & Social Inclusion;
- Integration;
- Physical Activity.

8.1.2 A summary matrix of the appraisal of each Option, using these six criteria, is included in the Project Appraisal Matrix below in Table 8-1: Appraisal Summary Matrix

Table 8-1: Appraisal Summary Matrix

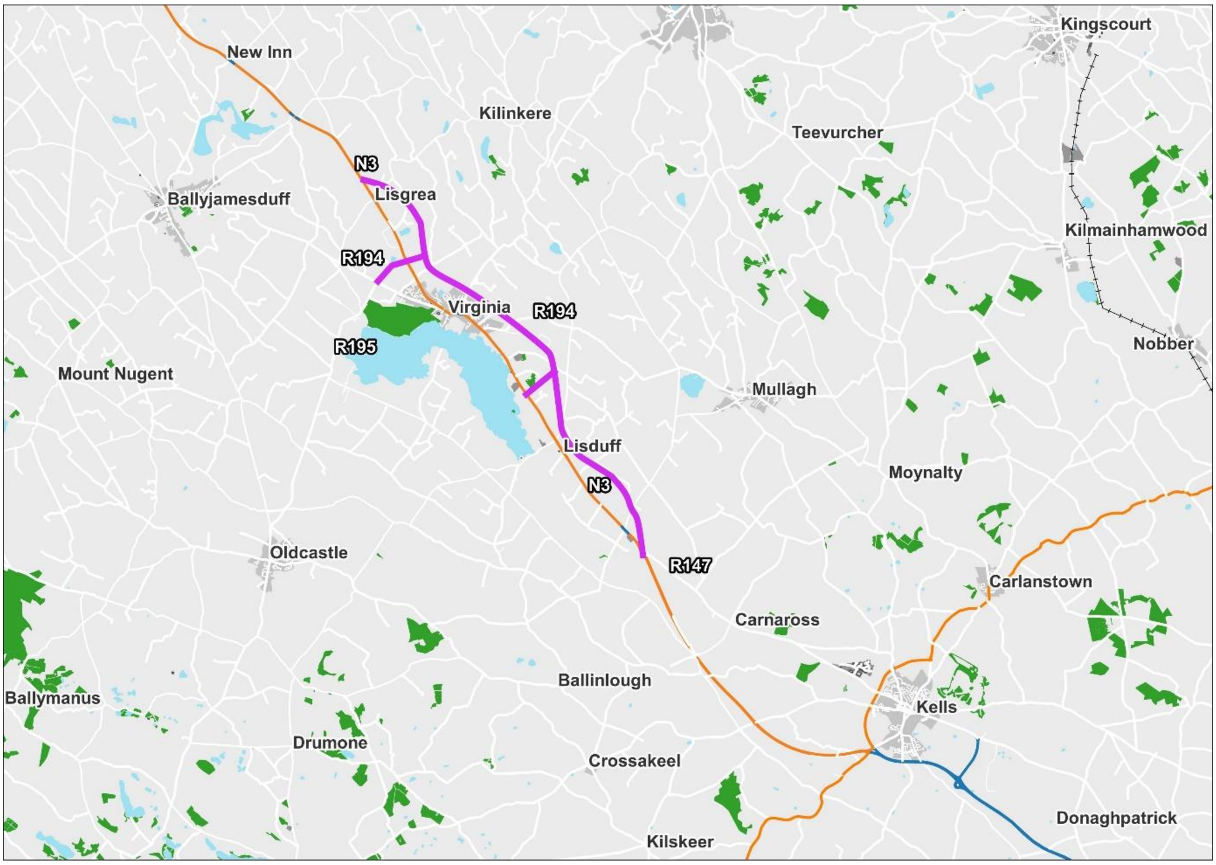
ROUTE OPTION	ECONOMY	SAFETY	ENVIRONMENT	ACCESSIBILITY	INTEGRATION	PHYSICAL ACTIVITY	OVERALL
Option A	Preferred	Intermediate	Least Preferred	Intermediate	Preferred	Preferred	Intermediate
Option B	Intermediate	Intermediate	Least Preferred	Intermediate	Preferred	Intermediate	Least Preferred
Option C	Preferred	Preferred	Least Preferred	Intermediate	Preferred	Preferred	Intermediate
Option Cv1	Intermediate	Intermediate	Least Preferred	Intermediate	Preferred	Intermediate	Least Preferred
Option Cv2	Preferred	Preferred	Least Preferred	Intermediate	Preferred	Preferred	Preferred
Option D	Intermediate	Intermediate	Intermediate	Intermediate	Preferred	Intermediate	Intermediate
Option Dv1	Intermediate	Intermediate	Intermediate	Intermediate	Preferred	Intermediate	Intermediate
Option E	Intermediate	Intermediate	Least Preferred	Intermediate	Preferred	Intermediate	Least Preferred
Option Ev1	Intermediate	Intermediate	Least Preferred	Intermediate	Preferred	Intermediate	Least Preferred
Option Ev2	Intermediate	Intermediate	Preferred	Intermediate	Preferred	Intermediate	Intermediate

8.1.3 Following the multi-criteria analysis and careful consideration of all factors, a variation of Option D, Option C and Option A, i.e. modified / refined version of Option CV2 was selected as the preferred option.

8.1.4 Full details of this appraisal and the selection of the Emerging Preferred Option are contained in the Option Appraisal Report.

8.1.5 The preferred option is presented in the figure below.

Figure 8-1: Emerging Preferred Option Corridor



8.2 EPOC Analysis

8.2.1 This section provides a summary of the performance of the Emerging Preferred Option Corridor (EPOC), based on the following Key Performance Indicators:

- Network Performance;
- Journey Times;
- Reduction of Traffic on Main Street in Virginia; and
- AADT Flows

Network Performance

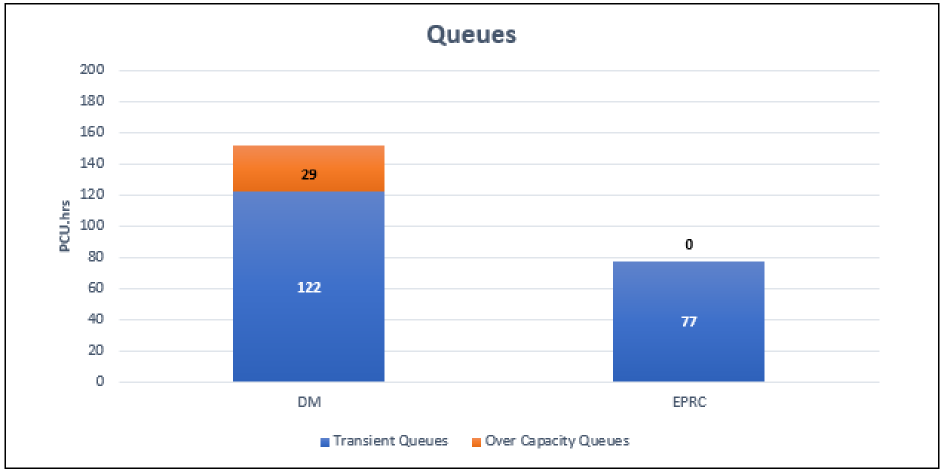
8.2.2 The tables and figures below present a summary of the network performance statistics for the scenarios modelled for the 2043 Design Year in the AM, Inter-peak and PM peak.

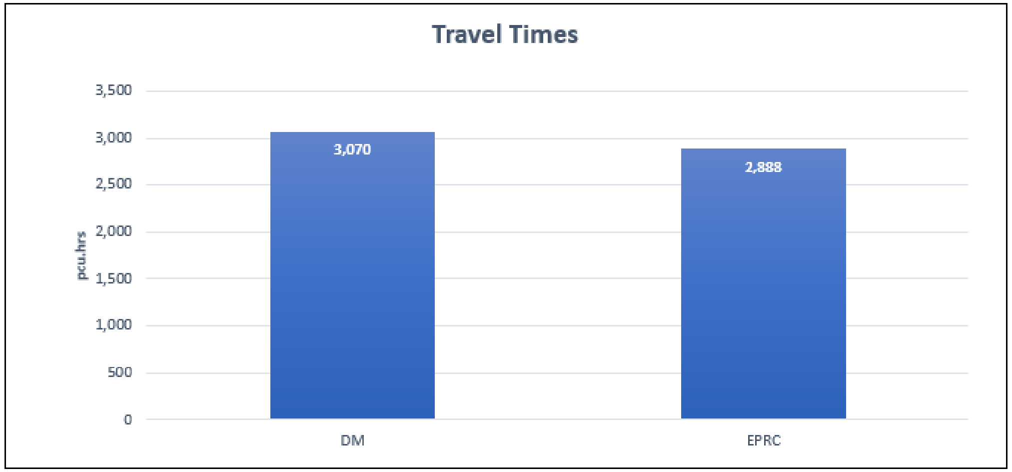
Table 8-2: Network Performance Indicators (AM Peak – 2043 Design Year)

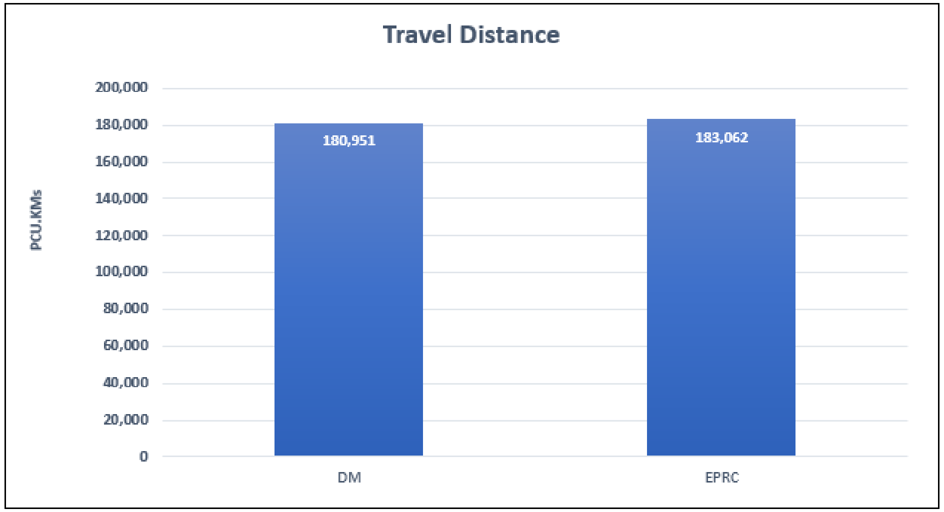
	DO MIN	EPOC
Transient Queues (pcu.hrs)	122	77
Over Capacity Queues (pcu.hrs)	29	0

Total Travel Times (pcu.hrs)	3,070	2,888
Total Travel Times (pcu.kms)	180,951	183,062
Average Speed (km/hr)	59	63

8.2.3 An analysis of the AM peak network statistics indicate that, in general the Emerging Preferred Option shows an improvement against the Do Minimum scenario. It provides an approx. 50% decrease in overall network delay (i.e. queues) when compared against the Do Minimum scenario. It also achieves an 4kph increase on the average speed and 6% reduction on total travel times. The EPOC shows a marginal increase in the total distance travelled in the model compared to the Do-minimum Scenario, this is to be expected given the alignment of the EPOC is longer than the existing N3.


Queues
200
180
160
140
120
100
80
60
40
20
0
PCU.hrs
29
122
0
77
DM
EPRC
Transient Queues
Over Capacity Queues


Travel Times
3,500
3,000
2,500
2,000
1,500
1,000
500
0
pcu.hrs
3,070
2,888
DM
EPRC


Travel Distance
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
PCU.KMs
180,951
183,062
DM
EPRC

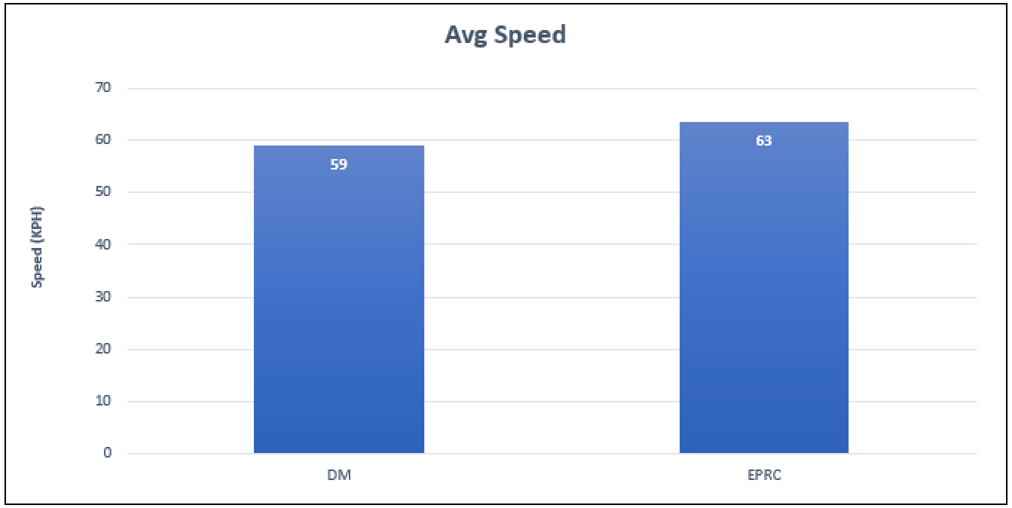
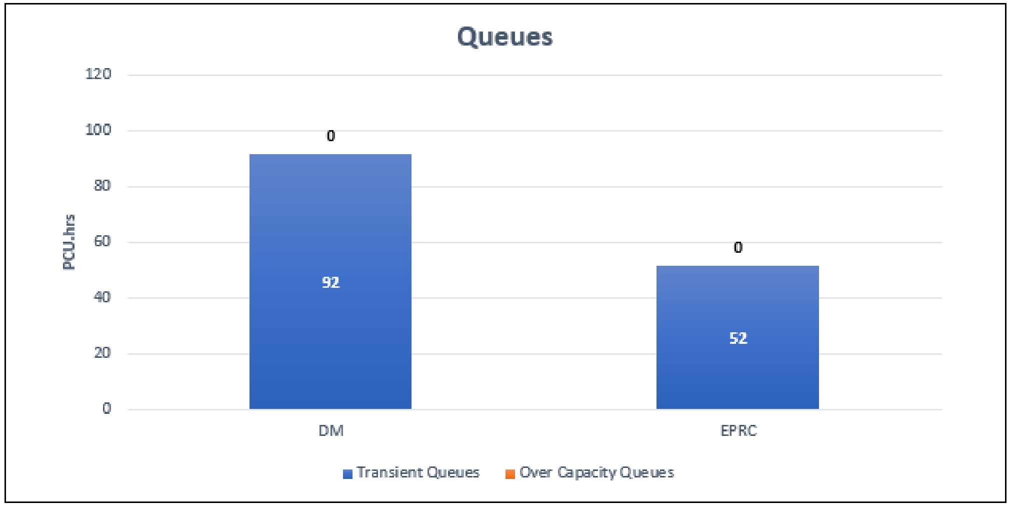

Avg Speed
70
60
50
40
30
20
10
0
Speed (KPH)
59
63
DM
EPRC

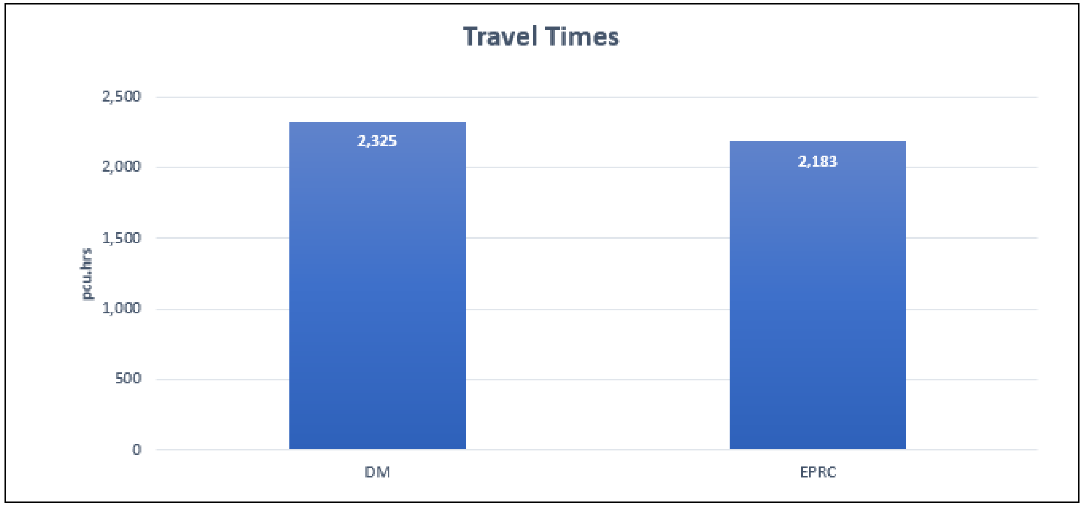
Table 8-3: Network Performance Indicators (Inter Peak – 2043 Design Year)

	DO MIN	EPOC
Transient Queues (pcu.hrs)	92	52
Over Capacity Queues (pcu.hrs)	0	0
Total Travel Times (pcu.hrs)	2,325	2,183
Total Travel Times (pcu.kms)	138,355	140,157
Average Speed (km/hr)	60	64

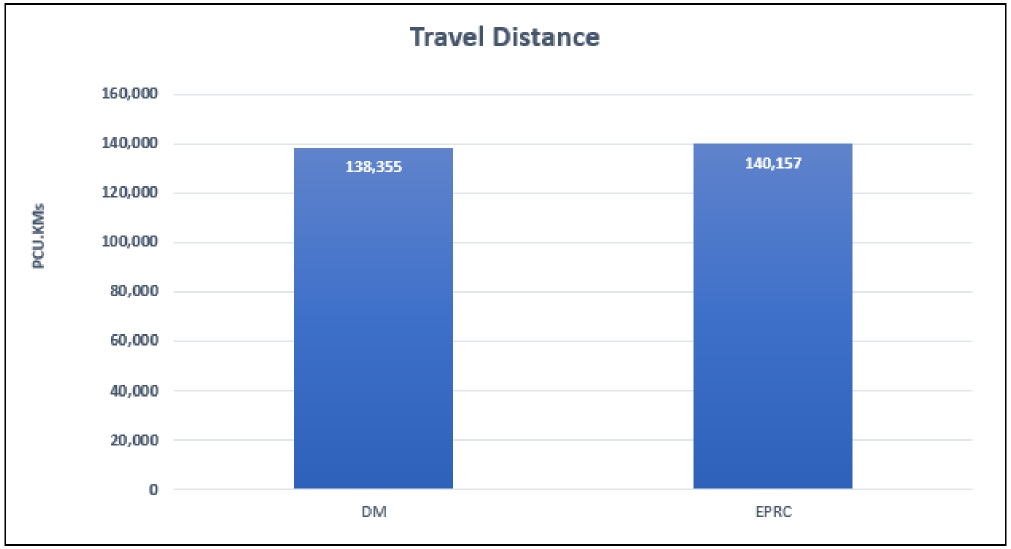
8.2.4 An analysis of the Inter peak network statistics indicate that, in general the Emerging Preferred Option shows an improvement against the Do Minimum scenario. It provides an approx. 45% decrease in overall network delay (i.e. queues) when compared against the Do Minimum scenario. It also achieves an 4kph increase on the average speed and 6% reduction on total travel times. The EPOC shows a marginal increase in the total distance travelled in the model compared to the Do-minimum Scenario, this is to be expected given the alignment of the EPOC is longer than the existing N3.



