Tendring Local Plan Modelling Stage 2

Essex County Council

Demand Update and Results

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Technical Note

1 September 2016

Tendring Local Plan Modelling Stage 2

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Executive Summary

In March 2015, Tendring District Council (TDC) asked Essex County council (ECC) for modelling support in response to their local plan proposals. ECC in turn requested Jacobs through Essex Highways to carry out this work, for which a report was submitted in December 2015.

Following submission of that report, ECC have subsequently requested that Jacobs produce revised modelling for TDC's preferred development scenario.

The objectives of this study are the updating of the demand data and of the junction models according to the revised residential and employment developments contained within the preferred scenario, the assessment of the junction traffic flows and the qualitative assessment of achievability of demand reduction.

The forecast traffic flows resulting from the development proposals were calculated using trip generation data from TRICS and using Census journey to work data for the trip distribution. For the background growth, count data factored up using adjusted TEMPro factors was used. LinSig and Arcady/Picady software were used in order to build the junction models by taking the junction geometries and checking high definition aerial images. The forecasted traffic flows were also added to the junction models and an assessment of the junction performance was made.

The results of junction modelling suggested that a number of junctions would be adversely affected due to the emerging of the proposed residential and employment developments. Specifically for this study 10 key junctions have been identified where mitigation measures have been evaluated against projected future junction demand. The mitigation measures that were assumed have improved the traffic situation in all the tested junctions, however not all of them have been improved to the extent that all arms perform within acceptable levels of service. For those junctions whose performance was in excess of capacity even after the proposed mitigation measures, further measures have been suggested.

1. Introduction

1.1 Introduction

In March 2015, Tendring District Council (TDC) asked Essex County Council (ECC) for traffic modelling support in relation to their Local Plan Proposals. ECC in turn requested Jacobs through Essex Highways to carry out this work. A report was submitted in December 2015.

Following the submission of the report, ECC have subsequently requested from Jacobs to produce modelling results for the preferred development scenario.

This technical note summarises the updates undertaken to the traffic model and the results from subsequent model runs. Specifically, it identifies the developments included in the preferred scenario, presents the results of the junction modelling, and assesses the achievability of the required demand reductions at the problematic junctions.

The note reports only on the results of the preferred development scenario.

1.2 Objectives

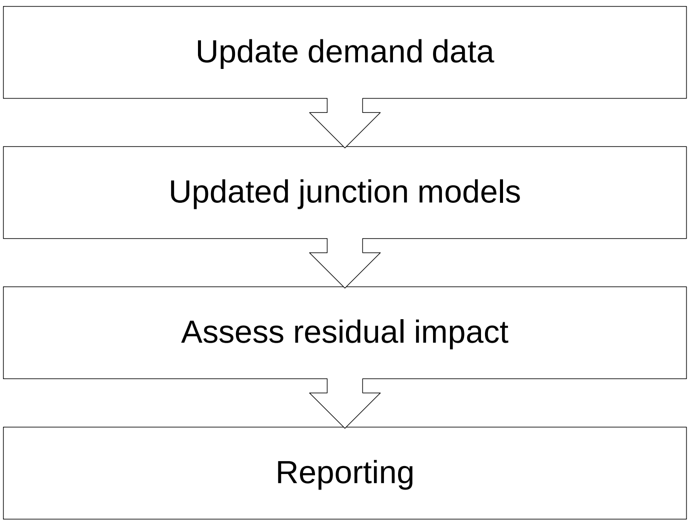
The objectives of the project are:

- the revision of the future year development assumptions;
- the re-running of the junction models for the preferred scenario;
- the identification of any residual impacts following the junction mitigation measures and the quantification of the amount of demand reduction that would be required in order to bring the junction to an acceptable state; and
- a qualitative assessment of the achievability of the demand reductions.

1.3 Methodology

In order to meet the objectives, the study is divided into 4 stages as shown in Figure 1.

Figure 1: Stage Division



For the calculation of the future traffic volumes through key junctions in Tendring, in the absence of an existing traffic assignment model, a two stage approach was applied. Initially, the peak hour traffic volumes currently using the junctions was ascertained from a number of manual classified turning count surveys. Background growth (i.e. growth in traffic due to factors other than the specific modelled developments was applied to the count data using TEMPro forecasts. After that, trips generated by the developments were calculated and added to the turning flows. During the collection of the turning count surveys a road traffic accident caused the closure of the A133, affecting a limited number of surveyed junctions in the vicinity of the A133 between Weeley and Clacton. For these junctions, only the AM peak traffic counts were used, which was sufficient to demonstrate a future impact at those junctions. The absence of PM peak traffic data was therefore not a constraint.

To calculate the additional traffic resulted due the new developments, TRICS trip rates were applied to each development. An appropriate trip distribution was the applied to the generated trips. The distribution identified the origin and destination locations for the trips generated by the development. On the basis of the trip origin and destination, an assessment of the most likely route taken through Tendring by that trip was made. The combined movement of all the development trips through the district thereby allowed identification of the turning movements through the assessed junctions.

The process is detailed in the following sections.

2. Preferred Scenario

The Preferred Scenario was specified by TDC and it is a variation of the three scenarios previously tested. The full schedule suggests that this scenario will be fulfilled by the end of the year 2032. It comprises of 10 residential developments, ranging from 100 to 2,500 dwellings, and 11 employment sites located within Tendring District. The focus of this study has been on larger sites and so smaller developments sites have not been modelled explicitly but are included within the background growth figures.

The 2,500 dwelling development at Colchester Fringe 1 has also been assessed as part of a similar study for Colchester, albeit with a different methodology. Only 1,250 of the 2,500 dwellings here are within Tendring but the full 2,500 has been tested for the preferred scenario in order to ascertain the impact of the whole development.

A description of the residential and employment sites for the preferred scenario is given in Table 1 and Table 2. The locations of these developments within Tendring are shown in Figure 2.

Table 1: Preferred Scenario – Residential Sites

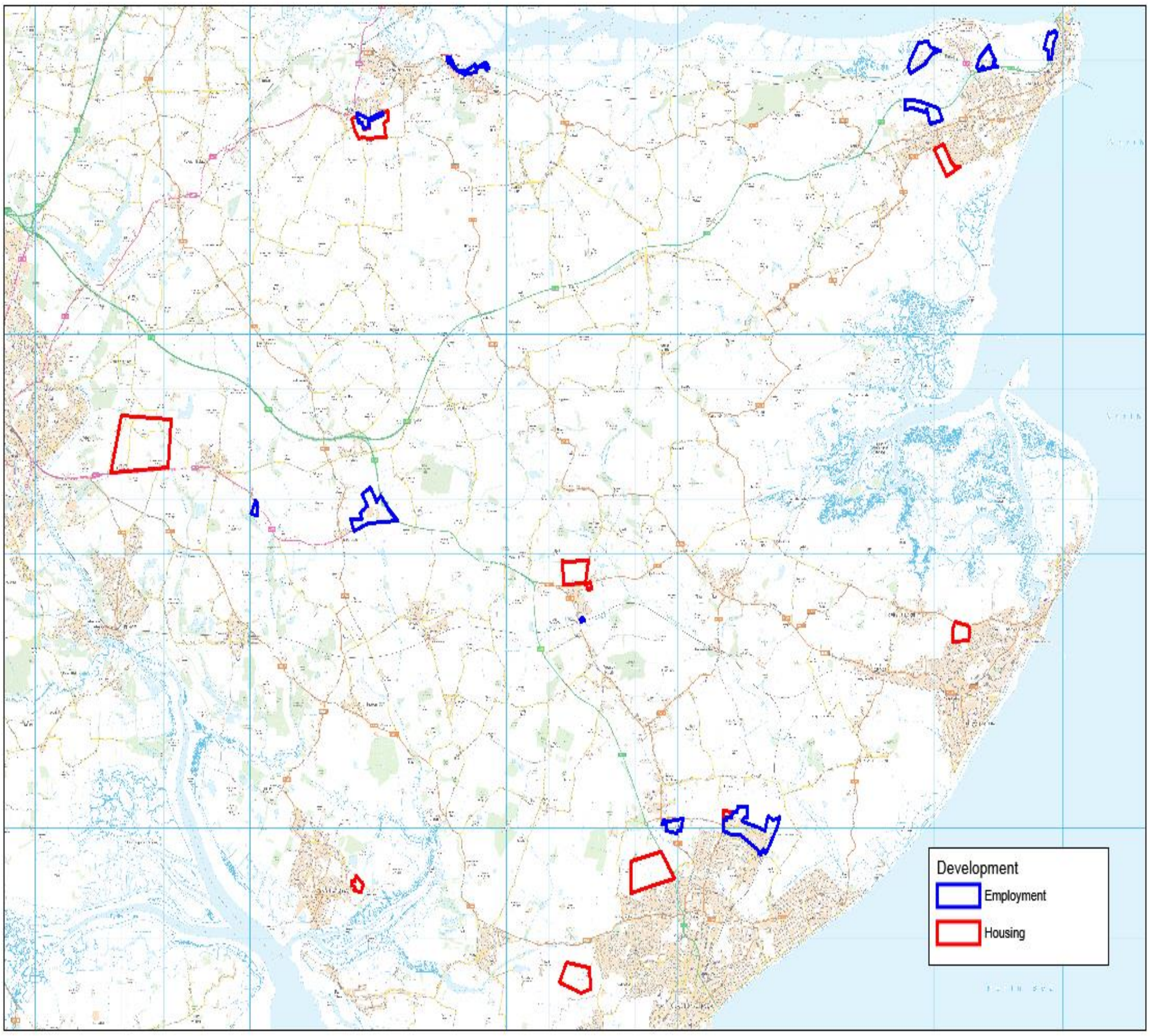
Number	Site	Purpose	Development Scale/Type
1	Rouses Farm, Clacton	Residential	800 dwellings, a primary school and medical/community facilities
2	Oakwood Park, Clacton	Residential	750 dwellings, a primary school and medical/community facilities
3	Hartley Meadows 1, Clacton	Residential	800 dwellings + primary school + medical/community facilities to be delivered following construction of a link road
4	Low Road, Harwich	Residential	315 dwellings
5	Turpins Farm, Frinton	Residential	250 dwellings
6	Bromley Road/Long Road, Lawford	Residential	360 dwellings
7	Robinson Road, Brightlingsea	Residential	100 dwellings
8	Colchester Fringe 1	Residential	1,250 dwellings within Tendring, 2,500 in total.
9	Tendring Park Services, Weeley	Residential	800 dwellings + primary school + community/medical facilities
10	Land south and north of Weeley Council offices	Residential	587 dwellings

This table reflects the latest development scenario provided by TDC at the time that the work was done, although it is understood that a number of changes have been forthcoming since then. This includes an additional development at Landamere Road,of 100 residential units. Given the low trip generation that would be associated with such a development, the additional inclusion of Landamere Road in the local plan scenario is not considered to represent a significant increase on the existing assumptions and therefore the conclusions in this report are also consistent with a scenario which includes that development. In addition to the above, development of 320 residential developments at Brantham has been included. This development is outside of Tendring district but nonetheless has been included as the trip generation from the development may have an impact on junctions within Tendring.