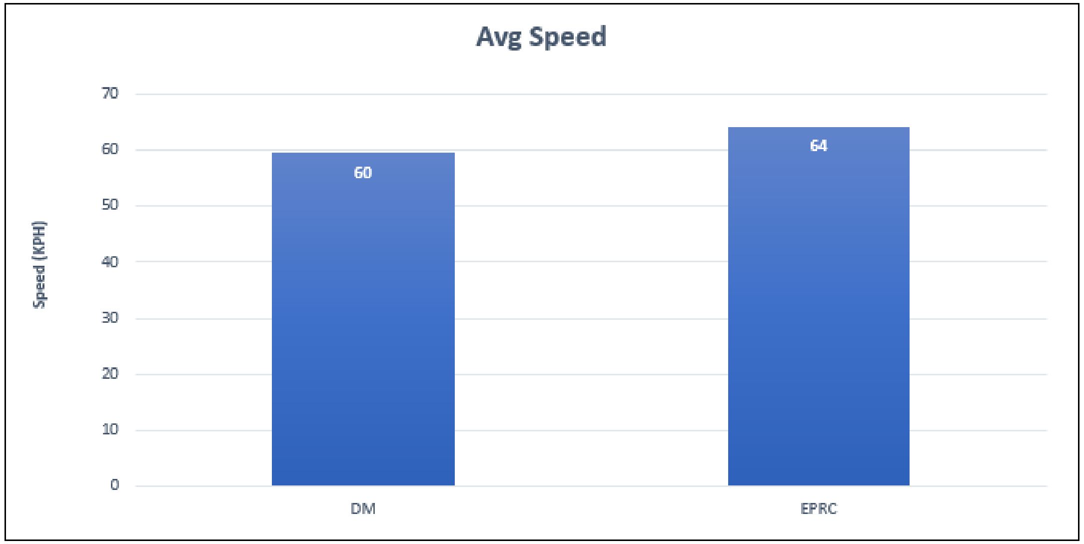
Queues
120
100
80
60
40
20
0
PCU.hrs
0
92
0
52
DM
EPRC
Transient Queues
Over Capacity Queues



Travel Times
2,500
2,000
1,500
1,000
500
0
pcu.hrs
2,325
2,183
DM
EPRC



Travel Distance
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
PCU.KMs
138,355
140,157
DM
EPRC

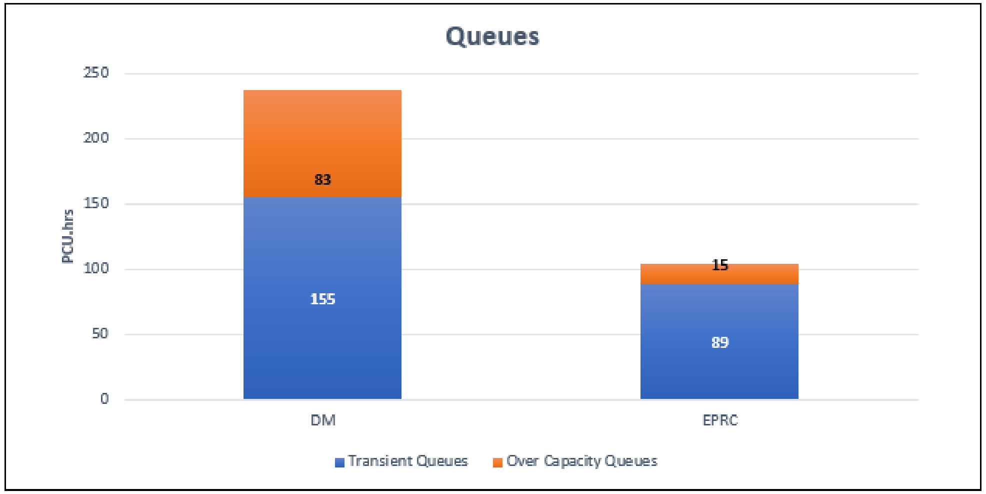


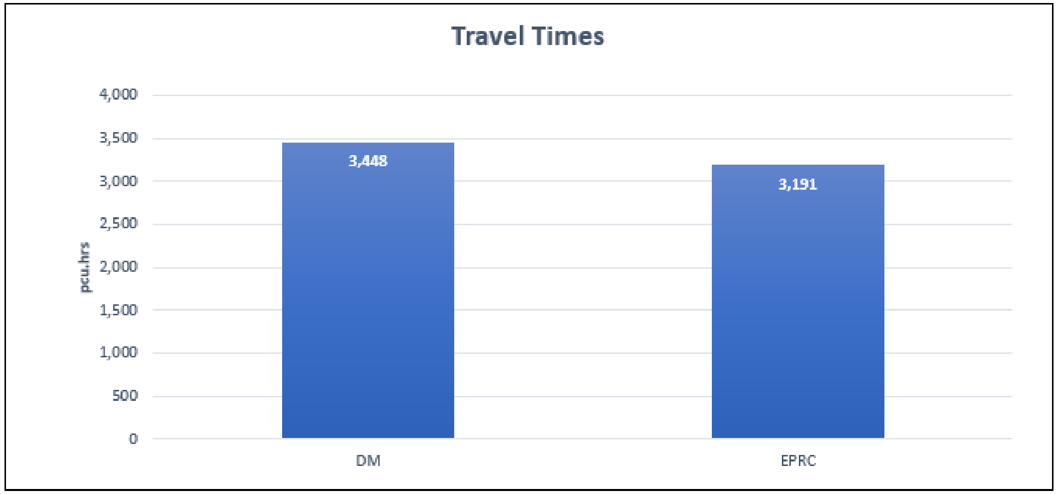
Avg Speed
70
60
50
40
30
20
10
0
Speed (KPH)
60
64
DM
EPRC

Table 8-4: Network Performance Indicators (PM Peak – 2043 Design Year)

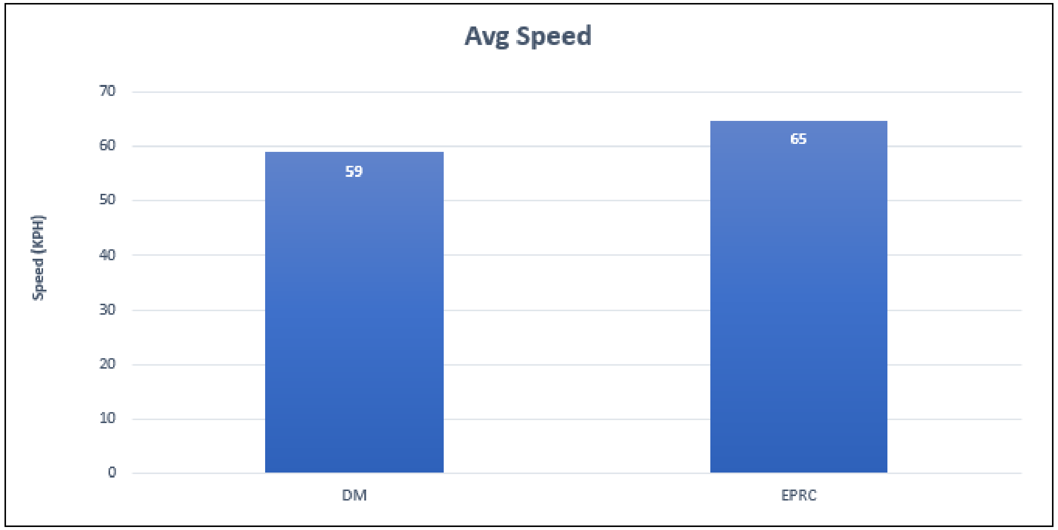
	DO MIN	EPOC
Transient Queues (pcu.hrs)	155	89
Over Capacity Queues (pcu.hrs)	83	15
Total Travel Times (pcu.hrs)	3,448	3,191
Total Travel Times (pcu.kms)	202,982	206,371
Average Speed (km/hr)	59	65

8.2.5 An analysis of the Inter peak network statistics indicate that, in general the Emerging Preferred Option shows an improvement against the Do Minimum scenario. It provides an approx. 55% decrease in overall network delay (i.e. queues) when compared against the Do Minimum scenario. It also achieves an 6kph increase on the average speed and 7% reduction on total travel times. The EPOC shows a marginal increase in the total distance travelled in the model compared to the Do-minimum Scenario, this is to be expected given the alignment of the EPOC is longer than the existing N3.


Queues
250
200
150
100
50
0
PCU.hrs
83
155
15
89
DM
EPRC
Transient Queues
Over Capacity Queues


Travel Times
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
pcu.hrs
3,448
3,191
DM
EPRC


Travel Distance
250,000
200,000
150,000
100,000
50,000
0
PCU.KMs
202,982
206,371
DM
EPRC


Avg Speed
70
60
50
40
30
20
10
0
Speed (KPH)
59
65
DM
EPRC

Journey Times

8.2.6 A journey time analysis has been undertaken for the EPOC and is summarised in the tables below for the two main routes in and out of Virginia town for all time periods. In the Do-minimum scenario the journey times shown below are along the existing N3 while the journey times for the EPOC are taken along the proposed alignment.

8.2.7 In the southbound direction in the AM, the EPOC sees a reduction of 38% compared to the Do Minimum time which is a saving of approx. 10 minutes. Meanwhile in the northbound direction, the EPOC sees a reduction of 28% compared to the Do Minimum time which is a saving of approx. 6 minutes.

Table 8-5: Journey Time Comparison (AM Peak – 2043 Design Year)

	JOURNEY TIME (MINS)		DIFF (%)
ROUTE	DO MIN	EPOC	EPOC
N3 Northbound	23.5	16.8	-28%
N3 Southbound	27.4	16.9	-38%

8.2.8 In the southbound direction during the Inter Peak, the EPOC sees a reduction of 29% compared to the Do Minimum time which is a saving of approx. 6 minutes. Meanwhile in the northbound direction, the EPOC sees a reduction of 28% compared to the Do Minimum time which is a saving of approx. 6 minutes.

Table 8-6: Journey Time Comparison (Inter Peak – 2043 Design Year)

	JOURNEY TIME (MINS)		DIFF (%)
ROUTE	DO MIN	EPOC	EPOC
N3 Northbound	23.4	16.8	-28%
N3 Southbound	23.5	16.7	-29%

8.2.9 In the southbound direction in the PM, the EPOC sees a reduction of 30% compared to the Do Minimum time which is a saving of approx. 7 minutes. Meanwhile in the northbound direction, the EPOC sees a reduction of 46% compared to the Do Minimum time which is a saving of approx. 14 minutes.

Table 8-7: Journey Time Comparison (PM Peak – 2043 Design Year)

	JOURNEY TIME (MINS)		DIFF (%)
ROUTE	DO MIN	EPOC	EPOC
N3 Northbound	31.7	17.2	-46%
N3 Southbound	24.0	16.8	-30%

Reduction of Traffic Volumes in Virginia Town Centre

8.2.10 Currently Virginia experiences considerable congestion within its Town Centre. Successive county plans have noted the need for a bypass which would help alleviate this congestion and provide an improved environment and more accessibility for vulnerable road users within Virginia. Therefore, an analysis has been undertaken to assess the reduction in traffic through Virginia town following the inclusion of the EPOC. The results are presented in the following tables for all traffic travelling through the town during the AM and PM peak hours and the average inter-peak hour.

8.2.11 The results show that the EPOC has a significant impact in terms of removing traffic in Virginia town across all time periods with a 74% reduction in the AM, a 79% reduction in the inter peak and 72% reduction in the PM peak hour.

Table 8-8: Reduction in Traffic (AM Peak – 2043 Design Year)

	TOTAL (PCUS)		DIFF (%)
TYPE	DO MIN	EPOC	EPOC
Total Traffic	1,717	442	-74%

Table 8-9: Reduction in Traffic (IP Peak – 2043 Design Year)

	TOTAL (PCUS)		DIFF (%)
TYPE	DO MIN	EPOC	EPOC
Total Traffic	1,659	345	-79%

Table 8-10: Reduction in Traffic (PM Peak – 2043 Design Year)

	TOTAL (PCUS)		DIFF (%)
TYPE	DO MIN	EPOC	EPOC
Total Traffic	1,930	534	-72%

EPOC AADTs

8.2.12 The forecast AADT flows for the EPOC are presented in the table and in the following section of this report.

Figure 8-2: EPOC – AADT Site Locations

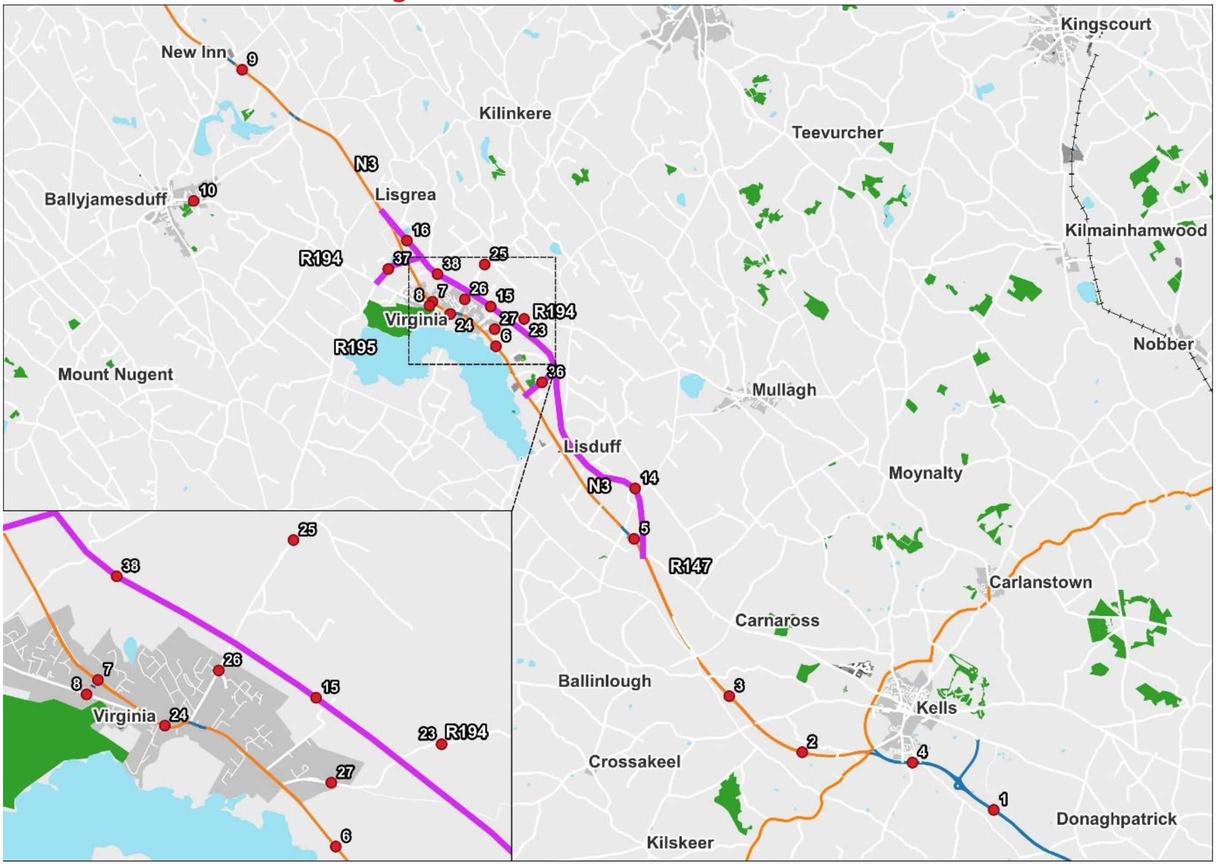


Table 8-11: 2043 AADT Values

AADT POINT	DO MINIMUM		EPOC	
	TOTAL AADT	% HGV	TOTAL AADT	% HGV
1	13,900	13%	13,932	13%
2	12,189	14%	12,425	14%
3	9,155	16%	9,889	15%
4	13,724	14%	13,717	14%
5	11,792	16%	3,477	15%
6	10,339	14%	1,052	12%
7	9,622	14%	1,062	4%
8	5,043	13%	1,737	3%
9	8,859	15%	8,833	15%
10	5,468	11%	6,282	11%
11	-	-	-	-
12	-	-	-	-
13	-	-	-	-
14	-	-	9,863	21%
15	-	-	11,363	19%

AADT POINT	DO MINIMUM		EPOC	
	TOTAL AADT	% HGV	TOTAL AADT	% HGV
16	-	-	8,468	16%
17	-	-	-	-
18	-	-	-	-
19	-	-	-	-
20	-	-	-	-
21	-	-	-	-
22	-	-	-	-
23	1,850	33%	1,047	3%
24	13,463	15%	2,157	4%
25	-	-	-	-
26	-	-	-	-
27	-	-	-	-
28	-	-	-	-
29	-	-	-	-
30	-	-	-	-
31	-	-	-	-
32	-	-	-	-
33	-	-	-	-
34	-	-	-	-
35	-	-	-	-
36	-	-	1,500	4%
37	-	-	6,509	22%
38	-	-	14,082	15%

8.3 EPOC Alternative Scenario Analysis

8.3.1 As mentioned in Chapter 7, the Do Minimum and Do Something scenarios include measures that are either committed for the town, or are in advanced stages of delivery and aim to make the town safer and more attractive for vulnerable road users:

- Recently implemented 80 Kph speed limits between Maghera and Virginia and on the north side of Virginia to Cornaslieve;
- Reconfigured signal timings in the town to facilitate longer pedestrian / cyclist crossing times, to be completed prior to the end of the street enhancement works which are currently under construction; and
- Upgrading the Main Street and change of R194 Ballyjamesduff Road junction to a roundabout junction, currently under construction:
  - Including modelling a 30 kph speed limit along the N3 through Virginia town to simulate slower traffic speeds as a result of the four additional zebra crossings and new roundabout on the N3, currently under construction.