Table 2: Preferred Scenario – Employment Sites

Number	Site	Purpose	Development Scale/Type
1	Pond Hall Farm, Harwich	Employment	6.3 ha (B2/B8)
2	Mercedes Site, Bathside Bay	Employment	7.4 ha (B1/B2/B8)
3	Carless Extension, Harwich	Employment	2.41 ha (B1/B2/B8)
4	Mistley Port Expansion	Employment	3.1 ha (B1/B2/B8)
5	Oakwood Extension (Dalau Site)	Employment	2.43 ha (B1/B2/B8)
6	Hartley Gardens, Clacton Gateway	Employment	7 ha (A1-Food/A3/D2)
7	Stanton Europark	Employment	3.3 ha (B2/B8)
8	Landswoodpark, Elmstead Market	Employment	4.34 ha (B1/B2/B8)
9	Weeley	Employment	10 ha (B1/B2/B8)
10	West Tendring	Employment	15 ha (B1/B2/B8)
11	Land South of Long Road, Mistley	Employment	2 ha (B1/B2/B8)

Figure 2: Preferred Scenario Map



The total planned development for the Preferred Scenario is shown in Table 3. For reference, the previously tested development scenarios are also included.

Table 3: Development Summary for All Scenarios

Scenario	Dwellings	A1/A3/A4/A5 m2	B1/B2/B8 m2	Other m2
Full Development	25,720	24,376	360,304	67,073
Scenario 1	9,720	0	182,106	55,040
Scenario 2	9,820	8,162	182,106	57,061
Scenario 3	10,020	0	232,106	55,040
Preferred Scenario	7,582	2,167	287,899	0

3. Background growth

The background growth refers to additional dwellings at smaller sites and windfall sites which are not included within the specific modelled developments. Alternatively, background growth refers to committed development anticipated to come forward separately from the emerging local plans.

In order to calculate the growth for the Preferred Scenario, TEMPro with NTEM version 6.2 data was used. The forecast year of the tested scenario is 2032. The growth assumptions are listed in Table 4.

Table 4: Background Growth Assumptions

Region	Number of expected dwellings
Clacton	430
Harwich	504
Frinton / Walton	117
Manningtree	230
Brightlingsea	100
Colchester Fringe	0
Village Developments	333
Small Windfall Sites across the district	1,000
Total	2,714

For the growth in jobs, TDC suggested an increase of 142 jobs a year in the district. Based on that and on the new assumptions and by applying the same process used for the calculating the old factors, the traffic growth factors are given in Table 5. This leads to a reduction in expected dwellings in the Preferred Scenario, which in turn results in smaller growth factors compared to the previous model runs.

Note that the inclusion of 100 dwelling in Brightlingsea is in addition to the residential site at Robinson Road listed in Table 1. There may therefore be the potential for double counting of this site, however, as it only accounts for less than 4% of the background growth in houses, the effect of the double counting is minimal and would not change the conclusions reached in this report.

Table 5 shows that the traffic factors for the Preferred Scenario follow the same trend as the factors from the previous scenarios; being that PM peak is slightly bigger than the AM one.

Table 5: Tendring Growth

	Previous Scenarios		Preferred Scenario	
Year	**AM peak**	**PM peak**	**AM peak**	**PM peak**
2032	1.23	1.25	1.21	1.23

This growth factor is applied to the base year count data, and the trip generation from developments listed in section 2 is then added on top.

4. Development Trips

4.1 Trip Generation

4.1.1 Trip Rates

For the calculation of the trip generation trip rates were applied to the development quanta. The trip rates in this case refer to the amount of trips generated per unit of land use. The rates were derived from TRICS 7.1.3 and they are expressed in terms of a given unit of land. For the residential developments, the unit is one dwelling, while for the employment developments the unit is typically 100m^2 of gross floor area (GFA) or one job. The employment trip rate differs depending on the type of the employment. The trip rates were extracted for all transport modes.

The rates extracted from TRICS for residential developments, expresses as number of person trips per dwelling are summarized in Table 6.

Table 6: Trip Rates Summary for Residential Developments

Residential	Cyclists	Vehicle Occupants	Pedestrians	Bus / Tram Passengers	Rail Passengers
AM peak Arrivals	0.002	0.213	0.046	0.002	0.001
AM peak Departures	0.017	0.599	0.186	0.018	0.022
PM peak Arrivals	0.011	0.497	0.088	0.013	0.009
PM peak Departures	0.006	0.312	0.055	0.004	0.001

For the employment land use types, Table 7 summarises the TRICS development category selected for each land use.

Table 7: Land Uses

Land Use Class	Categories
A1	Food Superstores / Non Food Retail
A3	Restaurant
A4	Pub – Restaurant
A5	Fast Food / Take Away / Drive Through Restaurant
B1	Office / Business Park
B2	Industrial Estate
B8	Warehousing
C1	Hotel
D2	Multiplex Cinema / Leisure Centre / Sports Centre

Trip rates were extracted on a ‘per job’ basis. Thus, it was essential to calculate the number of jobs at each of the employment developments.

TDC provided information on employment sites either in terms of GFA, in square metres, or total plot size, in hectares. In the latter case, plot size required converting to GFA before the number of jobs could be calculated. This was done by assuming a plot ratio (i.e. the ratio of plot size to GFA) of 0.5 based on a TDC document "Tendring Employment Land Review", October 2013[1]. Using this ratio, a 1 hectare plot is converted to 5,000sqm of GFA.

Then for all developments, the GFA was converted to jobs using employment densities taken from the Homes and Communities Agency's "Employment Densities Guide", 2nd edition, December 2010[2]. The employment densities taken from the report and used as part of this work are summarised in Table 8.

Table 8: Employment Densities

Categories	Use Class	Use Type	Area per FTE (m^2)
Industrial	B2	General	36
	B1(c)	Light Industry (Business Park)	47
Warehouse & Distribution	B8	General	70
	B8	Large Scale and High Bay Warehousing	80
Office	B1(a)	General Office	12
	B1(a)	Business Park	10
Retail	A1	Food Superstores	17
	A1	Other Superstores/ Retail Warehouses	90
	A3	Restaurants & Cafes	18
Leisure & Visitor Attractions	C1	Hotels	100
	D2	Cinemas	90

After applying the employment densities, the jobs totals by land use are presented in Table 9. The table demonstrates that for the Preferred Scenario 116 jobs for the A1/A3/A4/A5 and 10,842 jobs for the B1/B2/B8 use class are expected to be created. The trip rates used for employment sites are shown in Appendix A.

Table 9: Jobs per Use Class

Scenario	A1/A3/A4/A5	B1/B2/B8	Other	Total
Preferred Scenario	116	10,842	0	10,958

The trip rates described above were derived from the TRICS database without any filtering based on location. It is acknowledged however that Tendring District, which has relatively little public transport infrastructure is likely to have a mode share which differs from the average for the whole country.

1 http://www.tendringdc.gov.uk/sites/default/files/documents/planning/planning%20policy/Tendring%20Employment%20Land%20Review%202013.pdf

2 https://www.gov.uk/government/publications/employment-densities-guide

To ensure that the development trip generation is appropriate for the location of the development, an adjustment was made to make the trip rates and mode share more appropriate for Tendring. Journey to work data from Census 2011 was used to adjust the mode share from a national average to be Tendring specific. It should be noted that although the census data only covers commuting trips, it is considered that the relative difference in mode share between the national average and Tendring is consistent across all trip purposes.

To apply the adjustment, the observed mode share at a national and local (i.e. Tendring) level was extracted, and the difference between the two was applied to the mode share derived from TRICS data. An example of this is illustrated in Table 10 for the residential trip rate for AM peak departures.

Table 10: Mode Share Adjustment

Residential AM peak Departures	TRICS mode share	National Census	Tendring Census	Adjusted mode share
Vehicle Occupants	70.89%	68.05%	76.00%	74.31%
Cyclists	2.01%	2.88%	3.33%	2.19%
Pedestrians	22.01%	11.49%	11.80%	21.23%
Bus/Tram Passengers	2.49%	8.22%	2.46%	0.70%
Rail Passengers	2.60%	8.75%	5.65%	1.58%

As the table above demonstrates, census data showed that nationally, 68.05% of all trips were made in a private vehicle (either as a driver or passenger). Within Tendring, this mode share increases to 76%. From the TRICS trip rates, the mode share was 70.89%, which, when adjusted by the change observed from the census data, becomes 74.31%.

The same adjustment was applied for all other trip rates, and used to recalculate the trip generation of each development.

The TRICS rates were used to generate trips by vehicle occupants, and these were used to infer a mode share which was then adjusted based on Census journey to work data. To assess the highway impacts of development, vehicle trip generation is needed. Average vehicle occupancies were taken from the TAG data book to convert from vehicle occupants to vehicles.

4.1.2 Total Trip Generation

After applying the adjusted TRICS trip rates and converting to vehicles, the total vehicular trip generation for residential and employment developments are shown in Table 11 and Table 12 respectively.

Table 11: Residential Developments' Vehicle Trip Generation

Scenario	Dwellings	Origin AM peak	Destination AM peak	Origin PM peak	Destination PM peak
Preferred Scenario	7,582	3,261	1,130	1,578	2,545

Table 12: Employment Developments' Vehicle Trip Generation

Scenario	Jobs	Origin AM peak	Destination AM peak	Origin PM peak	Destination PM peak
Preferred Scenario	10,974	823	2,899	2,807	799

Comparing the two tables, it shows that the residential developments generate more trips than the employment development.

For residential developments, the highest number of trips occurs for origin trips during the AM peak. The PM peak has more than double the destination trips, and half the number of Origin trips, when compared with the AM peak. Regarding the employment developments, the table shows that these zones attract approximately 2,900 trips during the AM peak and produce an almost identical number of destination trips during the PM peak.

4.2 Trip Distribution

4.2.1 Overview

The methodology used to distribute the trips generated by the proposed developments varies by trip purpose. Trips generated by the residential developments were categorised into trips to school, or trips elsewhere (commuting and all other trips). For trips to school, the distribution was calculated by finding the nearest school or schools to the development and assuming that the trips would go to that school(s).

The trip distribution for commuting and other trips was derived from the 2011 census journey to work data. This data is representative of commuting trips, and is also acceptable for other non-commuting trips (e.g. shopping, personal business).

The calculation of education and commuting and other trips is described in more detail in the following subsections.

4.2.2 Commuting and Other Trips

The 2011 census journey to work data provides information about the usual location of home and work. This data is aggregated at different levels, with the finest level of detail provided in the Middle Super Output Areas (MSOA).

Tendring District consists of 18 MSOAs. Two major movements were identified, trip distribution for people who live within the district, and trip distribution for people who work within the district. The former was used to distribute trips generated by the residential development, and the latter for trips generated by the employment development. For trips which had a work or residential location which was outside the district, the likely entry/exit point, in terms of road on the district boundary, was identified. Thus a base pattern of trips for people living or working in the district was established.

However, it was anticipated that the trip distribution will change in the future due to the presence of new residential or employment development within the district. For example, if a sufficiently large employment development was built within the district, then all else being equal, that development would attract more trips to the MSOA in which the development lies, thus adjusting the distribution for trips from residential areas in Tendring.

The future trip distribution was therefore adjusted according to future developments. For trips arriving at an employment location from a residential location, the proportion of trips arriving from each MSOA was adjusted according to the increases in housing in the MSOA. So, if new development resulted in the MSOA experiencing a 10% increase in the number of houses, then the proportion of trips arriving at an employment site from that MSOA was increased by 10%. This was done for all MSOAs within the district. The following tables show the census distribution, and the adjusted future distribution, for a selection trips arriving at an employment location:

Table 13: Base Distribution for Trips Arriving at an Employment Site

Home end	Work end Tendring 001	Tendring 002	Tendring 003	Tendring 004	Tendring 005
Babergh 010	0.94%	0.84%	5.83%	0.52%	1.82%
Tendring 001	10.16%	16.95%	2.53%	13.45%	0.68%
Tendring 002	23.70%	20.25%	4.81%	22.59%	1.59%
Tendring 003	4.72%	5.13%	23.35%	3.62%	6.55%
Tendring 004	30.08%	24.65%	5.54%	31.55%	1.76%
Tendring 005	0.63%	0.58%	2.49%	0.86%	8.08%
Tendring 006	0.79%	0.89%	0.94%	1.03%	1.08%
Tendring 007	2.05%	1.52%	2.65%	2.07%	1.59%
Tendring 008	2.44%	1.78%	2.57%	2.76%	0.91%
Tendring 009	1.02%	1.15%	1.92%	1.21%	5.58%
Tendring 010	0.47%	0.94%	0.94%	1.03%	1.20%
Tendring 011	0.87%	0.89%	1.67%	0.34%	3.36%
Tendring 012	0.87%	0.84%	0.69%	1.03%	0.46%
Tendring 013	1.18%	1.05%	1.06%	0.52%	1.37%
Tendring 014	0.55%	0.63%	1.18%	0.69%	1.08%
Tendring 015	0.79%	0.37%	1.39%	0.52%	1.02%
Tendring 016	0.08%	0.42%	0.49%	0.52%	0.68%
Tendring 017	0.79%	0.84%	0.81%	0.34%	0.85%
Tendring 018	0.63%	0.89%	0.90%	0.34%	0.68%
A120	9.13%	10.94%	15.32%	10.17%	30.22%
A133	1.81%	2.77%	6.23%	2.24%	19.75%
A137	6.30%	5.70%	16.71%	2.59%	9.68%
B1027	0.00%	0.00%	0.00%	0.00%	0.00%
Total	100.00%	100.00%	100.00%	100.00%	100.00%

So, for example, the census data showed that of the people working in the MSOA Tendring 001, 30.08% of them came from a residence in Tendring 004. In the 2011 Census, Tendring 004 had 3,904 dwellings. In the full development scenario, 2,000 additional dwellings are expected, an increase of 51%. The 30.08% figure therefore increases to 45%. Similar increases occur for other MSOAs with residential development, such that the total no longer adds up to 100%. Therefore, once factored up, the totals are adjusted once more by factoring all the percentages down so that they add up to 100%. The resulting trip distribution is below:

Table 14: Adjusted Base Distribution for Trips Arriving at an Employment Site

Home end	Work end Tendring 001	Tendring 002	Tendring 003	Tendring 004	Tendring 005
Babergh 010	0.9%	0.8%	5.6%	0.5%	2.4%
Tendring 001	9.8%	16.8%	2.6%	12.7%	1.0%
Tendring 002	20.2%	17.7%	4.3%	18.9%	2.0%
Tendring 003	6.2%	6.9%	32.2%	4.6%	12.4%
Tendring 004	38.7%	32.6%	7.5%	39.8%	3.3%
Tendring 005	2.3%	2.2%	9.6%	3.1%	43.1%
Tendring 006	0.7%	0.8%	0.9%	0.9%	1.4%
Tendring 007	3.3%	2.5%	4.5%	3.3%	3.7%
Tendring 008	2.3%	1.7%	2.5%	2.5%	1.2%
Tendring 009	1.7%	1.9%	3.3%	1.9%	13.3%
Tendring 010	0.7%	1.3%	1.4%	1.4%	2.4%
Tendring 011	0.8%	0.8%	1.6%	0.3%	4.3%
Tendring 012	0.7%	0.7%	0.6%	0.9%	0.6%
Tendring 013	2.1%	1.9%	1.9%	0.9%	3.4%
Tendring 014	0.5%	0.5%	1.1%	0.6%	1.3%
Tendring 015	0.7%	0.3%	1.3%	0.5%	1.4%
Tendring 016	0.1%	0.4%	0.4%	0.4%	0.8%
Tendring 017	0.7%	0.7%	0.7%	0.3%	1.1%
Tendring 018	0.6%	0.8%	0.8%	0.3%	0.9%
A120	3.9%	4.8%	6.9%	4.2%	0.0%
A133	0.8%	1.2%	2.8%	0.9%	0.0%
A137	2.7%	2.5%	7.5%	1.1%	0.0%
B1027	0.0%	0.0%	0.0%	0.0%	0.0%
Total	100.00%	100.00%	100.00%	100.00%	100.00%

After factoring, the proportion of trips at employment sites in Tendring 001 arriving from Tendring 004 is 38.7%. For MSOAs which have no, or relatively little residential development, the proportions decrease, reflecting the fact they will generate relatively fewer trips compared to the MSOAs which have significant development.

Similar adjustments for trips distributed from residential developments were also made, using the change in the number of jobs within an MSOA as the basis of the trip proportion adjustments.

The adjusted trip distributions identify, for each new development trip, which MSOA the trip will go to or come from. It does not distinguish whether that opposite end of the trip is itself a new development, or is part of the existing land uses within the MSOA. Therefore, an assumption has been made, that a proportion of these trips will be going to or coming from a new development within the MSOA, rather than from existing development. The trip would therefore be between two new developments. The proportion has been estimated from the relative size of a development within its MSOA.

For trips leaving a new residential development and distributed to an MSOA using the adjusted census trip distribution, if the MSOA contains one or more employment sites, then the volume of trips assumed to travel to the new development (as opposed to existing development within the MSOA) is based on the ratio of the development's employment to the total employment in the MSOA. Similarly, for trips arriving at a residential development, which have come from a particular MSOA according to the adjusted distribution, the proportion assumed to have arrived from a new employment development within the MSOA, as opposed to existing land use, is also based on the ratio of the development's employment to the total employment in the MSOA (from existing and new development).

Following this calculation, the total trip generation at each development is constrained to the original trip generation totals (calculated before trip distribution was applied).

4.2.3 School Trips

A proportion of trips were assumed to be dedicated to education purposes i.e. escorting pupils to school. To establish the likely proportion of residential trip generation that were education trips, the National Travel Survey was used. This showed that, 50% of AM peak trips are for education purposes and 42% of these trips were made by car. Therefore, we assumed that 21% of the trip generation from residential developments would be education trips (the remainder were commuting and other trips). It was assumed that the same number of trips would return to the residential starting point within the AM Peak hour. These trips were distributed to the nearest schools (either within or outside the new developments). If more than one school was identified, trips were distributed equally to all schools.

4.3 Trip Routing

Having established the number of trips between developments and MSOAs, the trips then required assignment to the highway network in order to establish the flows through the key junctions. This process was automated by using strategic highway modelling software to speed up the process. A very simple model of the Tendring highway network was created.

The modelled network was created using an OpenStreetMap dataset[3] representing the road network of the area as links and nodes. It contained details of the characteristics of each road including, amongst others, the speed limit for every link. The network was loaded into the strategic modelling package VISUM, which converted it into a series of links and nodes appropriate for determining route choice. The developments and MSOAs were also added to the model as zones, which would load trips on to the network via zone loaders. The trips were added to the model as a trip matrix. A new link road around the Hartley Meadows, Clacton development was added to the network.

The model determined the most appropriate route for each trip to take, using the link speed limit to identify which route would give the shortest travel time, and assuming that would be the actual route chosen by the trips. The resulting route choice was sense checked and verified through the use of route planning software in both Google Maps and the AA travel planner website[4]. In only a few cases the route determined differed from the route suggested by the route planners. This was rectified by making some minor adjustments to the link speeds in the model. The model was adjusted by increasing or decreasing link speeds appropriately.