8.3.2 But while the 30kph speed limit and the reconfigured signal timings are planned, they are not yet committed schemes. So as a test, these measures were removed from both the Do Minimum and the Emerging Preferred Option Corridor (EPOC) and the analysis for both scenarios was redone based on the same Key Performance Indicators:

- Network Performance;
- Journey Times;
- Reduction of Traffic on Main Street in Virginia; and
- AADT Flows

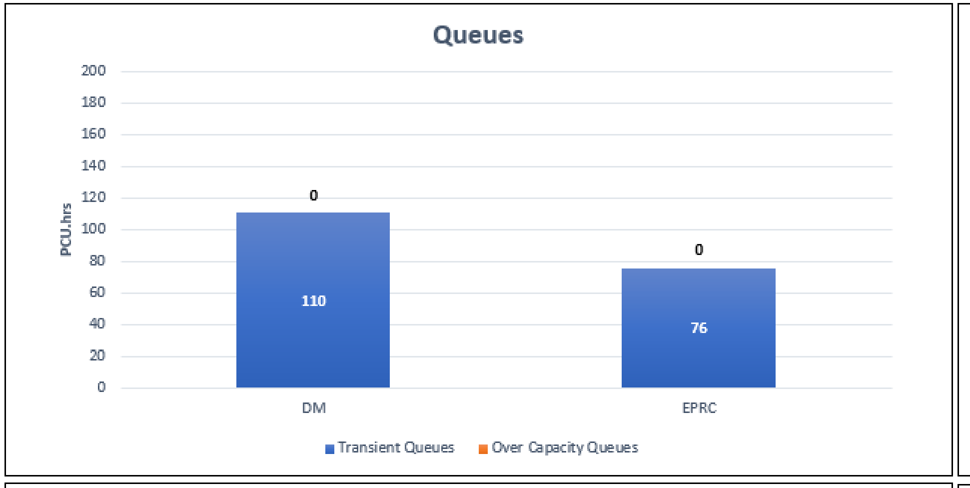
Network Performance

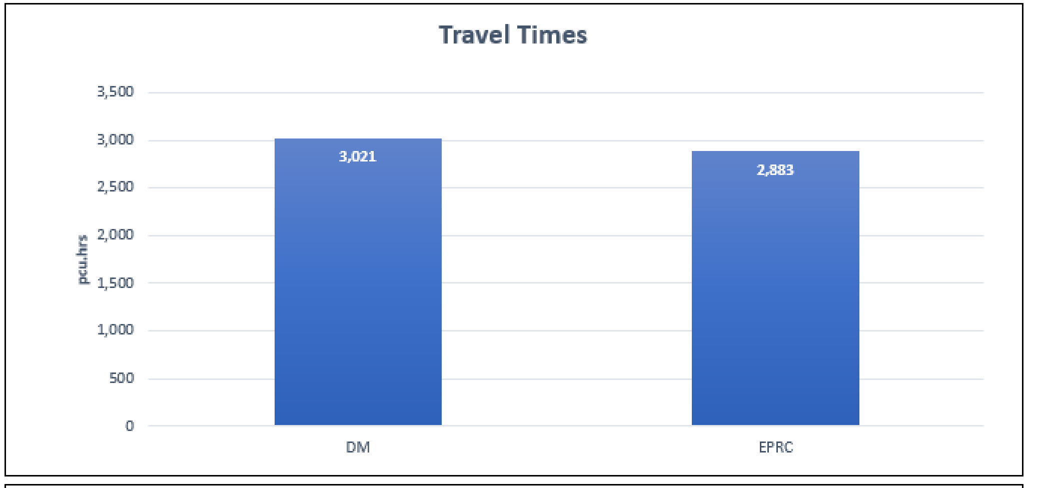
8.3.3 The tables and figures below present a summary of the network performance statistics for the scenarios modelled for the 2043 Design Year in the AM, Inter-peak and PM peak.

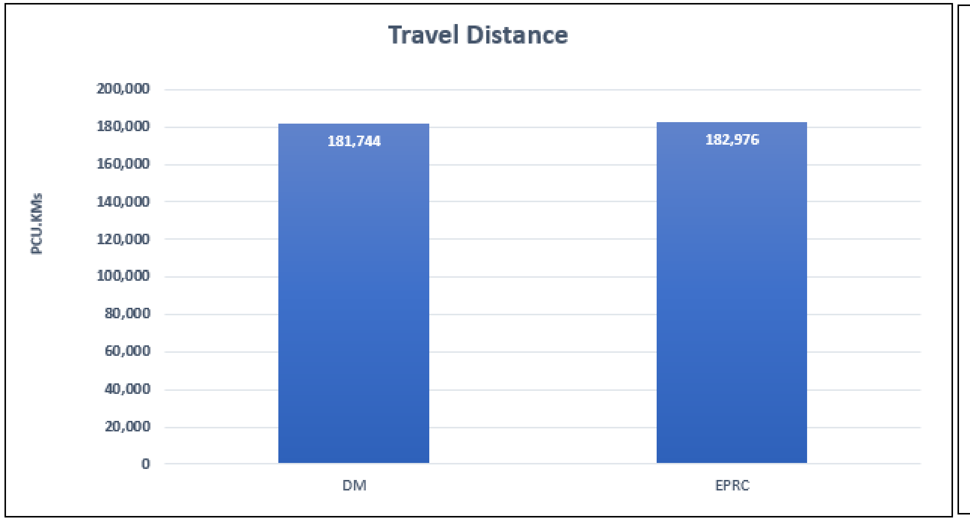
Table 8-12: Network Performance Indicators (AM Peak – 2043 Design Year)

	DO MIN (ALTERNATIVE)	EPOC (ALTERNATIVE)
Transient Queues (pcu.hrs)	110	76
Over Capacity Queues (pcu.hrs)	0	0
Total Travel Times (pcu.hrs)	3,021	2,883
Total Travel Times (pcu.kms)	181,744	182,976
Average Speed (km/hr)	60	64

8.3.4 An analysis of the AM peak network statistics indicate that, in general the Emerging Preferred Option shows an improvement against the Do Minimum scenario. It provides an approx. 30% decrease in overall network delay (i.e. queues) when compared against the Do Minimum scenario. It also achieves an 4kph increase on the average speed and 5% reduction on total travel times. The EPOC shows a marginal increase in the total distance travelled in the model compared to the Do-minimum Scenario, this is to be expected given the alignment of the EPOC is longer than the existing N3.


Queues
PCU.hrs
200
180
160
140
120
100
80
60
40
20
0
0
110
0
76
DM
EPRC
Transient Queues
Over Capacity Queues


Travel Times
pcu.hrs
3,500
3,000
2,500
2,000
1,500
1,000
500
0
3,021
2,883
DM
EPRC


Travel Distance
PCU.KMs
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
181,744
182,976
DM
EPRC

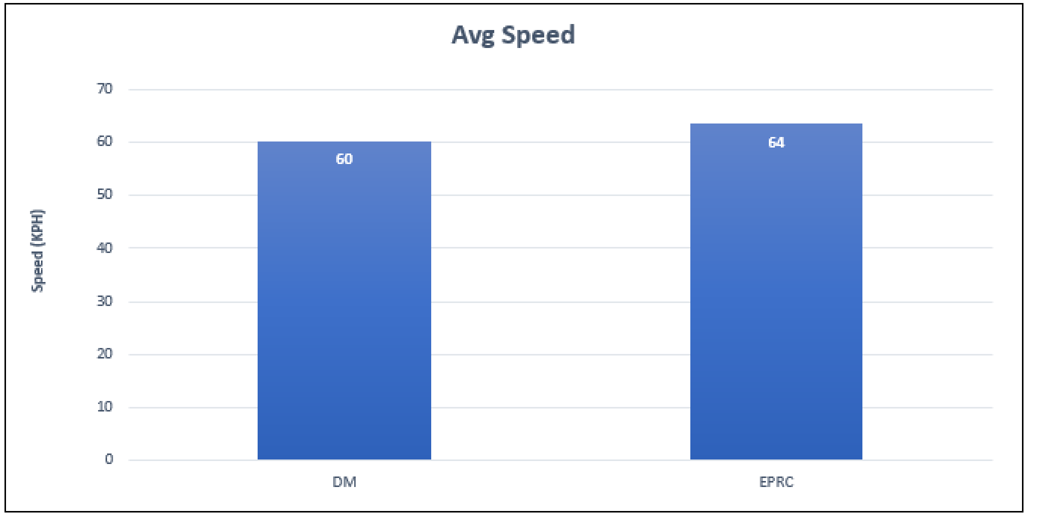
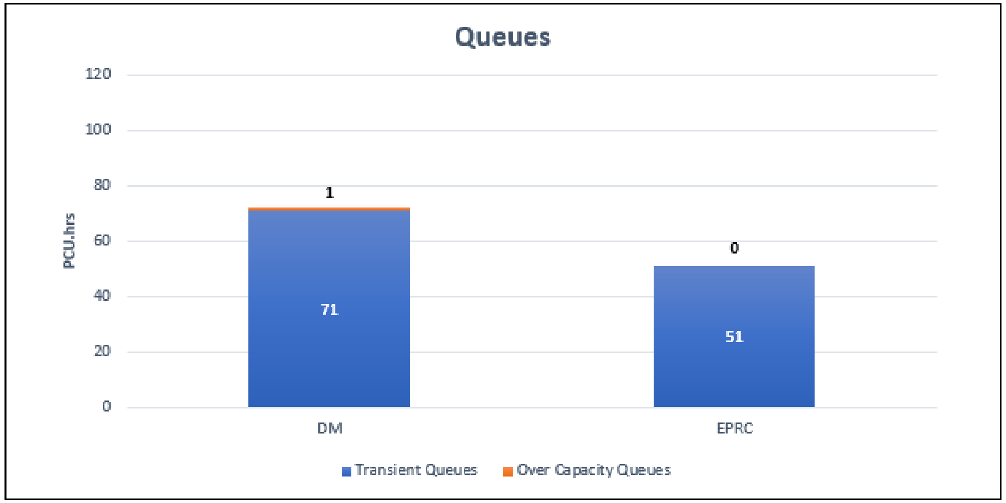

Avg Speed
Speed (KPH)
70
60
50
40
30
20
10
0
60
64
DM
EPRC

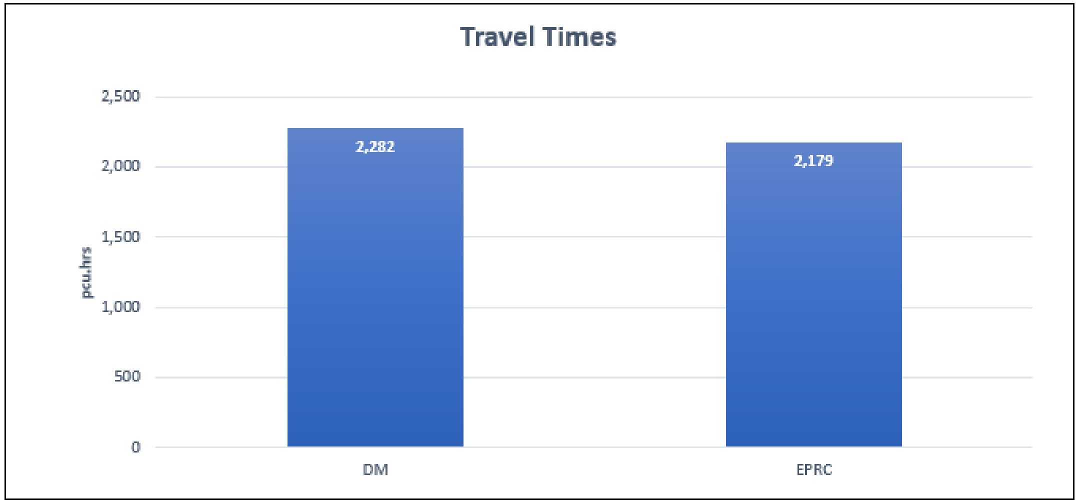
Table 8-13: Network Performance Indicators (Inter Peak – 2043 Design Year)

	DO MIN	EPOC
Transient Queues (pcu.hrs)	71	51
Over Capacity Queues (pcu.hrs)	1	0
Total Travel Times (pcu.hrs)	2,282	2,179
Total Travel Times (pcu.kms)	138,313	140,108
Average Speed (km/hr)	61	64

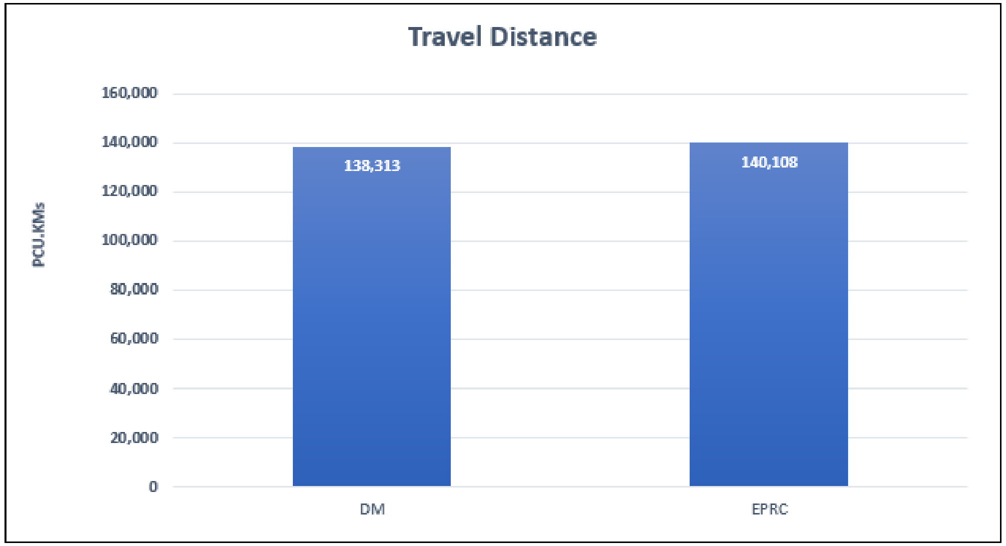
8.3.5 An analysis of the Inter peak network statistics indicate that, in general the Emerging Preferred Option shows an improvement against the Do Minimum scenario. It provides an approx. 30% decrease in overall network delay (i.e. queues) when compared against the Do Minimum scenario. It also achieves an 3kph increase on the average speed and 4% reduction on total travel times. The EPOC shows a marginal increase in the total distance travelled in the model compared to the Do-minimum Scenario, this is to be expected given the alignment of the EPOC is longer than the existing N3.