The traffic flows through the key junctions were then simply extracted from the assignment model.

[3] www.openstreetmap.org
[4] http://www.theaa.com/route-planner/index.jsp

5. Junction Modelling

5.1 Key Junctions

To measure the transport impact of the new housing and residential developments within Tendring, the effect of additional traffic at key junctions was assessed by using junction models. The junctions tested have been identified through liaison with ECC, as the key junctions in the district. These are located either in the vicinity of the new developments, or on key corridors within the Tendring area.

Models for each were built using appropriate software. For roundabouts and priority junctions, Junctions 8 software was used (Arcady and Picady respectively). Signalised junctions were tested using LinSig.

Junction geometries were measured in AutoCAD using high resolution aerial photography scaled against an OS MasterMap background.

For signalised junctions no signal timing data was available, therefore, timings which would best accommodate the traffic flows at the junctions were used.

The demand data produced for the Preferred Scenario was used as an input for the junction models. The final flows for the junction modelling were the sum of the development traffic flows extracted from the assignment model and the base year traffic counts multiplied by the new background growth. The detailed description of the methodology followed for deriving the total flows is explained in the initial report.

5.2 Traffic Flows

The junction models were tested with the new demand flows and with and without mitigation. The mitigation measures refer to low cost junction improvements.

The 10 key junctions where mitigation was considered to be a priority were agreed with both ECC and TDC and are listed below:

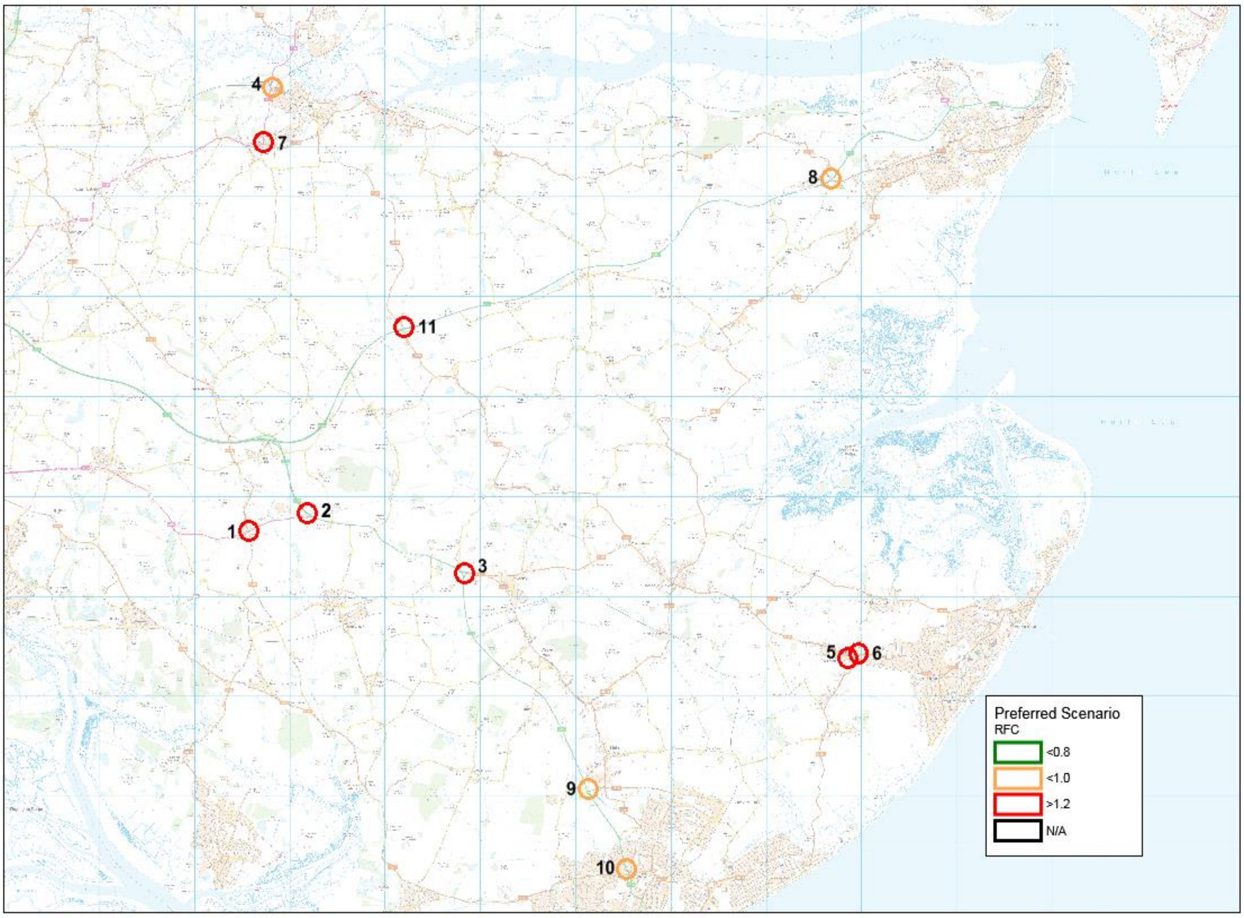
1) A133 Main Road/B1029 Great Bentley Road/B1029 Bromley Road
2) A133 Main Road/Colchester Road/A133 to A120
3) A133 Colchester Road/B1033 Colchester Road
4) A137 Cox's Hill/B1352 Station Road/Cotman Avenue
5) B1033 Frinton Road/B1033 Thorpe Road/B1032 Holland Road
6) B1033 Frinton Road/Halstead Road
7) A137 Cox's Hill/A137 Wignall Street/B1352 Long Road
8) A120 Tinker Street/B1352 Wrabness Road/B1352 Church Hill
9) A133/B1442 Progress Way/ St Osyth Road
10) A133/B1027 St John's Road/A133 London Road

In addition, an additional junction, of the A120/B1035 (Horsley Cross) has also been assessed as part of this work. This junction has been added as part of this assessment as it is considered to be on a key route in Tendring and therefore it was considered appropriate to assess it. For this junction, no mitigation measures were assumed and therefore the junction modelling results will refer only to the unmitigated scenario.

The effect of additional traffic on junction performance is presented in Figure 3. The figure identifies the maximum ratio of flow capacity (RFC) for each junction in either time period. The circles represent the maximum RFC of each of the arms of the tested junctions. The red circles suggest that the junction has at least one arm operating at least 20% over capacity. Overall, all the tested junctions have at least one arm that operate above or close to their capacity.

The junction results for the unmitigated junctions are detailed in Appendix B.

Figure 3: Preferred Scenario Junction impact for non-mitigation measures



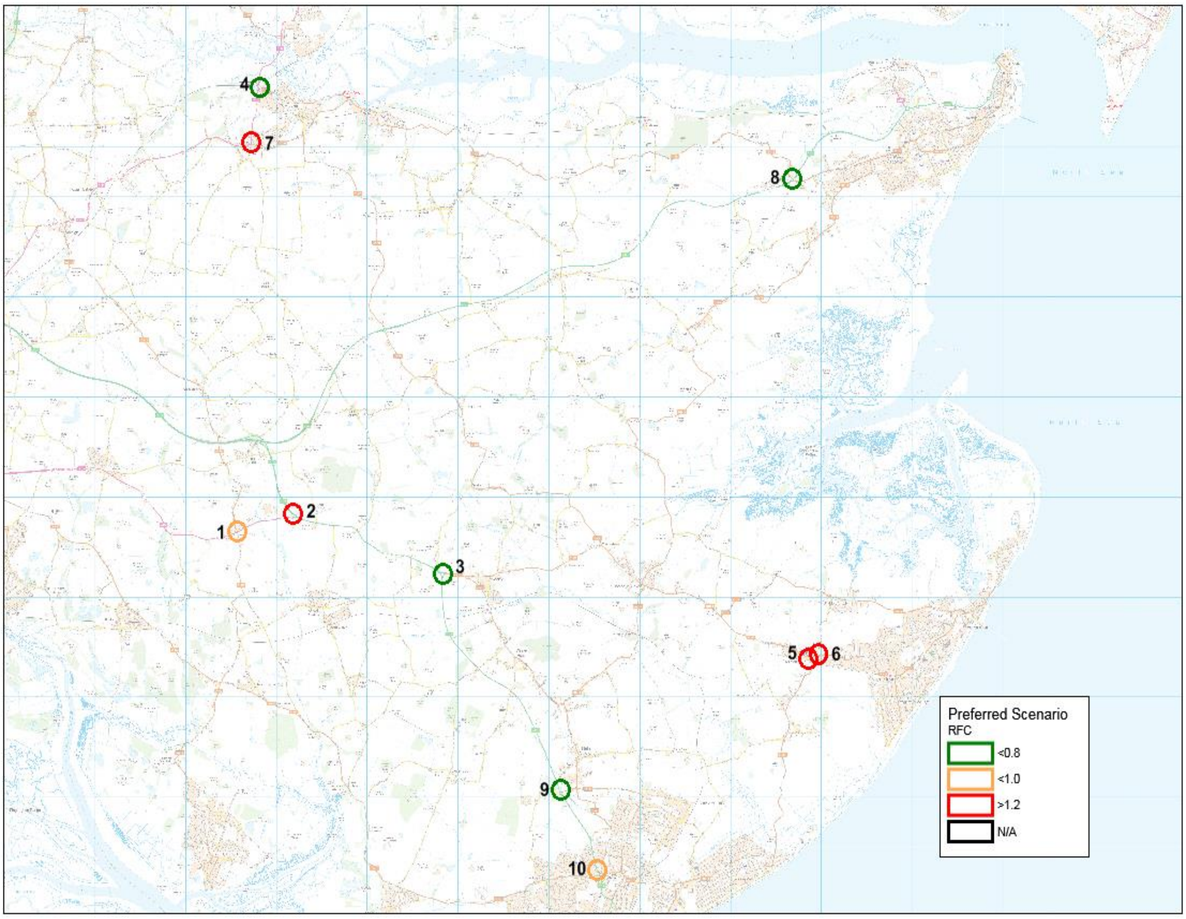
The image above shows that seven of the 11 junctions have at least one arm in excess of capacity during the peak hours, and the remaining four are all approaching their theoretical capacity.

5.3 Mitigation Measures

The mitigation measures assessed are limited to those previously tested, thus no new mitigation measures are proposed as part of this stage of work. The measures include optimisation of signal timings, changes to geometric measurements (i.e. entry width, approach half width, etc.), addition of dedicated lanes and an extra lane on the congested arm. Detailed description of the assumed measures can be found in the initial report.

The impact of the mitigation measures on the modelled junctions is summarized in Figure 4. Contrary to the unmitigated measures, the proposed improvements resulted in better junction performance. In particular, only four junctions operate above capacity.

Figure 4: Preferred Scenario Junction impact for after mitigation measures



To get more insight, the full details of the junction performance in the Preferred Scenario are given in Table 15. The table shows the highest ratio of flow to capacity (RFC) or the equivalent Degree of Saturation (Dos) for the signalised junctions before and after mitigation measures. The lower the RFC value is, the better performance the junction has. An RFC ranging from 0.8 to 1 indicates that the arm is close to capacity, while values greater than 1 suggest that the junction arm is operating under congested conditions. For consistency, the cells have been coloured according to the RFC value used in the figure above. For reference, the junction performance in the 'no development' scenario from a previous stage of work has been included in the table.

Table 15: Summary of Junction Modelling with and without Mitigation Measures

	No development scenario	Preferred Scenario	
Junction	Highest RFC with no development	Highest RFC before mitigation	Highest RFC after mitigation
1. A133 Main Road/B1029 Great Bentley Road/B1029 Bromley Road	106.6% DoS	153.2% DoS	97.0% DoS
2. A133 Main Road/Colchester Road/A133 to A120	1.37	2.37	1.86
3. A133 Colchester Road/B1033 Colchester Road	0.83	1.93	0.79
4. A137 Cox's Hill/B1352 Station Road/Cotman Avenue	0.72	0.89	0.56
5. B1033 Frinton Road/B1033 Thorpe Road/B1032 Kirby Road	1.53	1.54	1.37
6. B1033 Frinton Road/Halstead Road	1.46	1.48	122.3% DoS
7. A137 Cox's Hill/A137 Wignall Street/B1352 Long Road	1.37	1.74	1.48
8. A120 Tinker Street/B1352 Wrabness Road/B1352 Church Hill	0.49	0.66	0.62
9. A133/B1442 Progress Way/St Osyth Road	0.63	0.78	0.78
10. A133/B1027 St John's Road/A133 London Road	0.82	1.1	0.97
11. A120/B1035 (Horsley Cross)	Not available	2.38	Not applicable

The table demonstrates that in the Preferred Scenario and for the before mitigation case, eight junctions will probably have at least one arm operating above capacity. Only the A120 Tinker Street/B1352 Wrabness Road/B1352 Church Hill, the A133/B1442 Progress Way/St Osyth Road and the A137 Cox's Hill/B1352 Station Road/Cotman Avenue junctions are expected to perform within acceptable limits.

For the mitigation measures and for all the tested junctions, the RFC decreases dramatically compared to the values for the unmitigated scenario. The biggest improvement is at the A133 Colchester Road/B1033 Colchester Road junction, where the RFC drops from 1.93 to 0.79. The A137 Cox's Hill/B1352 Station Road/Cotman Avenue junction performs the best after mitigation measures with its RFC being decreased down to 0.56.

Overall, the mitigation measures have improved the traffic situation in all junctions. However, not all of them have been improved to the extent that all arms perform within acceptable levels of service and therefore congestion will occur.

For junctions 5, 6, and 7 in the table above, it should be noted that the junction models show them to be operating in excess of capacity even without the local plan developments. Indeed, the addition of local plan development made relatively little difference to the junction performance.

The detailed modelling results for the mitigated junctions can be found in Appendix C.

6. Qualitative assessment

For the Preferred Scenario, the mitigation measures are largely successful in decreasing traffic congestion and bringing junction performance to acceptable levels of service. Nevertheless, some junctions are still experiencing large delays as they have a RFC value above the threshold level in either the AM or PM peak period.

The methodology used for producing the junction model outputs does not take into account the effects of traffic reassignment due to traffic delays in the network or change in demand due to, for instance, switching to different modes or travelling outside of the peak hours in order to avoid the peak congestion times. These effects can only be assessed through a strategic highway assignment model and a variable demand model, neither of which are available for Tendring.

In the absence of such models covering the Tendring area, a qualitative assessment of the extent to which the identified flows in excess of capacity would in reality be removed in response to changes in the trip generation is attempted in this section.

The junctions that are still performing above capacity after the mitigation measures are those listed below:

- A133 Main Road/Colchester Road/A133 to A120
- B1033 Frinton Road/B1033 Thorpe Road/B1032 Kirby Road
- B1033 Frinton Road/Halstead Road
- A137 Cox's Hill/A137 Wignall Street/B1352 Long Road.

It should be noted that with the exception of the A133 Main Road junction, the junctions listed above perform above capacity even without local plan development; the additional local plan development does not sificantly worsen the performance at those three junctions. For those four junctions but also for the A120/B1035 (Horsley Cross), the flow in excess of capacity for each arm and for every peak period was calculated and is shown in the following figures. The presented numbers represent the volume of trips (in total vehicles) that would need to be removed in order to improve the junction performance and make the junction operate within capacity.

Figure 5: A133 Main Road/Colchester Road/A133 to A120: flow in excess

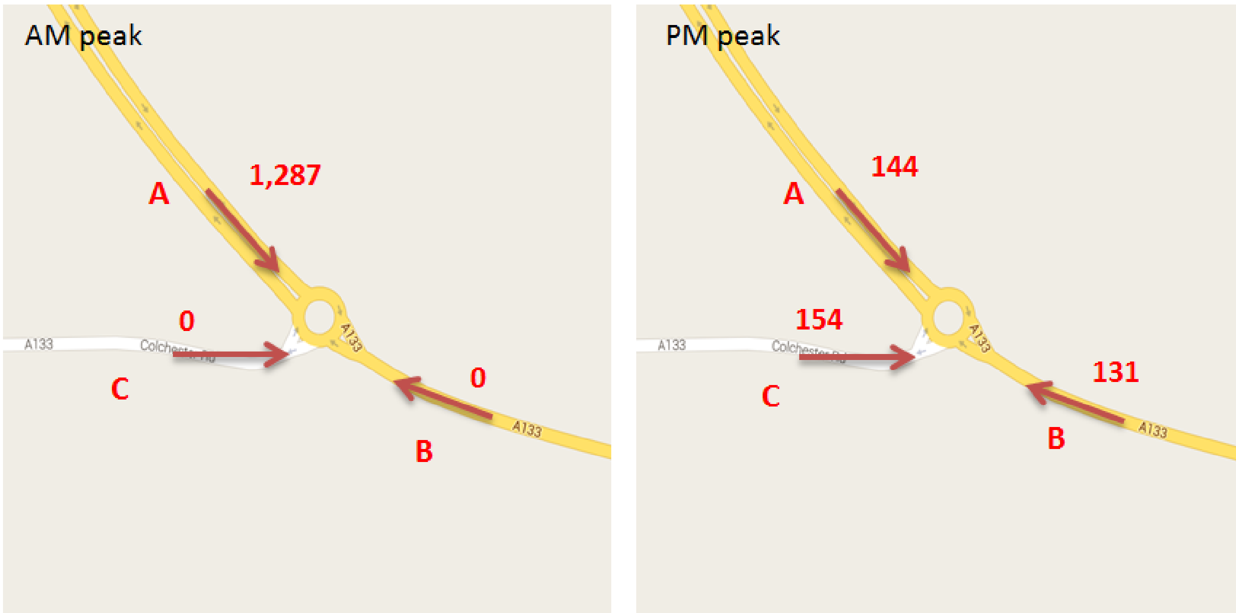


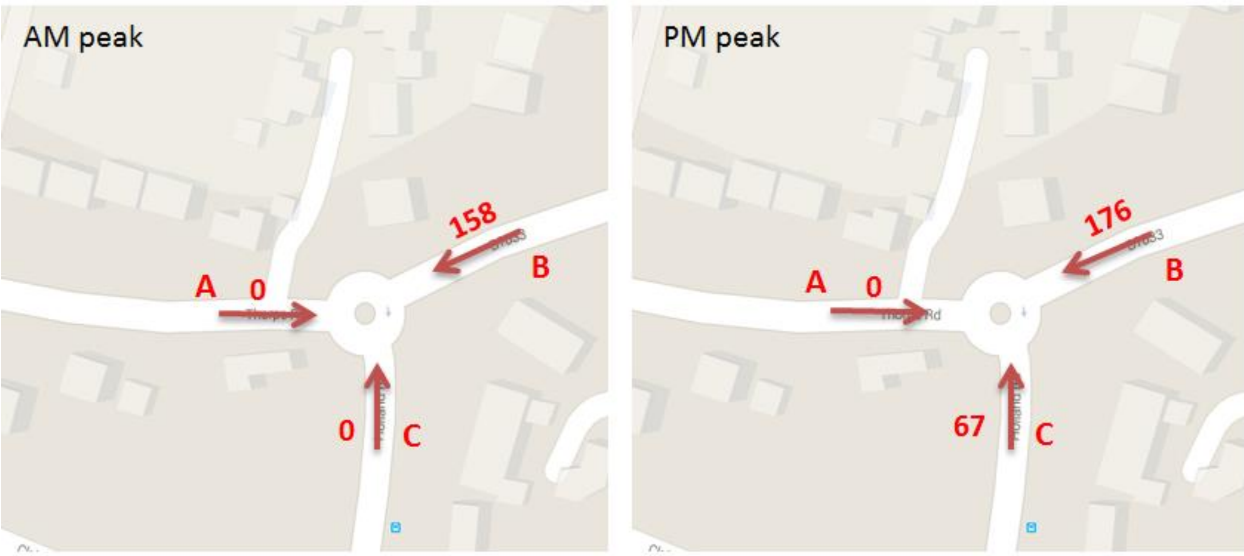
Figure 5 indicates that arm A (from Colchester to Clacton) of the A133 Main Road/Colchester Road/A133 to A120 junction will probably operate above capacity during the AM peak period, even if the proposed mitigation measures are applied. The magnitude of excess flow suggests that even if some traffic can be assumed to be reassigned to different routes, there will still be an excess flow issue at the junction. The traffic demand at this junction is generated by existing trips as well as new trips generated by the local plan development; around a third of the trips are due to the new local plan development, and even if these trips were reduced to zero, the junction would still require some form of mitigation to perform to acceptable levels. One potential mitigation to this could be the proposed A120/A133 link road to the east of Colchester, which may help to reduce the demand at this junction as traffic reassigns using the new link.