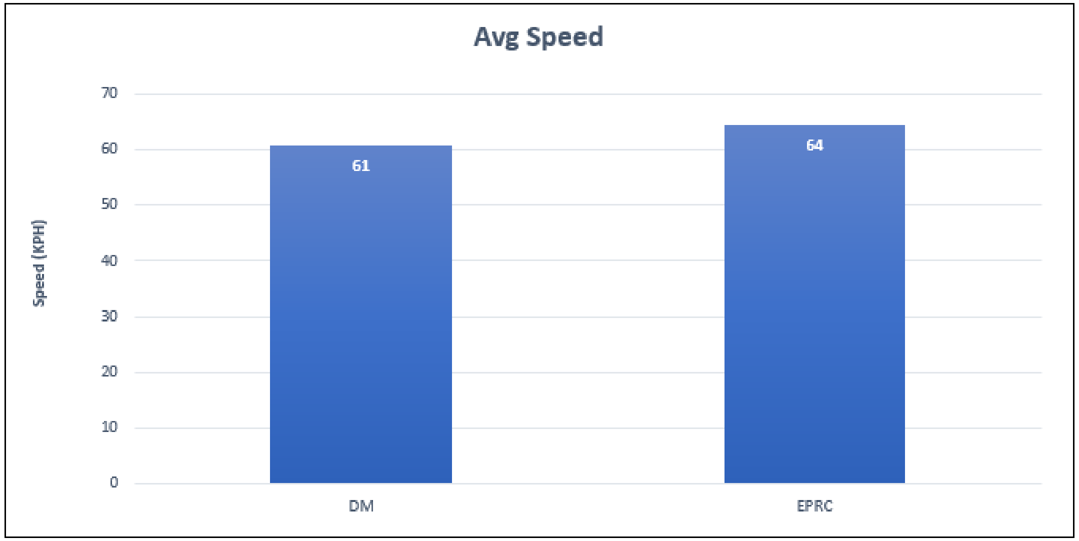
Queues
120
100
80
60
40
20
0
PCU.hrs
1
71
0
51
DM
EPRC
Transient Queues
Over Capacity Queues



Travel Times
2,500
2,000
1,500
1,000
500
0
pcu.hrs
2,282
2,179
DM
EPRC



Travel Distance
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
PCU.KMs
138,313
140,108
DM
EPRC

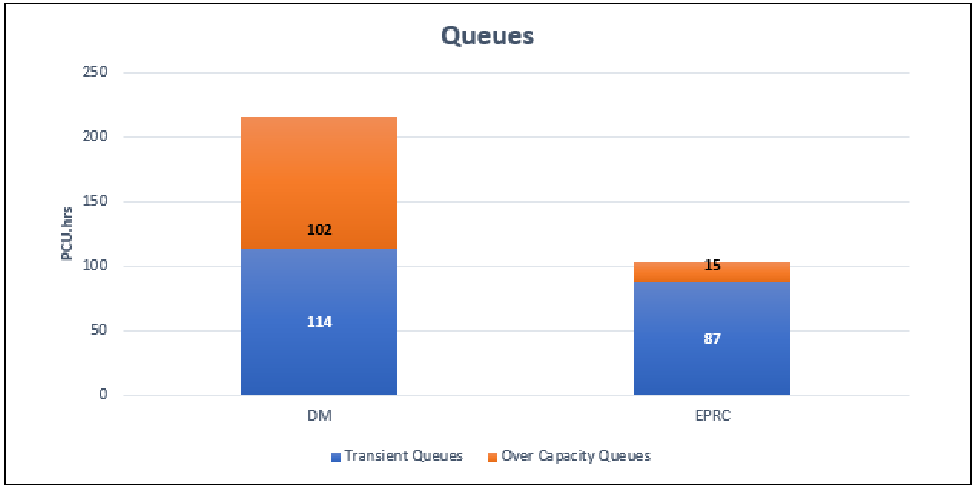


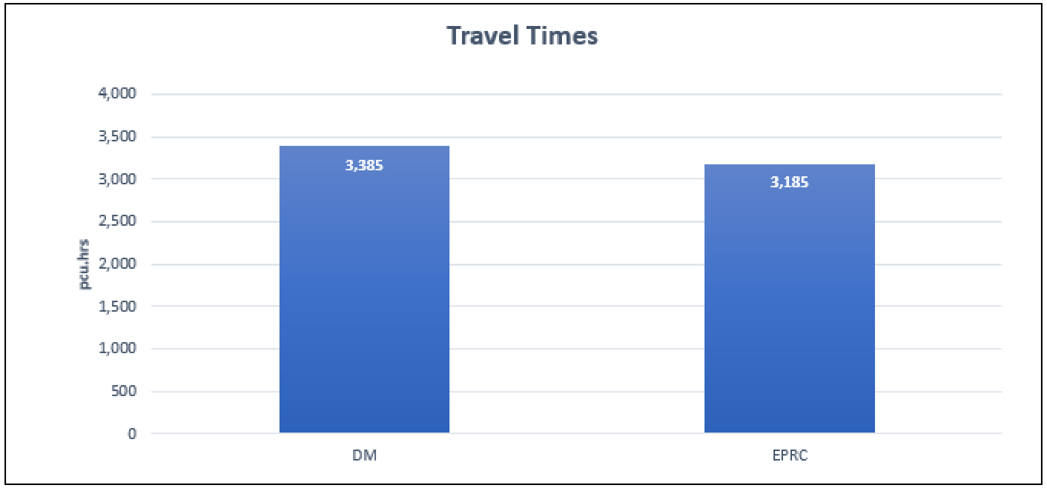
Avg Speed
70
60
50
40
30
20
10
0
Speed (KPH)
61
64
DM
EPRC

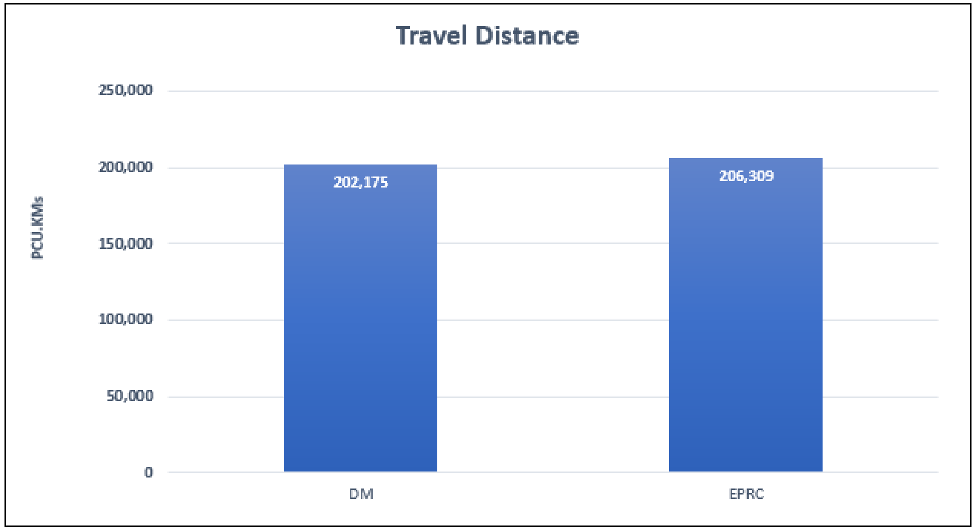
Table 8-14: Network Performance Indicators (PM Peak – 2043 Design Year)

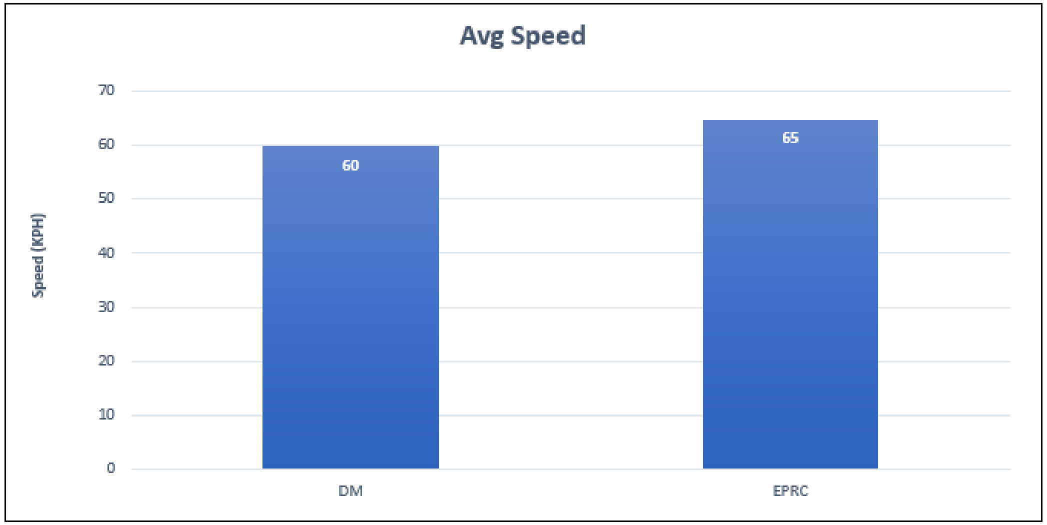
	DO MIN	EPOC
Transient Queues (pcu.hrs)	114	87
Over Capacity Queues (pcu.hrs)	102	15
Total Travel Times (pcu.hrs)	3,385	3,185
Total Travel Times (pcu.kms)	202,175	206,309
Average Speed (km/hr)	60	65

8.3.6 An analysis of the Inter peak network statistics indicate that, in general the Emerging Preferred Option shows an improvement against the Do Minimum scenario. It provides an approx. 50% decrease in overall network delay (i.e. queues) when compared against the Do Minimum scenario. It also achieves an 5kph increase on the average speed and 6% reduction on total travel times. The EPOC shows a marginal increase in the total distance travelled in the model compared to the Do-minimum Scenario, this is to be expected given the alignment of the EPOC is longer than the existing N3.


Queues
250
200
150
100
50
0
PCU.hrs
102
114
15
87
DM
EPRC
Transient Queues
Over Capacity Queues


Travel Times
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
pcu.hrs
3,385
3,185
DM
EPRC


Travel Distance
250,000
200,000
150,000
100,000
50,000
0
PCU.KMs
202,175
206,309
DM
EPRC


Avg Speed
70
60
50
40
30
20
10
0
Speed (KPH)
60
65
DM
EPRC

Journey Times

8.3.7 A journey time analysis has been undertaken for the EPOC and is summarised in the tables below for the two main routes in and out of Virginia town for all time periods. In the Do-minimum scenario the journey times shown below are along the existing N3 while the journey times for the EPOC are taken along the proposed alignment.

8.3.8 In the southbound direction in the AM, the EPOC sees a reduction of 28% compared to the Do Minimum time which is a saving of approx. 7 minutes. Meanwhile in the northbound direction, the EPOC sees a reduction of 22% compared to the Do Minimum time which is a saving of approx. 5 minutes.

Table 8-15: Journey Time Comparison (AM Peak – 2043 Design Year)

	JOURNEY TIME (MINS)		DIFF (%)
ROUTE	DO MIN	EPOC	EPOC
N3 Northbound	21.4	16.8	-22%
N3 Southbound	23.5	16.8	-28%

8.3.9 In the southbound direction during the Inter Peak, the EPOC sees a reduction of 22% compared to the Do Minimum time which is a saving of approx. 5 minutes. Meanwhile in the northbound direction, the EPOC sees a reduction of 22% compared to the Do Minimum time which is a saving of approx. 5 minutes.

Table 8-16: Journey Time Comparison (Inter Peak – 2043 Design Year)

	JOURNEY TIME (MINS)		DIFF (%)
ROUTE	DO MIN	EPOC	EPOC
N3 Northbound	21.4	16.7	-22%
N3 Southbound	21.4	16.7	-22%

8.3.10 In the southbound direction in the PM, the EPOC sees a reduction of 24% compared to the Do Minimum time which is a saving of approx. 5 minutes. Meanwhile in the northbound direction, the EPOC sees a reduction of 43% compared to the Do Minimum time which is a saving of approx. 13 minutes.

Table 8-17: Journey Time Comparison (PM Peak – 2043 Design Year)

	JOURNEY TIME (MINS)		DIFF (%)
ROUTE	DO MIN	EPOC	EPOC
N3 Northbound	29.9	17.1	-43%
N3 Southbound	21.9	16.7	-24%

Reduction of Traffic Volumes in Virginia Town Centre

8.3.11 Currently Virginia experiences considerable congestion within its Town Centre. Successive county plans have noted the need for a bypass which would help alleviate this congestion and provide an improved environment and more accessibility for vulnerable road users within Virginia. Therefore, an analysis has been undertaken to assess the reduction in traffic through Virginia town following the inclusion of the EPOC. The results are presented in the following tables for all traffic travelling through the town during the AM and PM peak hours and the average inter-peak hour.

8.3.12 The results show that the EPOC has a significant impact in terms of removing traffic in Virginia town across all time periods with a 75% reduction in the AM, a 78% reduction in the inter peak and 72% reduction in the PM peak hour.

Table 8-18: Reduction in Traffic (AM Peak – 2043 Design Year)

TYPE	TOTAL (PCUS)		DIFF (%)
	DO MIN	EPOC	EPOC
Total Traffic	1,883	473	-75%

Table 8-19: Reduction in Traffic (IP Peak – 2043 Design Year)

TYPE	TOTAL (PCUS)		DIFF (%)
	DO MIN	EPOC	EPOC
Total Traffic	1,684	375	-78%

Table 8-20: Reduction in Traffic (PM Peak – 2043 Design Year)

TYPE	TOTAL (PCUS)		DIFF (%)
	DO MIN	EPOC	EPOC
Total Traffic	2,020	569	-72%

EPOC AADTs

8.3.13 The forecast AADT flows for the EPOC are presented in the table and in the following section of this report.

Figure 8-3: EPOC – AADT Site Locations

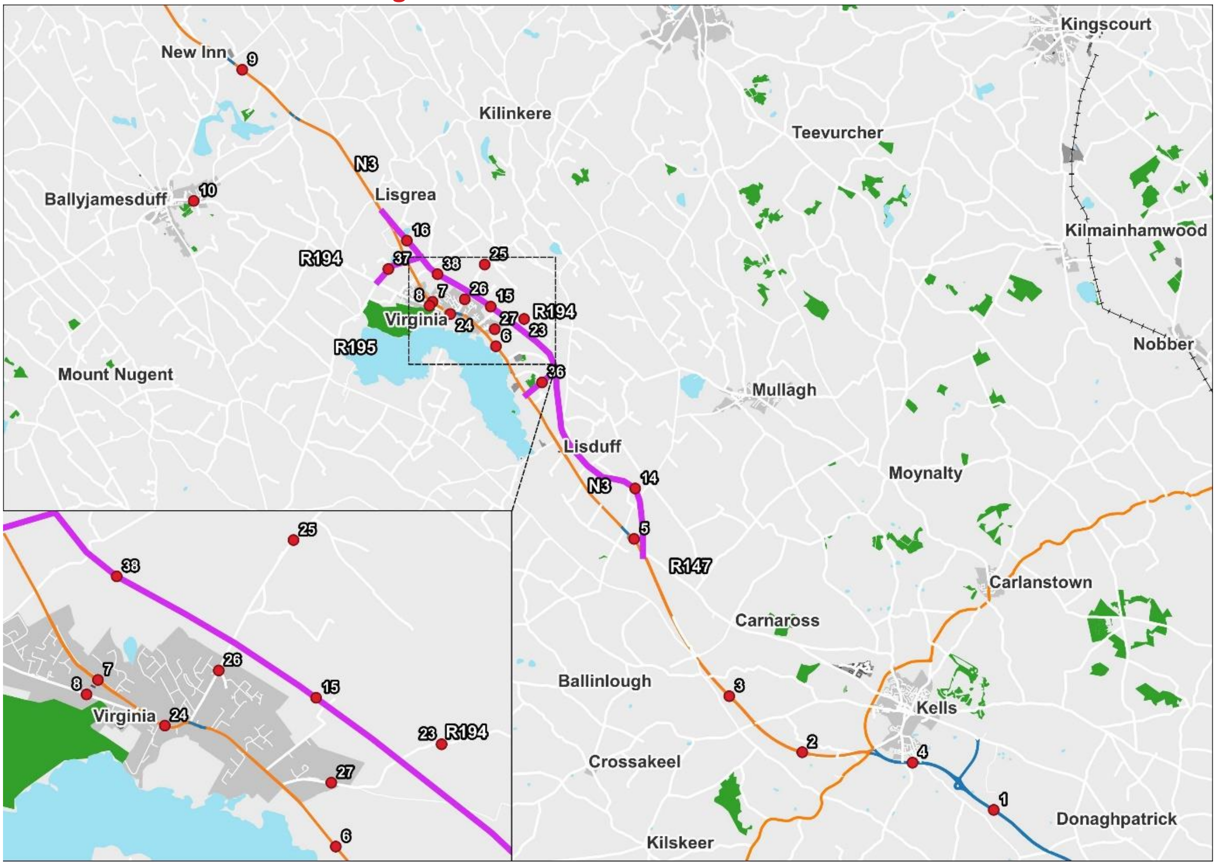


Table 8-21: 2043 AADT Values

AADT POINT	DO MINIMUM		EPOC	
	TOTAL AADT	% HGV	TOTAL AADT	% HGV
1	13,928	13%	13,932	13%
2	12,270	14%	12,441	14%
3	9,289	16%	9,896	15%
4	13,720	14%	13,733	14%
5	11,985	16%	3,785	14%
6	10,677	14%	1,427	10%
7	9,700	14%	1,249	3%
8	5,539	12%	1,904	3%
9	8,831	15%	8,833	15%
10	5,561	11%	6,284	11%
11	-	-	-	-
12	-	-	-	-
13	-	-	-	-
14	-	-	9,551	21%
15	-	-	10,988	19%

AADT POINT	DO MINIMUM		EPOC	
	TOTAL AADT	% HGV	TOTAL AADT	% HGV
16	-	-	8,470	16%
17	-	-	-	-
18	-	-	-	-
19	-	-	-	-
20	-	-	-	-
21	-	-	-	-
22	-	-	-	-
23	1,879	32%	1,265	3%
24	14,060	14%	2,510	4%
25	-	-	-	-
26	-	-	-	-
27	-	-	-	-
28	-	-	-	-
29	-	-	-	-
30	-	-	-	-
31	-	-	-	-
32	-	-	-	-
33	-	-	-	-
34	-	-	-	-
35	-	-	-	-
36	-	-	1,436	3%
37	-	-	6,398	22%
38	-	-	13,750	15%

9. SUMMARY AND CONCLUSION

9.1 Model Development

9.1.1 This Traffic Modelling Report documents the development of the N3 Local Area Traffic Model (in accordance with TII Project Appraisal Guidance) and its application to assist in the Phase 2 Option Selection process for the bypass of Virginia town.

9.1.2 The LAM has been developed, calibrated and validated to reflect the observed base year (2020) traffic conditions for the following time periods:

- AM Morning peak period: 08:00 to 09:00
- PM Evening peak period: 17:00 to 18:00
- Inter peak period: 10:00 to 16:00

9.1.3 The model has been calibrated and validated in-line with TII Project Appraisal Guidelines and conforms to all link calibration criteria specified in PAG Unit 5.1 for each period modelled.

9.1.4 The traffic surveys that were used to develop the Virginia LAM were undertaken during the last week of September and the first week of October in 2020. The majority of the country was under "Level 3" travel restrictions at this time which involved limited numbers for social gatherings and advising people to not travel outside their county, amongst other restrictions. Therefore, as these restrictions will have resulted in non-typical travel patterns within the study area, an analysis of TII's Traffic Monitoring Units (TMU) has been undertaken to establish the impact.

9.1.5 This analysis shows that the 2019 and 2020 traffic flows show a similar profile, however the 2020 traffic flows are approximately 12% lower than those in 2019 (pre – pandemic). As a result of this, the forecast AADTs output from the models (which have been calibrated to 2020 data) are likely to be approximately 12% lower than if the model had been developed using "typical" or Pre-Covid Traffic data. Additionally, it follows that the calculated benefits of each option are also likely to be underestimated.

9.1.6 Notwithstanding the above, the Virginia Local Area Model developed will still provide a robust and consistent platform with which to assess the various options during Phase 2 of this project. During Phase 3, the models will be updated using survey data collected post pandemic (without travel restrictions in place).

9.2 Option Assessment

9.2.1 The following indicators have been used to assess the performance of 4 options –

- Overall Network Performance Stats;
- Journey Times;
- Reduction in Town Centre Traffic; and
- AADTs.

9.2.2 The Network Performance Stats indicate that all options reduce the total travel time throughout the study area relative to the Do-Minimum scenario and provide a similar average speed. In the AM, all four options also achieve a similar average speed increase (3 – 4 kph increase) and a similar total travel time reduction (5 – 6% decrease). While in the PM, they all achieve a similar average speed increase (5 – 6 kph increase) and a similar total travel time reduction (6 – 7% decrease).

9.2.3 The journey time analysis shows that options A, C, D and E produce similar end to end journey times and thus similar savings compared to the DM (37% - 38% saving in the southbound direction in the AM which is a saving of approx. 10 minutes and 45% - 46% saving in northbound direction in the PM which is a saving of approx. 13 minutes). Meanwhile, Option B results in a 30% reduction in the southbound journey time in the AM which is the equivalent of approx. 8 minutes and a 39% reduction in the northbound journey time in the PM which is the equivalent of approx. 11 minutes. This is to be expected given that option B is the longest option and thus vehicles have further to travel.

9.2.4 Virginia experiences considerable congestion within its Town Centre. Successive county plans have noted the need for a bypass which would help alleviate this congestion and provide an improved environment and more accessibility for vulnerable road users within Virginia. Therefore, an analysis has been undertaken to check the reduction in traffic through Virginia town following the inclusion of each option. The results are presented in the following tables for all traffic travelling through the town.

9.2.5 The results show that Options A and C are the best performing options in terms of removing the most traffic from Virginia town across all time periods with a 74% reduction in the AM, a 79% reduction in the inter peak and 72% reduction in the PM. While options B, D and E all produce very similar results (50 – 52% in the AM, 49 – 54% in the inter peak and 45 – 50% in the PM.

9.2.6 In terms of AADT and transference of traffic from the existing N3, Options A and C show the highest forecast AADTs with approximately 11,500 vehicles using the new road adjacent to Virginia town. Option B has the next highest transference with approx. 10,600 vehicles, while Options D and E both produce similar results with approx. 9,000 vehicles.

9.3 Emerging Preferred Option

9.3.1 Following a comprehensive Multi-Criteria Analysis (MCA) appraisal, which considers each option in respect to various criteria, a variation of Option C and Option A, i.e. CV2 has been selected as the emerging preferred option.

9.3.2 Traffic Modelling analysis of the EPOC demonstrates that the route provides benefits on all of the assessed criteria above. The Network Performance Stats indicate that the route reduces the total travel time throughout the entire study area relative to the Do-Minimum scenario (6% - 7% decrease in all time periods) and provides a slightly higher average speed (4 - 6Kph increase).

9.3.3 The journey time analysis shows that when compared to the Do-Minimum (DM), the route provides a saving of between 28% – 46% in the northbound direction and between 29% - 38% in the southbound direction for all time periods.

9.3.4 In terms of removing traffic from the existing N3 through Virginia town, the EPOC shows a reduction of 74% in the AM, 79% in the Inter Peak and a 72% reduction in the PM.

9.3.5 In terms of AADT and transference of traffic from the existing N3, the EPOC is forecast to have an AADT of approximately 11,400 vehicles using the new road adjacent to Virginia town.

9.4 Emerging Preferred Option (Alternative Scenario)

9.4.1 As mentioned in Chapter 7, the Do Minimum and Do Something scenarios include measures that are either committed for the town, or are in advanced stages of delivery and aim to make the town safer and more attractive for vulnerable road users:

- Recently implemented 80 Kph speed limits between Maghera and Virginia and on the north side of Virginia to Cornaslieve;
- Reconfigured signal timings in the town to facilitate longer pedestrian / cyclist crossing times, to be completed prior to the end of the street enhancement works which are currently under construction; and
- Upgrading the Main Street and change of R194 Ballyjamesduff Road junction to a roundabout junction, currently under construction:
  - Including modelling a 30 kph speed limit along the N3 through Virginia town to simulate slower traffic speeds as a result of the four additional zebra crossings and new roundabout on the N3, currently under construction.

9.4.2 While the reconfigured signal timings are committed, they are not implemented. In addition, the simulated 30 kph traffic speeds through Virginia has not been proven. So as a test, these measures were removed from both the Do Minimum and the Emerging Preferred Option Corridor (EPOC) and the analysis for both scenarios was redone based on the same Key Performance Indicators.

9.4.3 The Network Performance Stats indicate that the route reduces the total travel time throughout the entire study area relative to the Do-Minimum scenario (4% - 6% decrease in all time periods compared with a 6% - 7% decrease previously) and provides a slightly higher average speed (3 - 5Kph increase compared with a 4 – 6kph increase previously).

9.4.4 The journey time analysis shows that when compared to the Do-Minimum (DM), the route provides a saving of between 22% – 43% in the northbound direction (compared with a 28% - 46% saving previously) and between 22% - 28% in the southbound direction (compared with a 29% - 38% saving previously) for all time periods.

9.4.5 In terms of removing traffic from the existing N3 through Virginia town, the EPOC shows a reduction of 75% in the AM, 78% in the Inter Peak and a 72% reduction in the PM (these figures have remained at similar levels).

9.4.6 In terms of AADT and transference of traffic from the existing N3, the EPOC is forecast to have an AADT of approximately 11,000 vehicles (previously 11,400) using the new road on the section between the Burrencarragh Link Road and the R178 Bailieborough Road, and approximately 13,750 vehicles (previously 14,050) on the section between the R178 Bailieborough Road and the Ballyjamesduff Link Road.

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Appendix A

Calibration Counts

AM Calibration

Saturn Lookup			Count			Model			GEH		
A Node	B Node	C Node	LV	HV	Total	LV	HV	Total	LV	HV	Total
38454	38384	0	166	14	180	165	14	179	0.1	0.1	0.0
38384	38454	0	149	19	168	150	19	169	0.1	0.1	0.1
38375	38439	0	770	170	940	774	170	944	0.1	0.0	0.1
38377	38378	0	809	225	1034	814	228	1042	0.2	0.2	0.2
38376	38374	0	137	68	205	140	70	210	0.3	0.4	0.4
38440	38385	0	240	105	345	243	79	321	0.2	2.8	1.3
38385	38440	0	159	87	246	158	61	219	0.1	3.0	1.8
38407	38409	0	265	106	371	264	112	376	0.1	0.5	0.2
38409	38407	0	140	79	219	140	78	219	0.0	0.1	0.0
464	36271	0	283	21	304	283	18	302	0.0	0.6	0.1
36271	464	0	290	21	311	290	21	311	0.0	0.0	0.0
38385	38440	0	157	84	241	158	61	219	0.1	2.7	1.5
38440	38385	0	243	109	352	243	79	321	0.0	3.1	1.7
466	38406	0	231	45	276	231	33	264	0.0	1.9	0.7
38406	466	0	263	47	310	263	47	310	0.0	0.0	0.0
232	38408	0	260	30	290	260	30	290	0.0	0.0	0.0
38408	232	0	122	38	160	122	38	160	0.0	0.1	0.0
38276	38410	0	167	95	262	169	95	264	0.1	0.0	0.1
38410	38276	0	111	50	161	111	50	162	0.0	0.0	0.0
31161	38178	0	119	9	128	84	9	93	3.4	0.1	3.3
38178	31161	0	182	12	194	156	12	168	2.0	0.1	2.0
38409	38407	0	141	78	219	140	78	219	0.0	0.0	0.0
38407	38409	0	272	111	383	264	112	376	0.5	0.1	0.4
233	38274	0	194	102	296	213	103	316	1.3	0.1	1.1
38274	233	0	162	57	219	170	58	228	0.6	0.2	0.6
460	38275	0	79	9	88	67	9	76	1.4	0.1	1.2
38275	460	0	53	9	62	53	9	62	0.0	0.2	0.1
38410	38276	0	111	50	161	111	50	162	0.0	0.0	0.0
38276	38410	0	169	95	264	169	95	264	0.0	0.0	0.0
243	241	239	58	0	58	82	19	101	2.9	6.1	4.8
243	241	424	17	2	19	17	1	18	0.0	1.1	0.3
239	241	243	27	2	29	29	19	47	0.3	5.2	3.0
239	241	424	86	11	97	95	20	116	1.0	2.2	1.8
424	241	243	9	0	9	9	0	9	0.0	0.2	0.0
424	241	239	76	13	89	180	13	193	9.2	0.1	8.8
251	253	252	31	2	33	31	6	37	0.0	2.2	0.8
251	253	438	32	0	32	32	2	34	0.0	1.8	0.3
251	253	431	23	3	26	23	1	24	0.0	1.1	0.3
252	253	251	36	2	38	36	11	47	0.0	3.7	1.5
252	253	438	41	3	44	41	3	44	0.0	0.1	0.0
252	253	431	94	0	94	94	4	98	0.0	2.8	0.4
438	253	251	27	0	27	27	2	29	0.0	1.8	0.3
438	253	252	39	3	42	39	3	42	0.0	0.1	0.0
438	253	431	1	0	1	1	0	1	0.0	0.2	0.0
431	253	251	20	5	25	20	1	21	0.0	2.5	0.9
431	253	252	100	2	102	100	2	102	0.0	0.1	0.0
431	253	438	3	0	3	3	0	3	0.0	0.2	0.0
431	255	260	48	3	51	54	3	57	0.9	0.1	0.9
431	255	258	9	2	11	9	2	11	0.1	0.0	0.1
260	255	431	48	5	53	48	2	50	0.0	1.3	0.3
260	255	258	2	0	2	2	0	2	0.0	0.1	0.0
258	255	431	13	0	13	13	0	13	0.0	0.0	0.0
258	255	260	6	0	6	6	0	6	0.0	1.0	0.2
262	547	261	13	2	15	13	2	15	0.0	0.1	0.0
262	547	206	60	10	70	60	10	70	0.0	0.2	0.1
262	547	546	11	0	11	11	0	11	0.0	0.0	0.0
261	547	262	19	0	19	19	3	22	0.0	2.5	0.7
261	547	206	2	4	6	1	0	1	1.0	2.8	2.7
261	547	546	9	0	9	9	0	9	0.0	0.1	0.0
206	547	262	35	0	35	35	14	49	0.0	5.2	2.1
206	547	261	6	2	8	1	0	1	2.7	1.9	3.3
206	547	546	4	0	4	4	0	4	0.0	0.0	0.0
546	547	262	16	3	19	16	0	16	0.0	2.4	0.7
546	547	261	13	0	13	13	0	13	0.0	0.3	0.0
546	547	206	2	0	2	2	0	2	0.0	0.0	0.0
209	208	446	15	8	23	15	0	15	0.0	3.9	1.8
209	208	207	66	0	66	66	3	69	0.0	2.4	0.4
446	208	209	5	0	5	5	0	5	0.0	0.0	0.0
446	208	207	314	165	479	313	165	478	0.1	0.0	0.1
207	208	209	40	2	42	40	2	42	0.0	0.2	0.0
207	208	446	446	107	553	444	107	551	0.1	0.0	0.1
474	203	469	75	12	87	75	12	87	0.0	0.1	0.1
474	203	200	133	7	140	89	1	89	4.2	3.0	4.7
469	203	474	62	5	67	62	5	67	0.0	0.1	0.0
469	203	200	328	159	487	327	147	474	0.1	1.0	0.6
200	203	474	129	10	139	134	11	145	0.4	0.5	0.5
200	203	469	453	96	549	467	105	572	0.6	0.9	1.0
478	202	0	409	94	504	409	94	504	0.0	0.0	0.0

Saturn Lookup			Count			Model			GEH		
A Node	B Node	C Node	LV	HV	Total	LV	HV	Total	LV	HV	Total
202	478	0	246	126	372	246	126	372	0.0	0.0	0.0
203	200	0	417	140	557	416	147	563	0.1	0.6	0.3
200	203	0	602	116	718	600	116	716	0.1	0.0	0.1
480	201	0	205	22	227	205	22	227	0.0	0.0	0.0
201	480	0	183	14	197	184	22	205	0.1	1.8	0.6
545	544	482	9	0	9	9	0	9	0.0	0.3	0.0
545	544	307	29	0	29	29	1	30	0.0	1.1	0.1
482	544	545	1	0	1	1	0	1	0.0	0.4	0.1
482	544	307	263	122	385	262	122	384	0.1	0.0	0.1
307	544	545	16	0	16	17	3	20	0.1	2.6	0.9
307	544	482	313	99	413	317	99	416	0.2	0.0	0.2
414	415	499	32	6	38	32	6	38	0.0	0.1	0.0
414	415	364	53	41	94	53	41	94	0.0	0.0	0.0
414	415	416	36	10	46	18	4	22	3.5	2.0	4.0
499	415	414	16	5	21	16	5	21	0.0	0.1	0.0
499	415	364	127	6	133	127	6	133	0.0	0.1	0.0
499	415	416	68	10	78	68	10	78	0.0	0.0	0.0
364	415	414	49	17	66	49	16	65	0.0	0.2	0.1
364	415	499	1	0	1	97	7	104	13.7	3.7	14.2
364	415	416	17	0	17	0	0	0	5.8	0.0	5.8
416	415	414	36	0	36	36	3	39	0.0	2.4	0.5
416	415	499	158	7	165	158	7	165	0.0	0.1	0.0
416	415	364	40	3	43	0	0	0	8.9	2.4	9.3
416	364	415	5	0	5	0	0	0	3.2	0.0	3.2
416	364	495	31	3	34	31	3	34	0.0	0.1	0.0
416	364	501	14	2	16	14	2	16	0.0	0.1	0.0
415	364	416	5	2	7	0	0	0	3.2	1.9	3.7
415	364	495	97	17	114	76	17	93	2.3	0.2	2.1
415	364	501	112	31	143	104	31	134	0.8	0.1	0.7
495	364	416	56	9	65	56	9	65	0.0	0.1	0.0
495	364	415	52	10	62	51	10	61	0.1	0.1	0.1
495	364	501	20	12	32	20	11	31	0.0	0.3	0.2
501	364	416	54	8	62	54	7	61	0.0	0.3	0.1
501	364	415	118	13	131	95	13	108	2.3	0.1	2.1
501	364	495	27	4	31	27	4	31	0.0	0.1	0.0
505	413	0	48	3	51	48	3	51	0.0	0.1	0.0
413	505	0	39	9	48	39	9	48	0.0	0.1	0.1
415	416	0	86	14	100	86	14	100	0.0	0.1	0.0
416	415	0	226	10	236	194	10	204	2.2	0.1	2.1
364	416	0	114	16	130	110	16	126	0.4	0.1	0.4
416	364	0	51	5	56	45	5	50	0.9	0.1	0.8
397	413	0	177	12	189	191	12	203	1.0	0.1	1.0
413	397	0	109	21	130	157	21	178	4.1	0.0	3.8
367	359	452	39	0	39	39	0	39	0.0	0.3	0.0
367	359	347	46	3	49	83	5	88	4.6	1.3	4.7
367	359	361	0	0	0	0	0	0	0.0	0.0	0.0
452	359	367	22	2	24	22	1	23	0.0	1.1	0.3
452	359	347	15	3	18	26	3	29	2.5	0.2	2.3
452	359	361	0	0	0	0	0	0	0.0	0.0	0.0
347	359	367	33	10	43	43	10	53	1.6	0.1	1.4
347	359	452	20	0	20	21	0	21	0.3	0.3	0.3
347	359	361	0	0	0	0	0	0	0.0	0.0	0.0
361	359	367	0	0	0	0	0	0	0.0	0.0	0.0
361	359	452	0	0	0	7	0	7	3.6	0.0	3.6
361	359	347	0	0	0	0	0	0	0.0	0.0	0.0
359	347	344	1	0	1	0	0	0	1.4	0.0	1.4
359	347	533	112	8	120	109	8	117	0.3	0.1	0.3
359	347	358	0	0	0	0	0	0	0.4	0.0	0.4
344	347	359	0	0	0	0	0	0	0.0	0.0	0.0
344	347	533	3	0	3	0	0	0	2.4	0.0	2.4
344	347	358	1	0	1	0	0	0	1.4	0.0	1.4
533	347	359	64	10	74	64	10	74	0.0	0.1	0.0
533	347	344	2	0	2	0	0	0	2.0	0.0	2.0
533	347	358	67	12	79	67	12	79	0.0	0.2	0.1
358	347	359	0	0	0	0	0	0	0.5	0.2	0.6
358	347	344	1	0	1	0	0	0	1.4	0.0	1.4
358	347	533	125	11	136	125	11	136	0.0	0.1	0.0
533	349	346	93	11	104	93	11	104	0.0	0.1	0.1
533	349	348	92	15	107	92	15	107	0.0	0.1	0.0
533	349	350	56	2	58	56	2	58	0.0	0.1	0.0
346	349	533	58	13	71	58	13	71	0.0	0.1	0.1
346	349	348	41	9	50	0	0	0	9.1	4.1	10.0
346	349	350	36	6	42	36	6	42	0.0	0.1	0.0
348	349	533	99	20	119	99	20	119	0.0	0.0	0.0
348	349	346	55	6	61	55	6	61	0.0	0.1	0.0
348	349	350	8	0	8	8	0	8	0.0	0.5	0.0
350	349	533	73	0	73	73	0	73	0.0	0.5	0.0
350	349	346	69	13	82	69	13	82	0.0	0.1	0.0
350	349	348	24	2	26	24	2	26	0.0	0.1	0.0
523	332	339	1	0	1	0	0	0	1.4	0.0	1.4