For the PM peak period, the traffic situation substantially improves, as the excess flow is of a lower magnitude. Specifically for arm A, the amount of flow in excess is considerably smaller compared to that of the AM peak period. A reason for this big difference might be the fact that this arm is a key route for all drivers travelling to Clacton, which has two significantly large employment sites assumed in the preferred scenario. As a result, it is expected that this road will experience more traffic during the AM period.

For the flow in excess of capacity which occurs on all arms during the PM peak period, it is expected that at least some of these trips would either reassign to alternative routes in response to the traffic congestion, or would change their travel time to avoid the peak congestion period. Thus, it is considered plausible that for the PM peak period, the excess flow highlighted above may be lower than indicated, and the extent of congestion lessened.

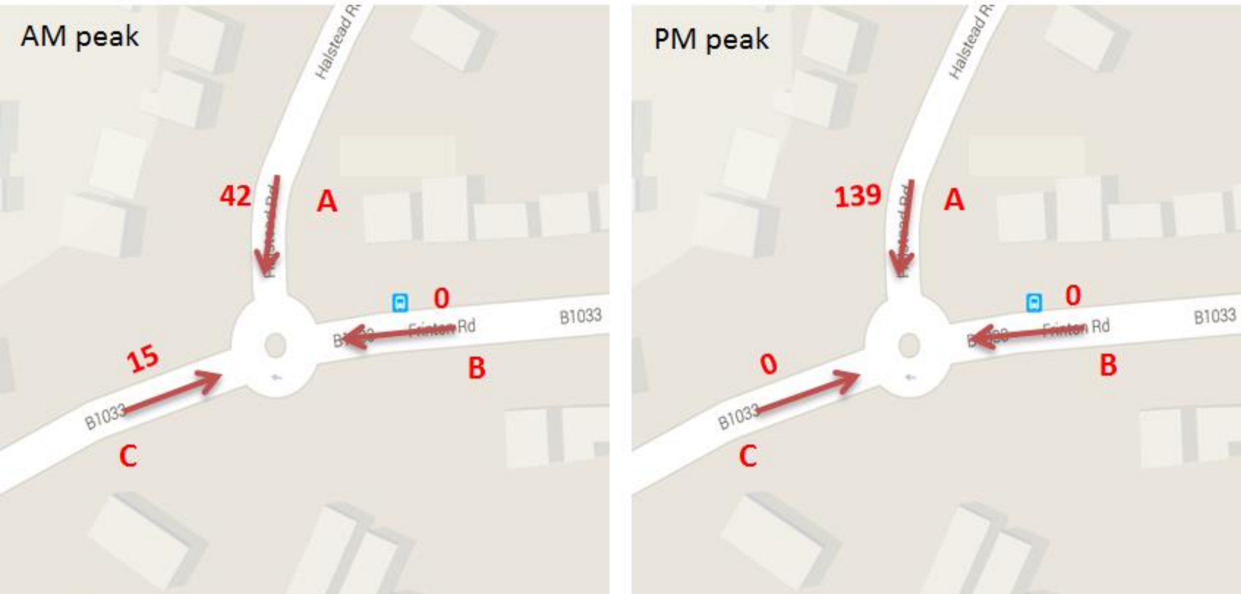
However, despite the improvements that may be achieved in the PM peak, it is clear that a significant problem will remain in the AM peak at this junction.

Figure 6: B1033 Frinton Road/B1033 Thorpe Road/B1032 Kirby Road: flow in excess



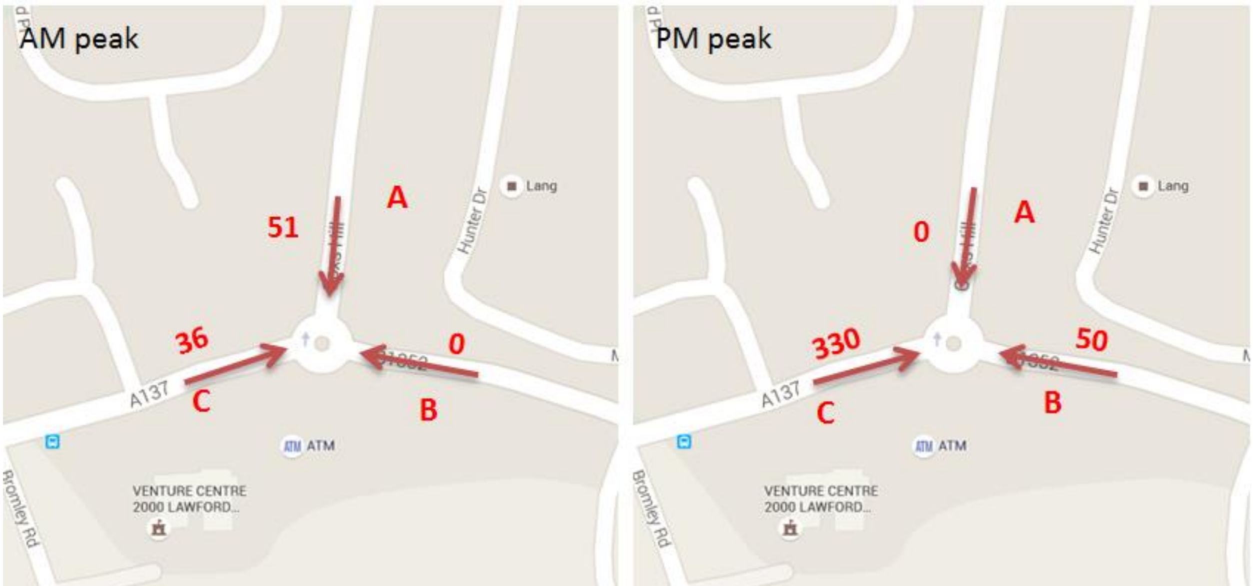
With regard to the B1033 Frinton Road/B1033 Thorpe Road/B1032 Kirby Road junction, Figure 6 shows that the amount of excess traffic is relatively low, and there is potential that at least some of this traffic would reroute, shift modes or change travel times outside of the peak period. It should be noted however that the excess flows at this junction largely do not occur as a result of local plan development, but due to committed growth.

Figure 7: B1033 Frinton Road/Halstead Road: flow in excess



As Figure 7 illustrates, the B1033 Frinton Road/Halstead Road junction is expected to operate over capacity despite the mitigation measures. However, the amount of excess flow in the AM peak is relatively small and there may be the potential for traffic to reassign, potentially this movement would also be linked with a similar effect at the nearby Kirby Road junction. In the PM peak, the excess flow is larger, and there is a lesser potential for this flow to be reduced. It should be noted however that the excess flows at this junction largely do not occur as a result of local plan development, but due to committed growth.

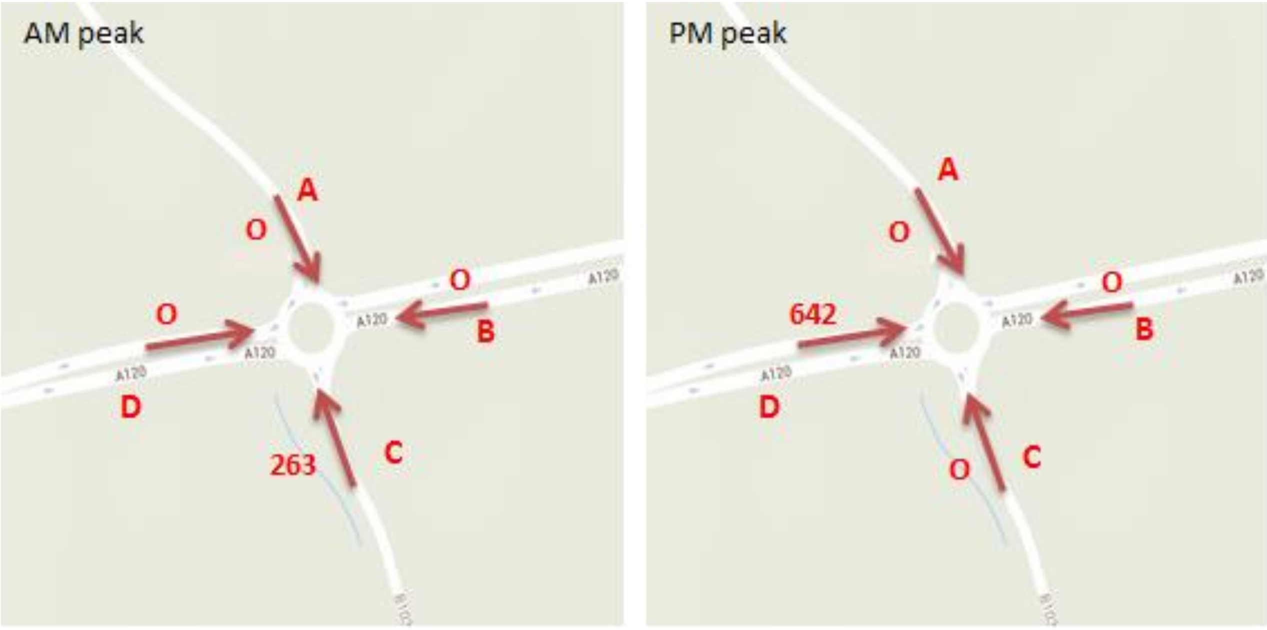
Figure 8: A137 Cox's Hill/A137 Wignall Street/B1352 Long Road: flow in excess



The excess flow of the fourth junction where congestion is likely to occur is presented in Figure 8. For the AM peak period, the amount of excess flow is relatively small, which suggests that the junction will possibly operate within acceptable levels of service as some of the trips would be reassigned or drivers would travel outside of the peak period to avoid congestion. It is noted however that for trips travelling along arm C, the potential for reassignment is relatively small due to a scarcity of alternative routes.

For the PM peak period the situation is similar with the exception of arm C. This arm is expected to experience considerable traffic as the flow in excess is of 330 compared to 36 during the AM peak. The exact origins of the excess trips is not well understand from the currently available data, and the theoretical impact of any trip reassignment or any change in the drivers' travel patterns most probably won't be sufficient to guarantee that the junction will operate within capacity.

Figure 9: A120/B1035 (Horsley Cross): flow in excess



As explained in section 5.2, the A120/B1035 (Horsley Cross) junction was added to the list since it is believed to be a key route for the Tendring area. If no mitigation measures are applied, this junction will possibly operate above capacity as Figure 9 suggests.

For the AM peak period, arm C has approximately 260 pcu flow in excess. This arm is a key route for all the drivers who want to go either to Manningtree or to Mistley where new employment developments are planned to be built in the future (Mistley port expansion and Land South of Long Road).

With regard to the PM peak period, arm D is expected to operate above capacity with about 650 pcu flow in excess. This arm is part of the A120 which leads to the Harwich region. For this region which has a large amount of residential trips, new housing development (Low Road) is planned to be built as part of the local plan. It is therefore likely that many commuters would choose this route for their trips from work to home during this period.

In conclusion, both for the AM and PM peak period the amount of flow in excess is relatively high. The impact of any potential reassignment or change in the demand pattern might not be sufficient on its own to compensate for the excess flow.

7. Summary

7.1 Key Findings

This study assesses the transport impact of the Preferred Scenario on the Tendring area. The new residential and employment developments will result in new travel patterns within the district. The updated demand data was used as an input for running the junction models.

The modelling indicates that a number of the tested junctions are likely to experience high levels of congestion. Specifically, for the existing geometry and operation of the junctions, 8 of them are expected to operate in excess of capacity. Of these, three junctions (B1033 Frinton Road/B1033 Thorpe Road/B1032 Kirby Road, B1033 Frinton Road/Halstead Road and A137 Cox's Hill/A137 Wignall Street/B1352 Long Road) also operate in excess of capacity even without the local plan developments. Indeed, these junctions are relatively unaffected by presence of local plan development.

In response, a sub-set of low cost junction improvements were assumed. Overall the mitigation measures saw an improvement in performance at all junctions, with the RFC of all the junctions being smaller than before mitigation. However, not all of the junctions improved sufficiently for all arms to operate within acceptable levels of service. The model results show four outstanding junctions that are expected to still experience congestion.

For the mitigated junctions that operated above their capacity a further assessment was performed. Specifically, the flow in excess of capacity was calculated for every arm. The identified flows showed that in most of the cases, the amount of excess flow may theoretically be reassigned in response to delays in the network. This is based on the assumption that in the real world, should a particular junction become congested, it is common that drivers would opt for alternative routes, or even change their travel time to avoid the peak congestion period. As a result, it is likely that the amount of traffic going through the junctions will decrease and the junction could potentially operate within acceptable levels of service.

This is not the case however for arm A of the A133 Main Road/Colchester Road/A133 to A120 and arm C of the A137 Cox's Hill/A137 Wignall Street/B1352 Long road junction, whereby both junctions experience a significant amount of excess flow for the AM and PM peak periods respectively. The impact of any potential reassignment or change in the demand pattern is expected not to be sufficient on its own to compensate for the excess flow.

The model results indicate that the Tendring district is likely to experience an increase in traffic in the near future. The mitigation measures identified are expected to be able to help to improve the performance at all junctions, with six of the ten junctions identified for this analysis operating within capacity. However, for two junctions; the proposed mitigation measures, combined with any potential for demand reduction, will not be capable of decreasing traffic flows to acceptable levels of junction performance.

A summary of the junction performance and mitigation options is presented in Table 16.

Table 16: Summary of junction performance and mitigation

Junction	Forecast to be over capacity	Are mitigation proposals required?	What mitigation has been considered?	What additional mitigation may be needed?
A133 Main Road/B1029 Great Bentley Road/B1029 Bromley Road	Yes	Yes	Changes to signal timings	None, as junction performs within capacity (97% degree of saturation).
A133 Main Road/Colchester Road/A133 to A120	Yes	Yes	Left lane segregated slip, segregated lane for ahead eastbound movement	Significant highway trip reduction measures, such as improved PT services to reduce highway demand, and/or additional junction improvements.
A133 Colchester Road/ B1033 Colchester Road	Yes	Yes	Increase flare on the eastbound approach, changes to the entry width in the northbound and southbound approach	No further mitigation is needed; junction within capacity.
A137 Cox's Hill/B1352 Station Road/Cotman Avenue	No	No	None required, junction within capacity.	Not applicable
B1033 Frinton Road/B1033 Thorpe Road/B1032 Kirby Road	Yes	Yes, although impacts are mostly unrelated to local plan development.	Segregated left turn lane	Significant highway trip reduction measures, such as improved PT services to reduce highway demand, and/or additional junction improvements
B1033 Frinton Road/Halstead Road	Yes	Yes, although impacts are mostly unrelated to local plan development.	Signalised junction	Significant highway trip reduction measures, such as improved PT services to reduce highway demand, and/or additional junction improvements
A137 Cox's Hill/A137 Wignall Street/B1352 Long Road	Yes	Yes, although impacts are mostly unrelated to local plan development.	Softened turning radius, approach half width has increased	Significant highway trip reduction measures, such as improved PT services to reduce highway demand, and/or additional junction improvements
A120 Tinker Street/B1352 Wrabness Road/B1352 Church Hill	No	No	None required	Not applicable
A133/B1442 Progress Way/St Osyth Road	No	No	None required	Not applicable

Junction	Forecast to be over capacity	Are mitigation proposals required?	What mitigation has been considered?	What additional mitigation may be needed?
A133/B1027 St John's Road/A133 London Road	Yes	Yes	Minor changes to the entry width in the northbound, southbound and westbound approach, widening the approach lane in the eastbound approach	No further mitigation is needed; junction within capacity.
A120/B1035 (Horsley Cross)	Yes	Yes	None	Some form of junction improvement as a minimum

7.2 Limitation of Work and Potential for Future Work

The methodology followed for generating the junction modelling outputs did not take into account the effects of traffic reassignment or demand changes in response to traffic congestion in the network. In fact, if an assignment model was available, it is possible that as a result of rerouting or due to the variable demand element some junctions that were initially operating under congestion would experience less traffic and potentially performs within acceptable levels of service.

Therefore in the absence of any strategic model for the Tendring area, the assessment of the residual impact due to the flows in excess is based on a qualitative assessment without any substantial modelling assessment base. This approach is a subjective undertaking and, and thus, results should to be treated with caution.

Improvements to public transport and facilities for walking and cycling may help to reduce the highway demand at affected junctions, and may have a significant role to play in mitigating impacts of local plan development. In addition, there is ongoing work to look at route based strategies within Tendring; the outcomes of that work would also have a bearing on assessing the impacts of local plan development.

As a recommendation for future work, refinements to the junction mitigation measures are advised. It may also be prudent to investigate further the potential for strategic reassignment and mode shift measures, possibly through an improved evidence base. A similar study looking at local plan development for Colchester was able to make use of those tools, as they were pre-existing for that area; the methodology described in this report is necessarily different from that.

Appendix A. Trip Rates for Employment Sites

Office – B1	Cyclists	Vehicle Occupants	Pedestrians	Bus / Tram Passengers	Rail Passengers
AM peak Arrival	0.004	0.171	0.031	0.028	0.051
AM peak Departure	0	0.028	0.007	0	0
PM peak Arrival	0	0.022	0.005	0.001	0.002
PM peak Departure	0.004	0.152	0.029	0.025	0.046

Business Park – B1, B2, B8	Cyclists	Vehicle Occupants	Pedestrians	Bus / Tram Passengers	Rail Passengers
AM peak Arrival	0.005	0.311	0.016	0.024	0.002
AM peak Departure	0	0.038	0.005	0.002	0
PM peak Arrival	0.001	0.045	0.003	0.002	0
PM peak Departure	0.005	0.291	0.017	0.021	0.002

Industrial estate – B2	Cyclists	Vehicle Occupants	Pedestrians	Bus / Tram Passengers	Rail Passengers
AM peak Arrival	0.011	0.349	0.017	0.006	0
AM peak Departure	0	0.2	0.004	0	0
PM peak Arrival	0.002	0.13	0.002	0	0
PM peak Departure	0.012	0.317	0.017	0.002	0

Warehouse – B8	Cyclists	Vehicle Occupants	Pedestrians	Bus / Tram Passengers	Rail Passengers
AM peak Arrival	0.009	0.149	0.016	0.014	0.003
AM peak Departure	0	0.042	0.002	0	0
PM peak Arrival	0	0.061	0.003	0.002	0
PM peak Departure	0.008	0.156	0.007	0.012	0.002

Food Store – A1	Cyclists	Vehicle Occupants	Pedestrians	Bus / Tram Passengers	Rail Passengers
AM peak Arrival	0.004	0.713	0.115	0.011	0.013
AM peak Departure	0.002	0.51	0.126	0.004	0.002
PM peak Arrival	0.011	1.521	0.198	0.015	0.011
PM peak Departure	0.007	1.555	0.21	0.019	0.006

Non Food Retail – A1	Cyclists	Vehicle Occupants	Pedestrians	Bus / Tram Passengers	Rail Passengers
AM peak Arrival	0.047	0.404	0.339	0	0
AM peak Departure	0	0.187	0.333	0	0
PM peak Arrival	0.029	0.409	0.111	0	0
PM peak Departure	0.058	0.509	0.111	0.012	0

Cinema – D2	Cyclists	Vehicle Occupants	Pedestrians	Bus / Tram Passengers	Rail Passengers
AM peak Arrival	0	0	0	0	0
AM peak Departure	0	0	0	0	0