Saturn Lookup			Count			Model			GEH		
A Node	B Node	C Node	LV	HV	Total	LV	HV	Total	LV	HV	Total
523	332	343	70	20	90	70	20	90	0.0	0.0	0.0
339	332	523	5	0	5	0	0	0	3.2	0.0	3.2
339	332	343	21	2	23	20	1	21	0.3	0.5	0.4
343	332	523	122	22	144	122	23	145	0.0	0.2	0.1
343	332	339	11	0	11	11	0	11	0.0	0.5	0.0
523	549	326	108	6	114	130	23	153	2.0	4.6	3.4
523	549	336	0	0	0	4	0	4	2.9	0.3	2.9
326	549	523	53	10	63	64	21	85	1.5	2.9	2.6
326	549	336	31	14	45	38	14	52	1.2	0.1	0.9
336	549	523	0	0	0	2	0	2	2.0	0.3	2.1
336	549	326	26	18	44	31	20	50	0.9	0.4	0.9
331	326	325	2	3	5	0	0	0	2.0	2.4	3.1
331	326	549	79	34	113	79	34	113	0.0	0.0	0.0
325	326	331	6	5	11	0	0	0	3.5	3.1	4.6
325	326	549	27	3	30	23	1	24	0.8	1.6	1.2
549	326	331	137	40	177	138	40	178	0.1	0.0	0.0
549	326	325	24	6	30	23	3	26	0.3	1.2	0.8
228	329	327	10	2	12	56	10	65	8.0	3.3	8.6
228	329	328	72	8	80	79	34	113	0.8	5.7	3.4
327	329	228	42	2	44	110	11	121	7.8	3.6	8.5
327	329	328	2	0	2	0	0	0	2.0	0.0	2.0
328	329	228	149	12	161	138	40	178	0.9	5.6	1.3
328	329	327	1	0	1	0	0	0	1.4	0.0	1.4
227	228	550	5	0	5	0	0	0	3.2	0.0	3.2
227	228	329	117	44	161	128	44	171	0.9	0.1	0.8
227	228	330	13	5	18	0	0	0	5.1	3.0	5.9
550	228	227	14	0	14	0	0	0	5.3	0.0	5.3
550	228	329	2	2	4	0	0	0	2.0	1.9	2.8
550	228	330	6	0	6	0	0	0	3.5	0.5	3.4
329	228	227	219	51	270	243	51	294	1.6	0.0	1.4
329	228	550	1	0	1	0	0	0	1.4	0.0	1.4
329	228	330	7	2	9	5	0	5	0.8	1.9	1.5
330	228	227	30	9	39	0	8	8	7.7	0.2	6.3
330	228	550	2	0	2	0	0	0	2.0	0.0	2.0
330	228	329	15	0	15	7	0	7	2.4	0.0	2.4
552	224	0	105	21	126	71	15	85	3.7	1.5	4.0
224	552	0	136	18	154	55	10	65	8.3	2.1	8.5
38383	226	0	235	189	424	234	185	419	0.0	0.3	0.2
225	38381	0	569	151	720	594	156	750	1.0	0.4	1.1
228	227	0	268	75	343	243	59	302	1.6	1.9	2.3
227	228	0	140	68	208	128	44	171	1.1	3.3	2.7
703	222	0	423	113	536	407	107	514	0.8	0.5	0.9
223	703	0	186	160	346	178	156	335	0.6	0.3	0.6
422	231	466	16	5	21	16	5	21	0.0	0.1	0.0
422	231	701	7	0	7	7	0	7	0.0	0.0	0.0
422	231	220	6	0	6	6	0	6	0.0	0.3	0.0
466	231	422	9	0	9	9	1	10	0.0	1.5	0.4
466	231	701	7	0	7	0	1	1	3.7	1.0	3.3
466	231	220	101	37	138	89	34	124	1.2	0.4	1.2
701	231	422	5	0	5	5	0	5	0.0	0.2	0.0
701	231	466	35	2	37	0	2	2	8.4	0.1	7.9
701	231	220	6	0	6	0	0	0	3.5	0.0	3.5
220	231	422	3	0	3	3	0	3	0.0	0.4	0.1
220	231	466	194	8	202	151	8	159	3.3	0.1	3.2
220	231	701	8	3	11	0	0	0	4.0	2.4	4.7
442	214	0	109	3	112	109	3	112	0.0	0.1	0.0
214	442	0	33	8	41	33	8	41	0.0	0.1	0.1
217	214	0	226	164	390	274	191	464	3.0	2.0	3.6
214	217	0	546	104	650	561	115	676	0.6	1.1	1.0
801	213	0	46	2	48	46	1	47	0.0	0.4	0.1
213	801	0	18	4	22	18	2	20	0.0	1.4	0.5
554	213	0	448	109	557	463	115	578	0.7	0.6	0.9
213	554	0	232	162	394	279	185	464	2.9	1.8	3.4
214	217	0	557	104	661	561	115	676	0.2	1.1	0.6
217	214	0	272	183	455	274	191	464	0.1	0.6	0.4
220	218	0	96	37	133	95	34	130	0.1	0.3	0.2
218	220	0	154	18	172	154	8	162	0.0	2.8	0.8
703	219	0	173	158	331	178	156	335	0.4	0.1	0.2
221	703	0	404	97	501	407	107	514	0.1	1.0	0.6
448	211	0	58	0	58	58	2	60	0.0	1.9	0.2
211	448	0	55	5	60	55	5	60	0.0	0.1	0.0
554	211	0	281	178	459	279	185	464	0.1	0.5	0.2
211	554	0	462	115	577	463	115	578	0.0	0.0	0.0
444	210	0	120	14	134	120	11	131	0.0	0.6	0.2
210	444	0	47	15	62	47	17	64	0.0	0.7	0.3
446	210	0	415	116	531	418	110	528	0.1	0.6	0.1
210	446	0	310	173	483	310	171	481	0.0	0.1	0.1
444	454	801	11	0	11	0	0	0	4.7	0.0	4.7
444	454	450	24	7	31	24	7	31	0.0	0.1	0.1
444	454	452	30	12	42	25	10	35	1.0	0.5	1.1

Saturn Lookup			Count			Model			GEH		
A Node	B Node	C Node	LV	HV	Total	LV	HV	Total	LV	HV	Total
801	454	444	1	0	1	0	0	0	1.4	0.0	1.4
801	454	450	0	4	4	1	0	1	1.3	2.8	2.0
801	454	452	11	0	11	2	0	2	3.8	0.0	3.8
450	454	444	43	5	48	43	5	48	0.0	0.1	0.0
450	454	801	2	5	7	2	0	2	0.0	3.1	2.3
450	454	452	7	0	7	7	0	7	0.0	0.0	0.0
452	454	444	64	0	64	64	5	69	0.0	3.1	0.6
452	454	801	12	0	12	12	0	12	0.0	0.0	0.0
452	454	450	3	0	3	3	0	3	0.0	0.0	0.0
38386	550	551	10	0	10	0	0	0	4.5	0.0	4.5
38386	550	229	47	6	53	110	68	178	7.1	10.2	11.7
38386	550	228	4	3	7	0	0	0	2.8	2.4	3.7
551	550	38386	7	0	7	0	0	0	3.7	0.0	3.7
551	550	229	2	0	2	0	0	0	2.0	0.0	2.0
551	550	228	3	0	3	0	0	0	2.4	0.0	2.4
229	550	38386	176	45	221	193	53	245	1.2	1.0	1.6
229	550	551	7	0	7	0	0	0	3.7	0.0	3.7
229	550	228	3	2	5	0	0	0	2.4	1.8	3.0
228	550	38386	4	2	6	0	0	0	2.8	1.9	3.4
228	550	551	4	0	4	0	0	0	2.8	0.0	2.8
228	550	229	1	0	1	0	0	0	1.4	0.0	1.4
38376	38374	0	140	69	209	140	70	210	0.0	0.1	0.1
38377	38378	0	811	229	1040	814	228	1042	0.1	0.0	0.1
705	38382	0	231	204	435	231	203	433	0.0	0.1	0.1
550	38386	0	223	53	276	193	53	245	2.1	0.1	1.9
38386	550	0	142	68	210	110	68	178	2.8	0.0	2.3
225	38381	0	594	156	750	594	156	750	0.0	0.0	0.0
38383	226	0	235	185	420	234	185	419	0.0	0.0	0.0
302	312	0	49	3	52	49	12	61	0.0	3.3	1.2
312	302	0	44	5	49	44	8	52	0.0	1.1	0.4
702	312	0	290	150	440	288	115	403	0.1	3.0	1.8
312	702	0	341	116	457	338	89	427	0.1	2.7	1.4
314	313	0	83	22	105	83	22	105	0.0	0.0	0.0
313	314	0	76	41	117	76	41	117	0.0	0.1	0.0
315	313	0	338	113	451	338	114	452	0.0	0.1	0.0
313	315	0	299	125	424	299	126	425	0.0	0.0	0.0

PM Calibration

Saturn Lookup			Count			Model			GEH		
A Node	B Node	C Node	LV	HV	Total	LV	HV	Total	LV	HV	Total
38454	38384	0	146	3	149	146	9	155	0.0	2.5	0.5
38384	38454	0	160	8	168	160	8	168	0.0	0.1	0.0
38375	38439	0	302	133	435	302	133	435	0.0	0.0	0.0
38377	38378	0	585	175	760	575	178	753	0.4	0.3	0.2
38376	38374	0	230	29	259	221	28	249	0.6	0.2	0.6
38440	38385	0	195	48	243	201	35	236	0.4	2.0	0.5
38385	38440	0	234	56	290	239	54	293	0.4	0.3	0.2
38407	38409	0	161	62	223	160	61	221	0.1	0.1	0.1
38409	38407	0	307	58	365	304	58	361	0.2	0.0	0.2
464	36271	0	335	16	351	334	16	350	0.0	0.1	0.1
36271	464	0	258	2	260	258	3	261	0.0	0.8	0.1
38385	38440	0	240	56	296	239	54	293	0.0	0.3	0.2
38440	38385	0	200	40	240	201	35	236	0.1	0.7	0.2
466	38406	0	321	18	339	321	18	339	0.0	0.0	0.0
38406	466	0	292	53	345	291	53	344	0.0	0.0	0.0
232	38408	0	143	14	157	143	14	157	0.0	0.2	0.1
38408	232	0	366	18	384	366	19	384	0.0	0.1	0.0
38276	38410	0	143	49	192	145	49	194	0.1	0.0	0.1
38410	38276	0	196	51	247	192	51	243	0.3	0.0	0.3
31161	38178	0	266	12	278	236	12	248	1.9	0.1	1.8
38178	31161	0	137	2	139	110	2	112	2.4	0.2	2.4
38409	38407	0	306	58	364	304	58	361	0.1	0.0	0.1
38407	38409	0	159	62	221	160	61	221	0.1	0.1	0.0
233	38274	0	197	54	251	200	54	254	0.2	0.0	0.2
38274	233	0	294	56	350	297	56	352	0.2	0.0	0.1
460	38275	0	123	5	128	123	5	128	0.0	0.1	0.0
38275	460	0	74	5	79	73	5	78	0.1	0.1	0.1
38410	38276	0	192	51	243	192	51	243	0.0	0.0	0.0
38276	38410	0	144	49	193	145	49	194	0.1	0.0	0.0
243	241	239	45	2	47	45	5	50	0.0	1.7	0.4
243	241	424	20	0	20	20	0	20	0.0	0.0	0.0
239	241	243	78	2	80	82	2	84	0.5	0.1	0.5
239	241	424	255	20	275	288	20	308	2.0	0.0	1.9
424	241	243	5	0	5	5	0	5	0.0	0.3	0.0
424	241	239	38	6	44	100	9	110	7.5	1.3	7.5
251	253	252	42	2	44	42	7	49	0.0	2.3	0.7
251	253	438	27	19	46	27	5	32	0.0	4.0	2.2
251	253	431	19	0	19	19	0	19	0.0	0.2	0.0
252	253	251	61	0	61	61	14	75	0.0	5.3	1.7
252	253	438	44	2	46	44	2	46	0.0	0.1	0.0
252	253	431	81	0	81	82	2	84	0.1	2.1	0.3
438	253	251	55	25	80	55	25	80	0.0	0.0	0.0
438	253	252	50	2	52	50	2	52	0.0	0.1	0.0
438	253	431	9	0	9	9	0	9	0.0	0.0	0.0
431	253	251	25	14	39	25	0	25	0.0	5.1	2.4
431	253	252	61	3	64	61	1	62	0.0	1.0	0.2
431	253	438	7	3	10	7	0	7	0.0	2.3	1.0
431	255	260	46	2	48	46	2	48	0.0	0.2	0.1
431	255	258	16	0	16	17	0	17	0.1	0.3	0.1
260	255	431	52	0	52	52	1	53	0.0	1.6	0.2
260	255	258	13	0	13	12	0	12	0.1	0.0	0.1
258	255	431	8	0	8	8	0	8	0.0	0.3	0.0
258	255	260	5	4	9	5	2	7	0.0	1.2	0.7
262	547	261	14	2	16	14	2	16	0.0	0.1	0.0
262	547	206	51	5	56	51	5	56	0.0	0.1	0.0
262	547	546	12	3	15	12	0	12	0.0	2.4	0.8
261	547	262	21	3	24	21	3	24	0.0	0.1	0.0
261	547	206	4	0	4	1	0	1	2.0	0.0	2.0
261	547	546	14	0	14	14	0	14	0.0	0.0	0.0
206	547	262	54	9	63	54	9	63	0.0	0.1	0.0
206	547	261	2	0	2	1	0	1	0.8	0.0	0.8
206	547	546	3	0	3	3	0	3	0.0	0.0	0.0
546	547	262	11	0	11	11	0	11	0.0	0.0	0.0
546	547	261	12	0	12	12	0	12	0.0	0.0	0.0
546	547	206	5	0	5	5	0	5	0.0	0.0	0.0
209	208	446	12	0	12	12	0	12	0.0	0.0	0.0
209	208	207	46	0	46	46	4	50	0.0	2.7	0.5
446	208	209	6	0	6	4	0	4	0.9	0.0	0.9
446	208	207	591	128	719	590	128	718	0.0	0.0	0.0
207	208	209	64	0	64	64	1	65	0.0	1.6	0.1
207	208	446	339	91	430	338	91	429	0.1	0.0	0.1
474	203	469	63	3	66	63	3	66	0.0	0.1	0.0
474	203	200	107	4	111	107	5	113	0.0	0.8	0.2
469	203	474	55	7	62	55	7	62	0.0	0.1	0.1
469	203	200	592	116	708	626	126	752	1.4	1.0	1.6
200	203	474	131	9	140	132	2	134	0.1	2.8	0.5
200	203	469	378	92	470	380	80	460	0.1	1.3	0.5
478	202	0	406	69	475	405	69	475	0.0	0.0	0.0

Saturn Lookup			Count			Model			GEH		
A Node	B Node	C Node	LV	HV	Total	LV	HV	Total	LV	HV	Total
202	478	0	522	102	624	524	89	614	0.1	1.3	0.4
203	200	0	743	145	888	733	132	864	0.4	1.1	0.8
200	203	0	524	75	599	512	82	594	0.5	0.8	0.2
480	201	0	198	6	204	198	13	211	0.0	2.4	0.5
201	480	0	300	43	343	300	43	343	0.0	0.0	0.0
545	544	482	3	0	3	3	0	3	0.0	0.3	0.0
545	544	307	21	3	24	21	3	24	0.0	0.1	0.0
482	544	545	7	0	7	7	0	7	0.0	0.4	0.0
482	544	307	458	82	540	462	86	548	0.2	0.4	0.3
307	544	545	14	5	19	16	6	22	0.5	0.7	0.8
307	544	482	126	31	157	273	70	344	10.4	5.5	11.8
414	415	499	33	3	36	33	3	36	0.0	0.1	0.0
414	415	364	84	31	115	84	31	115	0.0	0.0	0.0
414	415	416	25	0	25	25	3	28	0.0	2.5	0.6
499	415	414	19	0	19	19	7	26	0.0	3.7	1.4
499	415	364	117	8	125	155	8	163	3.3	0.1	3.2
499	415	416	100	10	110	100	10	110	0.0	0.1	0.0
364	415	414	67	11	78	67	11	78	0.0	0.1	0.0
364	415	499	1	0	1	105	10	115	14.3	4.5	15.0
364	415	416	39	0	39	0	0	0	8.8	0.0	8.8
416	415	414	27	6	33	35	6	41	1.5	0.1	1.4
416	415	499	65	0	65	83	3	87	2.1	2.6	2.5
416	415	364	94	2	96	0	0	0	13.7	1.9	13.8
416	364	415	14	0	14	0	0	0	5.3	0.0	5.3
416	364	495	30	3	33	30	3	33	0.0	0.1	0.0
416	364	501	19	0	19	33	0	33	2.7	0.1	2.7
415	364	416	36	0	36	0	0	0	8.5	0.0	8.5
415	364	495	127	14	141	117	14	131	0.9	0.1	0.8
415	364	501	132	25	157	122	25	147	0.9	0.0	0.8
495	364	416	104	9	113	104	14	118	0.0	1.6	0.5
495	364	415	92	7	99	71	7	78	2.3	0.1	2.2
495	364	501	58	16	74	58	13	71	0.0	0.8	0.4
501	364	416	55	13	68	55	6	61	0.0	2.4	0.9
501	364	415	116	14	130	101	14	115	1.5	0.1	1.3
501	364	495	43	3	46	43	3	46	0.0	0.1	0.0
505	413	0	45	6	51	45	4	49	0.0	0.6	0.2
413	505	0	56	10	66	56	6	62	0.0	1.3	0.4
415	416	0	136	13	149	125	13	138	1.0	0.1	0.9
416	415	0	173	8	181	119	9	128	4.5	0.6	4.3
364	416	0	191	20	211	159	20	179	2.4	0.0	2.3
416	364	0	63	3	66	63	3	66	0.0	0.1	0.0
397	413	0	138	8	146	138	8	146	0.0	0.1	0.0
413	397	0	218	27	245	230	27	257	0.8	0.0	0.7
367	359	452	28	3	31	28	2	30	0.0	0.8	0.2
367	359	347	44	4	48	47	4	52	0.5	0.2	0.6
367	359	361	0	0	0	0	0	0	0.0	0.0	0.0
452	359	367	62	0	62	62	0	62	0.0	0.1	0.0
452	359	347	17	2	19	18	2	20	0.1	0.1	0.1
452	359	361	0	0	0	0	0	0	0.0	0.0	0.0
347	359	367	54	2	56	56	2	58	0.3	0.1	0.3
347	359	452	17	0	17	18	1	18	0.1	1.2	0.3
347	359	361	0	0	0	0	0	0	0.0	0.0	0.0
361	359	367	0	0	0	0	0	0	0.0	0.0	0.0
361	359	452	0	0	0	7	0	7	3.7	0.0	3.7
361	359	347	0	0	0	0	0	0	0.0	0.0	0.0
359	347	344	0	0	0	0	0	0	0.0	0.0	0.0
359	347	533	64	10	74	64	6	70	0.0	1.2	0.4
359	347	358	1	0	1	1	0	1	0.0	0.0	0.0
344	347	359	0	0	0	0	0	0	0.0	0.0	0.0
344	347	533	4	0	4	0	0	0	2.8	0.0	2.8
344	347	358	3	0	3	0	0	0	2.4	0.0	2.4
533	347	359	97	5	102	73	3	76	2.5	1.1	2.7
533	347	344	6	0	6	0	0	0	3.5	0.0	3.5
533	347	358	129	24	153	129	24	153	0.0	0.0	0.0
358	347	359	0	0	0	0	0	0	0.6	0.0	0.6
358	347	344	3	0	3	0	0	0	2.4	0.0	2.4
358	347	533	61	16	77	61	16	77	0.0	0.1	0.0
533	349	346	74	3	77	74	3	77	0.0	0.1	0.0
533	349	348	120	20	140	120	20	140	0.0	0.1	0.0
533	349	350	57	0	57	57	0	57	0.0	0.8	0.0
346	349	533	57	7	64	57	7	64	0.0	0.1	0.0
346	349	348	82	0	82	0	0	0	12.8	0.0	12.8
346	349	350	84	8	92	84	8	92	0.0	0.1	0.0
348	349	533	108	21	129	108	21	129	0.0	0.0	0.0
348	349	346	78	7	85	78	7	85	0.0	0.1	0.0
348	349	350	22	3	25	22	3	25	0.0	0.1	0.0
350	349	533	56	2	58	56	2	58	0.0	0.1	0.0
350	349	346	70	7	77	70	7	77	0.0	0.1	0.0
350	349	348	36	3	39	36	3	39	0.0	0.1	0.0
523	332	339	5	2	7	0	0	0	3.2	1.9	3.7

Saturn Lookup			Count			Model			GEH		
A Node	B Node	C Node	LV	HV	Total	LV	HV	Total	LV	HV	Total
523	332	343	162	17	179	162	16	179	0.0	0.2	0.1
339	332	523	3	0	3	0	0	0	2.4	0.0	2.4
339	332	343	16	3	19	16	0	16	0.0	2.0	0.6
343	332	523	71	6	77	71	13	84	0.0	2.5	0.8
343	332	339	19	2	21	19	2	21	0.0	0.1	0.0
523	549	326	54	5	59	71	15	85	2.1	3.2	3.1
523	549	336	1	0	1	1	0	1	0.0	0.3	0.0
326	549	523	147	10	157	149	14	163	0.1	1.3	0.5
326	549	336	56	17	73	59	17	76	0.4	0.1	0.3
336	549	523	2	0	2	2	0	2	0.0	0.3	0.0
336	549	326	22	6	28	24	8	32	0.4	0.8	0.8
331	326	325	9	0	9	0	0	0	4.2	0.0	4.2
331	326	549	166	16	182	171	21	192	0.4	1.1	0.7
325	326	331	5	0	5	0	0	0	3.2	0.0	3.2
325	326	549	43	10	53	36	10	46	1.0	0.1	0.9
549	326	331	83	22	105	78	22	100	0.6	0.1	0.5
549	326	325	18	3	21	17	1	18	0.2	1.7	0.7
228	329	327	49	0	49	94	6	100	5.3	3.4	5.9
228	329	328	192	34	226	171	21	192	1.6	2.4	2.3
327	329	228	34	9	43	69	14	82	4.8	1.4	5.0
327	329	328	3	0	3	0	0	0	2.4	0.0	2.4
328	329	228	74	0	74	77	22	99	0.4	6.6	2.7
328	329	327	0	0	0	0	0	0	0.0	0.0	0.0
227	228	550	14	0	14	0	0	0	5.3	0.0	5.3
227	228	329	262	26	288	263	26	289	0.1	0.0	0.1
227	228	330	3	0	3	0	0	0	2.4	0.0	2.4
550	228	227	11	0	11	0	0	0	4.7	0.0	4.7
550	228	329	8	3	11	0	0	0	4.0	2.4	4.7
550	228	330	6	0	6	0	0	0	3.5	0.0	3.5
329	228	227	138	37	175	138	35	173	0.0	0.3	0.1
329	228	550	1	0	1	0	0	0	1.4	0.0	1.4
329	228	330	8	2	10	8	0	8	0.0	1.4	0.5
330	228	227	4	0	4	0	0	0	2.8	0.0	2.8
330	228	550	3	0	3	0	0	0	2.4	0.0	2.4
330	228	329	10	2	12	2	1	3	3.3	1.3	3.5
552	224	0	170	5	175	105	5	110	5.5	0.1	5.4
224	552	0	107	12	119	68	12	80	4.2	0.1	3.9
38383	226	0	676	122	798	709	119	828	1.3	0.3	1.0
225	38381	0	281	111	392	289	117	406	0.5	0.6	0.7
228	227	0	161	35	196	138	35	173	1.9	0.1	1.7
227	228	0	292	30	322	263	26	289	1.7	0.7	1.9
703	222	0	219	97	316	221	100	321	0.1	0.3	0.3
223	703	0	546	106	652	553	103	656	0.3	0.3	0.2
422	231	466	9	0	9	22	0	22	3.3	0.4	3.3
422	231	701	2	0	2	2	1	3	0.0	1.0	0.3
422	231	220	3	0	3	3	8	11	0.0	3.9	2.9
466	231	422	8	2	10	8	2	10	0.0	0.1	0.0
466	231	701	23	4	27	0	4	4	6.8	0.1	5.8
466	231	220	227	26	253	208	26	234	1.3	0.0	1.2
701	231	422	10	2	12	8	0	8	0.7	1.4	1.1
701	231	466	25	0	25	0	0	0	7.1	0.2	7.1
701	231	220	16	3	19	0	0	0	5.7	2.4	6.1
220	231	422	5	0	5	5	2	7	0.0	2.0	0.8
220	231	466	107	14	121	110	14	125	0.3	0.2	0.4
220	231	701	5	6	11	0	0	0	3.2	3.4	4.6
442	214	0	13	2	15	30	3	34	3.7	1.0	3.8
214	442	0	137	21	158	136	24	160	0.1	0.6	0.1
217	214	0	742	121	863	764	137	901	0.8	1.4	1.3
214	217	0	317	113	430	336	116	452	1.1	0.3	1.1
801	213	0	40	16	56	40	14	54	0.0	0.7	0.3
213	801	0	32	2	34	32	1	33	0.0	0.6	0.1
554	213	0	321	113	434	348	115	464	1.5	0.2	1.4
213	554	0	630	116	746	679	128	807	1.9	1.1	2.2
214	217	0	340	119	459	336	116	452	0.2	0.3	0.3
217	214	0	752	138	890	764	137	901	0.4	0.1	0.4
220	218	0	205	34	239	211	34	245	0.4	0.0	0.4
218	220	0	116	16	132	115	16	132	0.1	0.0	0.1
703	219	0	543	101	644	553	103	656	0.4	0.2	0.5
221	703	0	223	100	323	221	100	321	0.1	0.0	0.1
448	211	0	39	2	41	39	2	41	0.0	0.1	0.0
211	448	0	78	2	80	78	2	80	0.1	0.1	0.1
554	211	0	672	128	800	679	128	807	0.3	0.0	0.2
211	554	0	348	115	463	348	115	464	0.0	0.0	0.0
444	210	0	87	15	102	87	15	102	0.0	0.1	0.0
210	444	0	184	17	201	185	17	201	0.0	0.1	0.0
446	210	0	374	113	487	374	113	487	0.0	0.0	0.0
210	446	0	562	124	686	567	124	691	0.2	0.0	0.2
444	454	801	37	0	37	0	0	0	8.6	0.0	8.6
444	454	450	66	0	66	66	4	70	0.0	2.9	0.5
444	454	452	98	10	108	98	10	108	0.0	0.2	0.1

Saturn Lookup			Count			Model			GEH		
A Node	B Node	C Node	LV	HV	Total	LV	HV	Total	LV	HV	Total
801	454	444	2	0	2	0	0	0	2.0	0.0	2.0
801	454	450	0	0	0	1	0	1	1.1	0.0	1.1
801	454	452	37	3	40	2	0	2	8.1	2.4	8.4
450	454	444	32	5	37	37	5	42	0.9	0.1	0.8
450	454	801	8	3	11	8	0	8	0.0	2.4	0.9
450	454	452	8	0	8	8	0	8	0.0	0.0	0.0
452	454	444	36	2	38	36	2	38	0.0	0.1	0.0
452	454	801	12	0	12	10	0	10	0.6	0.0	0.6
452	454	450	6	0	6	6	0	6	0.0	0.0	0.0
38386	550	551	5	0	5	0	0	0	3.2	0.0	3.2
38386	550	229	205	25	230	223	26	248	1.2	0.1	1.2
38386	550	228	2	5	7	0	0	0	2.0	3.1	3.7
551	550	38386	6	0	6	0	0	0	3.5	0.0	3.5
551	550	229	0	0	0	0	0	0	0.0	0.0	0.0
551	550	228	8	3	11	0	0	0	4.0	2.4	4.7
229	550	38386	126	64	190	145	64	209	1.6	0.0	1.4
229	550	551	2	0	2	0	0	0	2.0	0.0	2.0
229	550	228	1	0	1	0	0	0	1.4	0.0	1.4
228	550	38386	0	2	2	0	0	0	0.0	1.9	1.9
228	550	551	2	0	2	0	0	0	2.0	0.0	2.0
228	550	229	0	0	0	0	0	0	0.0	0.0	0.0
38376	38374	0	236	27	263	221	28	249	1.0	0.2	0.9
38377	38378	0	560	178	738	575	178	753	0.6	0.0	0.6
705	38382	0	843	113	956	851	113	964	0.3	0.1	0.3
550	38386	0	150	65	215	145	64	209	0.4	0.1	0.4
38386	550	0	252	28	280	223	26	248	1.9	0.5	1.9
225	38381	0	289	112	401	289	117	406	0.0	0.5	0.3
38383	226	0	706	111	817	709	119	828	0.1	0.7	0.4
302	312	0	56	5	61	56	5	61	0.0	0.1	0.0
312	302	0	66	15	81	66	15	81	0.0	0.1	0.0
702	312	0	472	115	587	472	86	558	0.0	2.8	1.2
312	702	0	321	104	425	295	76	372	1.5	2.9	2.7
314	313	0	96	23	119	96	23	119	0.0	0.0	0.0
313	314	0	120	42	162	120	42	162	0.0	0.1	0.0
315	313	0	330	105	435	330	105	435	0.0	0.0	0.0
313	315	0	447	86	533	472	86	558	1.2	0.0	1.1

IP Calibration

Saturn Lookup			Count			Model			GEH		
A Node	B Node	C Node	LV	HV	Total	LV	HV	Total	LV	HV	Total
38454	38384	0	97	15	112	98	13	111	0.1	0.5	0.1
38384	38454	0	105	16	121	105	16	121	0.0	0.0	0.0
38375	38439	0	253	166	419	250	130	380	0.2	2.9	1.9
38377	38378	0	368	234	601	362	231	594	0.3	0.2	0.3
38376	38374	0	121	64	185	123	80	203	0.2	1.9	1.3
38440	38385	0	115	82	196	116	69	185	0.1	1.4	0.8
38385	38440	0	101	85	186	98	88	186	0.2	0.3	0.1
38407	38409	0	122	79	201	121	80	201	0.0	0.1	0.0
38409	38407	0	110	83	193	109	86	195	0.1	0.3	0.2
464	36271	0	209	23	231	209	23	232	0.0	0.0	0.0
36271	464	0	187	19	206	187	26	212	0.0	1.5	0.5
38385	38440	0	100	89	189	98	88	186	0.2	0.2	0.2
38440	38385	0	116	83	199	116	69	185	0.0	1.6	1.0
466	38406	0	190	46	236	190	43	233	0.0	0.4	0.2
38406	466	0	207	53	260	207	53	260	0.0	0.0	0.0
232	38408	0	119	33	152	119	32	151	0.0	0.2	0.0
38408	232	0	124	26	149	124	26	150	0.0	0.1	0.0
38276	38410	0	95	53	148	93	54	147	0.1	0.1	0.1
38410	38276	0	79	67	146	80	64	144	0.1	0.3	0.1
31161	38178	0	104	7	111	90	4	94	1.4	1.1	1.7
38178	31161	0	102	6	108	86	6	92	1.7	0.0	1.7
38409	38407	0	110	85	194	109	86	195	0.1	0.2	0.1
38407	38409	0	122	80	201	121	80	201	0.0	0.0	0.0
233	38274	0	142	56	197	152	57	209	0.9	0.2	0.8
38274	233	0	137	73	210	137	73	211	0.0	0.0	0.0
460	38275	0	73	9	82	63	9	72	1.3	0.0	1.2
38275	460	0	64	3	68	64	3	67	0.0	0.2	0.1
38410	38276	0	80	66	145	80	64	144	0.0	0.2	0.1
38276	38410	0	93	54	147	93	54	147	0.0	0.0	0.0
243	241	239	37	6	43	37	20	57	0.0	4.1	2.1
243	241	424	11	4	15	11	1	12	0.1	1.9	0.7
239	241	243	36	3	39	36	3	39	0.0	0.2	0.1
239	241	424	79	22	101	90	24	114	1.1	0.5	1.3
424	241	243	4	2	6	4	0	4	0.1	1.7	0.9
424	241	239	22	17	38	84	19	103	8.6	0.5	7.6
251	253	252	30	1	31	30	3	33	0.1	1.2	0.4
251	253	438	19	3	22	19	5	24	0.0	1.0	0.4
251	253	431	18	2	19	18	2	20	0.1	0.0	0.1
252	253	251	29	0	29	29	23	52	0.0	6.7	3.6
252	253	438	33	10	43	33	0	33	0.0	4.2	1.5
252	253	431	55	4	59	55	4	59	0.0	0.2	0.1
438	253	251	18	3	20	18	3	21	0.1	0.2	0.1
438	253	252	35	1	36	35	1	36	0.0	0.1	0.1
438	253	431	7	0	7	7	0	7	0.2	0.9	0.0
431	253	251	22	7	29	22	1	23	0.1	3.3	1.2
431	253	252	53	3	56	53	7	60	0.1	1.7	0.6
431	253	438	1	0	1	1	0	1	0.2	0.1	0.2
431	255	260	30	5	35	30	5	35	0.1	0.1	0.0
431	255	258	10	1	12	10	0	10	0.1	1.5	0.5
260	255	431	34	0	34	34	7	41	0.0	3.8	1.1
260	255	258	6	0	6	6	0	6	0.2	0.7	0.3
258	255	431	7	0	7	7	0	7	0.1	0.0	0.1
258	255	260	3	1	4	3	1	4	0.0	0.2	0.1
262	547	261	6	1	7	6	1	7	0.1	0.2	0.0
262	547	206	32	2	34	32	6	38	0.0	2.0	0.7
262	547	546	6	1	7	6	0	6	0.1	1.5	0.6
261	547	262	6	1	7	6	1	7	0.0	0.4	0.1
261	547	206	5	2	6	1	0	1	2.2	1.8	2.8
261	547	546	5.75	0	6	6	0	6	0.1	0.7	0.2
206	547	262	31.25	6	37	31	6	37	0.1	0.0	0.0
206	547	261	3.25	1	5	1	0	1	1.8	1.7	2.4
206	547	546	3.5	0	4	4	0	4	0.3	1.0	0.0
546	547	262	5.75	2	7	6	0	6	0.1	1.8	0.6
546	547	261	4.25	2	6	4	0	4	0.1	2.1	1.1
546	547	206	5	0	5	5	0	5	0.0	1.0	0.2
209	208	446	7.75	2	9	7	0	7	0.3	1.8	0.9
209	208	207	37.75	1	39	38	5	43	0.0	2.4	0.7
446	208	209	3.25	0	3	3	0	3	0.1	0.0	0.1
446	208	207	268.5	132	401	269	137	406	0.0	0.5	0.3
207	208	209	37.5	0	38	38	7	45	0.1	3.8	1.2
207	208	446	273	118	391	271	117	388	0.1	0.2	0.2
474	203	469	56	9	65	56	9	65	0.0	0.0	0.0
474	203	200	99	7	106	99	7	106	0.1	0.1	0.1
469	203	474	47	5	52	47	5	52	0.1	0.1	0.0
469	203	200	303	130	433	304	141	445	0.1	1.0	0.6
200	203	474	100	6	106	103	2	105	0.3	1.8	0.0
200	203	469	296	123	419	295	110	404	0.1	1.2	0.7
478	202	0	273	90	363	273	90	362	0.0	0.0	0.0

Saturn Lookup			Count			Model			GEH		
A Node	B Node	C Node	LV	HV	Total	LV	HV	Total	LV	HV	Total
202	478	0	262	124	386	262	119	381	0.0	0.4	0.3
203	200	0	406	153	559	403	148	551	0.1	0.4	0.3
200	203	0	400	112	512	397	112	510	0.1	0.0	0.1
480	201	0	183	23	205	183	23	206	0.0	0.1	0.0
201	480	0	199	30	230	199	30	229	0.0	0.1	0.1
545	544	482	5	0	5	5	0	5	0.2	0.4	0.3
545	544	307	15	3	17	15	3	18	0.1	0.2	0.1
482	544	545	8	1	9	8	1	9	0.2	0.4	0.0
482	544	307	246	122	368	246	126	372	0.0	0.3	0.2
307	544	545	7	2	9	7	2	9	0.0	0.2	0.1
307	544	482	234	87	321	233	87	320	0.1	0.1	0.0
414	415	499	21	3	24	21	3	24	0.0	0.1	0.0
414	415	364	61	27	88	61	27	88	0.0	0.0	0.0
414	415	416	18	8	26	18	8	26	0.1	0.1	0.0
499	415	414	14	3	17	14	3	17	0.1	0.1	0.0
499	415	364	110	10	119	110	12	122	0.0	0.6	0.2
499	415	416	31	3	33	31	5	36	0.1	1.0	0.4
364	415	414	53	22	75	53	22	75	0.0	0.0	0.1
364	415	499	0	0	0	125	10	135	15.8	4.5	16.4
364	415	416	32	0	32	0	0	0	8.0	1.0	8.0
416	415	414	26	7	33	27	10	37	0.1	1.0	0.6
416	415	499	71	7	78	83	7	90	1.4	0.1	1.3
416	415	364	61	4	65	0	0	0	11.0	2.8	11.4
416	364	415	12	1	13	0	0	0	4.8	1.5	5.1
416	364	495	25	4	29	26	4	30	0.1	0.1	0.1
416	364	501	20	2	22	24	2	26	0.9	0.1	0.9
415	364	416	18	2	20	0	0	0	6.0	2.0	6.3
415	364	495	101	15	116	68	15	83	3.6	0.0	3.3
415	364	501	113	24	137	103	24	127	0.9	0.1	0.9
495	364	416	59	7	66	59	8	67	0.1	0.3	0.2
495	364	415	78	14	91	78	14	92	0.1	0.1	0.1
495	364	501	53	5	58	53	5	58	0.1	0.1	0.0
501	364	416	51	7	57	51	7	58	0.1	0.1	0.1
501	364	415	100	18	119	100	18	118	0.0	0.1	0.1
501	364	495	48	3	51	48	3	51	0.1	0.2	0.0
505	413	0	37	4	40	37	4	41	0.0	0.2	0.1
413	505	0	39	5	44	39	5	44	0.0	0.0	0.0
415	416	0	81	15	96	49	13	62	4.0	0.5	3.8
416	415	0	151	19	170	110	17	127	3.6	0.4	3.5
364	416	0	118	15	133	110	15	125	0.7	0.1	0.7
416	364	0	50	6	56	50	6	56	0.1	0.1	0.0
397	413	0	124	19	143	124	19	143	0.0	0.0	0.0
413	397	0	120	23	143	121	23	144	0.1	0.1	0.1
367	359	452	25	2	26	25	1	26	0.1	1.1	0.1
367	359	347	29	3	33	38	6	44	1.5	1.1	1.8
367	359	361	0	0	0	0	0	0	0.0	0.0	0.0
452	359	367	21	1	22	21	1	22	0.1	0.9	0.1
452	359	347	12	1	13	12	1	13	0.1	0.1	0.1
452	359	361	0	0	0	0	0	0	0.0	0.0	0.0
347	359	367	17	4	21	35	8	43	3.5	1.7	3.9
347	359	452	16	2	17	17	0	17	0.4	1.6	0.0
347	359	361	0	0	0	0	0	0	0.0	0.0	0.0
361	359	367	0	0	0	0	0	0	0.0	0.0	0.0
361	359	452	0	0	0	5	0	5	3.2	0.0	3.2
361	359	347	0	0	0	0	0	0	0.0	0.0	0.0
359	347	344	0	1	1	0	0	0	0.7	1.2	1.4
359	347	533	50	8	58	50	7	57	0.0	0.5	0.2
359	347	358	0	0	0	0	0	0	0.5	0.0	0.5
344	347	359	1	0	1	0	0	0	1.0	0.0	1.0
344	347	533	1	0	1	0	0	0	1.4	0.0	1.4
344	347	358	1	0	1	0	0	0	1.0	0.0	1.0
533	347	359	52	10	61	52	8	60	0.0	0.7	0.2
533	347	344	2	0	2	0	0	0	1.7	0.0	1.7
533	347	358	54	13	67	54	13	67	0.0	0.1	0.0
358	347	359	0	0	1	0	0	0	0.4	1.0	1.0
358	347	344	1	0	1	0	0	0	1.4	0.0	1.4
358	347	533	61	14	75	61	14	75	0.0	0.0	0.0
533	349	346	45	7	52	45	7	52	0.0	0.1	0.0
533	349	348	62	18	80	62	18	80	0.1	0.0	0.1
533	349	350	25	2	26	25	1	26	0.1	0.2	0.0
346	349	533	27	4	31	27	4	31	0.0	0.1	0.0
346	349	348	67	9	76	0	0	0	11.6	4.1	12.3
346	349	350	31	4	35	31	7	38	0.0	1.3	0.5
348	349	533	66	21	87	66	21	87	0.0	0.1	0.0
348	349	346	67	3	70	67	3	70	0.0	0.1	0.0
348	349	350	7	4	11	7	3	10	0.1	0.5	0.3
350	349	533	36	4	40	36	1	37	0.0	1.9	0.5
350	349	346	52	6	58	52	6	58	0.0	0.1	0.0
350	349	348	30	5	35	30	3	33	0.1	1.1	0.3
523	332	339	3	1	4	0	0	0	2.2	1.5	2.7

Saturn Lookup			Count			Model			GEH		
A Node	B Node	C Node	LV	HV	Total	LV	HV	Total	LV	HV	Total
523	332	343	42	11	53	42	11	53	0.0	0.1	0.0
339	332	523	3	1	4	0	0	0	2.4	1.2	2.7
339	332	343	10	2	12	10	0	10	0.0	1.8	0.6
343	332	523	47	13	60	47	13	60	0.0	0.0	0.1
343	332	339	12	0	13	12	0	12	0.1	0.9	0.2
523	549	326	39	3	41	44	13	57	0.8	3.7	2.2
523	549	336	1	0	1	1	0	1	0.2	0.3	0.2
326	549	523	30	6	35	37	11	48	1.3	1.8	2.0
326	549	336	26	18	44	27	18	45	0.3	0.1	0.2
336	549	523	0	0	0	3	0	3	2.1	0.3	2.1
336	549	326	25	22	47	25	16	42	0.1	1.4	0.8
331	326	325	4	0	4	0	0	0	2.7	0.0	2.7
331	326	549	52	23	75	52	23	75	0.0	0.0	0.0
325	326	331	3	0	3	0	0	0	2.5	0.0	2.5
325	326	549	12	6	19	12	6	18	0.1	0.1	0.2
549	326	331	58	31	88	58	26	84	0.0	0.8	0.4
549	326	325	12	3	15	11	3	14	0.1	0.1	0.1
228	329	327	19	10	28	50	13	63	5.3	1.1	5.1
228	329	328	55	14	69	52	23	75	0.4	2.0	0.7
327	329	228	21	4	25	49	11	60	4.8	2.5	5.4
327	329	328	1	1	2	0	0	0	1.0	1.5	1.8
328	329	228	59	13	72	58	26	84	0.1	3.0	1.4
328	329	327	1	0	1	0	0	0	1.6	0.0	1.6
227	228	550	7	0	7	0	0	0	3.6	1.0	3.7
227	228	329	93	22	115	99	36	135	0.6	2.6	1.8
227	228	330	1	5	6	0	5	5	1.6	0.0	0.6
550	228	227	7	0	8	0	0	0	3.8	1.0	3.9
550	228	329	2	1	3	0	0	0	2.0	1.7	2.6
550	228	330	2	0	2	0	0	0	1.7	0.0	1.7
329	228	227	99	35	134	103	36	139	0.3	0.3	0.4
329	228	550	1	0	1	0	0	0	1.6	0.0	1.6
329	228	330	8	2	10	4	1	5	1.5	1.1	1.8
330	228	227	7	4	11	0	4	4	3.8	0.1	2.6
330	228	550	2	0	2	0	0	0	1.9	0.1	1.9
330	228	329	10	1	11	3	0	3	2.8	1.4	3.1
552	224	0	82	14	96	64	11	75	2.1	1.0	2.3
224	552	0	80	10	90	57	9	66	2.8	0.1	2.7
38383	226	0	210	157	366	213	157	370	0.2	0.0	0.2
225	38381	0	221	140	362	228	142	370	0.4	0.1	0.4
228	227	0	118	45	162	103	40	143	1.4	0.7	1.6
227	228	0	115	49	163	99	41	140	1.5	1.1	1.9
703	222	0	184	111	295	182	111	293	0.1	0.0	0.1
223	703	0	178	128	306	178	127	305	0.1	0.1	0.0
422	231	466	10	1	11	10	1	11	0.1	0.1	0.1
422	231	701	3	0	3	3	0	3	0.0	0.7	0.2
422	231	220	3	0	3	2	2	4	0.5	1.9	0.6
466	231	422	10	0	10	10	1	11	0.0	1.2	0.2
466	231	701	21	1	22	0	1	1	6.5	0.1	6.2
466	231	220	106	28	134	94	28	122	1.2	0.0	1.0
701	231	422	4	1	4	4	1	5	0.3	0.1	0.3
701	231	466	18	3	21	0	0	0	6.0	2.6	6.5
701	231	220	7	2	9	0	0	0	3.7	2.1	4.2
220	231	422	3	0	3	2	3	5	0.7	2.0	0.8
220	231	466	84	21	104	72	21	93	1.3	0.1	1.1
220	231	701	4	2	6	0	0	0	2.9	1.8	3.4
442	214	0	27	8	34	27	7	34	0.0	0.3	0.1
214	442	0	28	5	33	28	5	33	0.0	0.1	0.0
217	214	0	247	134	381	275	156	431	1.7	1.8	2.5
214	217	0	240	128	368	256	136	392	1.0	0.7	1.2
801	213	0	17	6	23	17	2	19	0.1	2.3	0.9
213	801	0	16	9	24	16	9	25	0.1	0.0	0.1
554	213	0	240	131	371	268	138	405	1.7	0.6	1.8
213	554	0	247	137	384	286	153	439	2.4	1.3	2.7
214	217	0	255	137	392	256	136	392	0.0	0.1	0.0
217	214	0	265	157	422	275	156	431	0.6	0.0	0.4
220	218	0	96	34	130	96	30	126	0.0	0.8	0.4
218	220	0	74	28	102	74	24	98	0.0	0.7	0.4
703	219	0	173	127	300	178	127	305	0.4	0.0	0.3
221	703	0	184	111	295	182	111	293	0.1	0.0	0.1
448	211	0	35	1	36	35	1	36	0.1	0.2	0.1
211	448	0	54	3	57	54	3	57	0.0	0.2	0.0
554	211	0	286	148	433	286	153	439	0.0	0.4	0.3
211	554	0	269	139	408	268	138	405	0.1	0.1	0.1
444	210	0	66	21	87	66	8	74	0.0	3.3	1.4
210	444	0	64	19	82	64	11	75	0.1	1.9	0.8
446	210	0	264	133	396	263	131	394	0.1	0.1	0.1
210	446	0	264	142	406	264	142	406	0.0	0.0	0.0
444	454	801	16	0	16	0	0	0	5.7	0.0	5.7
444	454	450	25	4	29	25	4	29	0.1	0.0	0.1
444	454	452	35	2	36	35	5	40	0.1	2.0	0.7

Saturn Lookup			Count			Model			GEH		
A Node	B Node	C Node	LV	HV	Total	LV	HV	Total	LV	HV	Total
801	454	444	2	0	2	0	0	0	1.9	0.0	1.9
801	454	450	1	2	2	1	0	1	0.3	1.8	1.1
801	454	452	16	0	16	2	0	2	4.8	0.0	4.8
450	454	444	20	2	21	22	2	24	0.6	0.2	0.6
450	454	801	4	1	5	4	0	4	0.3	1.5	0.3
450	454	452	7	0	7	7	0	7	0.1	0.0	0.1
452	454	444	30	2	32	30	2	32	0.0	0.1	0.0
452	454	801	13	1	14	4	0	4	3.1	1.6	3.4
452	454	450	7	0	7	7	0	7	0.1	0.0	0.1
38386	550	551	2	1	4	0	0	0	2.1	1.7	2.7
38386	550	229	93	60	153	96	63	159	0.4	0.4	0.5
38386	550	228	2	0	2	0	0	0	1.9	0.0	1.9
551	550	38386	2	1	3	0	0	0	2.0	1.7	2.6
551	550	229	0	0	0	0	0	0	0.7	0.0	0.7
551	550	228	3	0	3	0	0	0	2.3	0.0	2.3
229	550	38386	96	67	163	97	74	171	0.1	0.9	0.6
229	550	551	1	0	1	0	0	0	1.4	0.0	1.4
229	550	228	2	0	2	0	0	0	1.7	0.0	1.7
228	550	38386	3	1	4	0	0	0	2.2	1.5	2.7
228	550	551	5	0	5	0	0	0	3.0	0.0	3.0
228	550	229	2	1	2	0	0	0	1.7	1.2	2.1
38376	38374	0	123	62	185	123	80	203	0.0	2.1	1.3
38377	38378	0	362	231	593	362	231	594	0.0	0.0	0.0
705	38382	0	224	174	398	224	155	379	0.0	1.5	0.9
550	38386	0	111	74	185	97	74	171	1.4	0.0	1.1
38386	550	0	111	63	174	96	63	159	1.4	0.0	1.2
225	38381	0	228	141	369	228	142	370	0.0	0.0	0.0
38383	226	0	213	157	370	213	157	370	0.0	0.0	0.0
302	312	0	36	6	42	43	6	49	1.0	0.0	1.0
312	302	0	35	5	40	40	36	77	0.9	6.8	4.8
702	312	0	217	132	349	217	123	340	0.0	0.8	0.5
312	702	0	232	117	349	232	83	315	0.0	3.4	1.9
314	313	0	64	33	97	64	33	97	0.0	0.1	0.0
313	314	0	70	41	112	70	35	105	0.0	1.1	0.7
315	313	0	228	111	339	238	111	349	0.6	0.0	0.5
313	315	0	208	119	327	219	119	338	0.7	0.0	0.6