PM peak Arrival	0	0.789	0.237	0.316	0
PM peak Departure	0	1.105	0.237	0.211	0

Hotel – C1	Cyclists	Vehicle Occupants	Pedestrians	Bus / Tram Passengers	Rail Passengers
AM peak Arrival	0.008	0.261	0.089	0.011	0.013
AM peak Departure	0.002	0.466	0.201	0.025	0.04
PM peak Arrival	0.005	0.409	0.214	0.019	0.043
PM peak Departure	0.002	0.319	0.155	0.008	0.022

Restaurant – A3	Cyclists	Vehicle Occupants	Pedestrians	Bus / Tram Passengers	Rail Passengers
AM peak Arrival	0	0	0	0	0
AM peak Departure	0	0	0	0	0
PM peak Arrival	0	0.757	0.057	0.014	0
PM peak Departure	0	0.729	0.029	0	0

Drive Through – A5	Cyclists	Vehicle Occupants	Pedestrians	Bus / Tram Passengers	Rail Passengers
AM peak Arrival	0	0.3	0.283	0.1	0
AM peak Departure	0	0.217	0.267	0	0
PM peak Arrival	0	1.722	0.264	0.056	0
PM peak Departure	0	1.611	0.208	0	0

Pub/Restaurant – A4	Cyclists	Vehicle Occupants	Pedestrians	Bus / Tram Passengers	Rail Passengers
AM peak Arrival	0	0	0	0	0
AM peak Departure	0	0	0	0	0
PM peak Arrival	0	0.508	0.798	0.105	0.903
PM peak Departure	0	0.395	0.46	0.032	0.379

Appendix B. Junction Model Outputs

A137 Wignall St / A137 Cox's Hill / B1352 Long Rd

	AM			
	Queue (Veh)	Delay (s)	RFC	LOS
	No Mitigation			
Arm A	131.65	606.82	1.27	F
Arm B	4.82	27.52	0.84	D
Arm C	90.01	453.02	1.24	F

	PM			
	Queue (Veh)	Delay (s)	RFC	LOS
	No Mitigation			
Arm A	7.34	39.13	0.9	E
Arm B	38.13	151.38	1.07	F
Arm C	410.28	2081.08	1.74	F

A120 Tinker St / B1353 Wrabness Rd / B1352 Church Hill

	AM			
	Queue (Veh)	Delay (s)	RFC	LOS
	No Mitigation			
Arm A	0.69	3.41	0.41	A
Arm B	1.62	5.47	0.62	A
Arm C	1	4.03	0.5	A
Arm D	0.44	10.53	0.31	B

	PM			
	Queue (Veh)	Delay (s)	RFC	LOS
	No Mitigation			
Arm A	0.83	3.9	0.46	A
Arm B	0.33	2.63	0.25	A
Arm C	1.91	5.26	0.66	A
Arm D	1.22	20.5	0.56	C

A120 to A133 / A133 Main Rd / A133 Colchester Rd

	AM			
	Queue (Veh)	Delay (s)	RFC	LOS
	No Mitigation			
Arm A	1811.48	4437.34	2.37	F
Arm B	9.66	36.41	0.92	E
Arm C	5.62	12.1	0.86	B

	PM			
	Queue (Veh)	Delay (s)	RFC	LOS
	No Mitigation			
Arm A	328.79	795.4	1.35	F
Arm B	116.94	397.92	1.2	F
Arm C	258.41	441.94	1.23	F

A133 Colchester Rd / Tendring Park Services

	AM			
	Queue (Veh)	Delay (s)	RFC	LOS
	No Mitigation			
Arm A	8.04	18.58	0.9	C
Arm B	56.78	731.48	1.86	F
Arm C	935.07	2484.45	1.93	F
Arm D	0	0	0	A
Arm E	10.88	17.87	0.92	C

	PM			
	Queue (Veh)	Delay (s)	RFC	LOS
	No Mitigation			
Arm A	47.05	69.32	1.02	F
Arm B	53.17	673.95	1.66	F
Arm C	1.95	11.73	0.67	B
Arm D	0.05	21	0.05	C
Arm E	6.93	11.26	0.88	B

B1033 Thorpe Rd / B1033 Frinton Rd / B1032 Kirby Rd

	AM			
	Queue (Veh)	Delay (s)	RFC	LOS

	No Mitigation			
Arm A	328.21	1501.84	1.54	F
Arm B	46.63	276.72	1.13	F
Arm C	9.14	71.63	0.94	F

	PM			
	Queue (Veh)	**Delay (s)**	**RFC**	**LOS**
	No Mitigation			
Arm A	94.12	437.14	1.21	F
Arm B	99.68	601.53	1.27	F
Arm C	55.38	355.79	1.17	F

Halstead Rd / B1033 Frinton Rd

	AM			
	Queue (Veh)	**Delay (s)**	**RFC**	**LOS**
	No Mitigation			
Arm A	254.72	1151.54	1.46	F
Arm B	128.12	549	1.25	F
Arm C	0.77	13.73	0.44	B

	PM			
	Queue (Veh)	**Delay (s)**	**RFC**	**LOS**
	No Mitigation			
Arm A	40.09	161.77	1.07	F
Arm B	310.68	1301.1	1.48	F
Arm C	0.56	11.7	0.36	B

A133 / St Osyth Rd / Progress Way

	AM			
	Queue (Veh)	**Delay (s)**	**RFC**	**LOS**
	No Mitigation			
Arm A	1.88	7.52	0.66	A
Arm B	3.39	9.87	0.78	A
Arm C	1.96	12.95	0.67	B
Arm D	3.26	7.98	0.77	A

	PM			
	Queue (Veh)	Delay (s)	RFC	LOS
	No Mitigation			
Arm A	2.39	6.47	0.71	A
Arm B	1.24	4.72	0.56	A
Arm C	0.45	4.5	0.31	A
Arm D	1.41	6.75	0.59	A

A133 / B1027 St Johns Rd / A133 London Rd

	AM			
	Queue (Veh)	Delay (s)	RFC	LOS
	No Mitigation			
Arm A	6.44	34.24	0.88	D
Arm B	2.22	8.25	0.69	A
Arm C	74.39	160.64	1.1	F
Arm D	4.04	11.32	0.81	B
Arm E	2.03	15.47	0.68	C

	PM			
	Queue (Veh)	Delay (s)	RFC	LOS
	No Mitigation			
Arm A	27.68	131.41	1.05	F
Arm B	12.92	41.39	0.95	E
Arm C	4.19	13.46	0.81	B
Arm D	2.53	7.44	0.72	A
Arm E	22.95	95.26	1.01	F

A137 Cox's Hill/A137/B1352 Station Road/Cotman Avenue

	AM			
	Queue (Veh)	Delay (s)	RFC	LOS
	No Mitigation			
Arm A	0.98	6.93	0.5	A
Arm B	0.34	4.8	0.25	A
Arm C	1.02	3.83	0.51	A
Arm D	1.22	4.58	0.55	A

	PM

	Queue (Veh)	Delay (s)	RFC	LOS
	No Mitigation			
Arm A	3.76	23.05	0.8	C
Arm B	0.22	6	0.18	A
Arm C	0.98	3.61	0.5	A
Arm D	7.45	18.6	0.89	C

A120/B1035 (Horsley Cross)

	AM			
	Queue (Veh)	**Delay (s)**	**RFC**	**LOS**
	No Mitigation			
Arm A	0.49	2.42	0.33	A
Arm B	13.64	48.67	0.96	E
Arm C	0.52	3.55	0.34	A
Arm D	208.2	1359.9	1.61	F

	PM			
	Queue (Veh)	**Delay (s)**	**RFC**	**LOS**
	No Mitigation			
Arm A	0.65	2.75	0.39	A
Arm B	1.54	8.11	0.61	A
Arm C	0.32	2.48	0.24	A
Arm D	700.75	4129.31	2.38	F

A133 Main Road/B1029 Great Bentley Road/B1029 Bromley Road

No Mitigation, AM	Deg Sat (%)	Max Queue (PCU)
B1029 Bromley Road N Left Ahead Right	145.4%	39.5
A133 Colchester Road E Right Left Ahead	146.3%	183.4
Great Bentley Road S Ahead Right Left	147.2%	149.3
A133 Main Road W Left Ahead Right	149.3%	148.8

No Mitigation, PM	Deg Sat (%)	Max Queue (PCU)
B1029 Bromley Road N Left Ahead Right	153.2%	74.2
A133 Colchester Road E Right Left Ahead	151.4%	261.3
Great Bentley Road S Ahead Right Left	149.3%	75.7

A133 Main Road W Left Ahead Right	149.8%	145.2

JACOBS

Appendix C. Junction Performance with Mitigation Measures

A137 Wignall St / A137 Cox's Hill / B1352 Long Rd

	AM			
	Queue (Veh)	Delay (min)	RFC	LOS
	With Mitigation			
Arm A	40.93	2.33	1.06	F
Arm B	7.97	0.77	0.91	E
Arm C	33.14	2.27	1.05	F

	PM			
	Queue (Veh)	Delay (min)	RFC	LOS
	With Mitigation			
Arm A	2.97	0.25	0.76	C
Arm B	39.37	2.61	1.07	F
Arm C	264.24	19.27	1.48	F

A120 Tinker St / B1353 Wrabness Rd / B1352 Church Hill

	AM			
	Queue (Veh)	Delay (s)	RFC	LOS
	With Mitigation			
Arm A	0.69	3.41	0.41	A
Arm B	1.62	5.47	0.62	A
Arm C	0.69	2.8	0.41	A
Arm D	0.11	2.62	0.1	A

	PM			
	Queue (Veh)	Delay (s)	RFC	LOS
	With Mitigation			
Arm A	0.83	3.9	0.46	A
Arm B	0.33	2.63	0.25	A
Arm C	1.18	3.24	0.54	A
Arm D	0.19	3.11	0.16	A

A120 to A133 / A133 Main Rd / A133 Colchester Rd

	AM			
	Queue (Veh)	Delay (s)	RFC	LOS
	With Mitigation			
Arm A	1275.15	2517.23	1.86	F
Arm B	6.24	23.15	0.87	C
Arm C	2.76	5.81	0.74	A

	PM			
	Queue (Veh)	Delay (s)	RFC	LOS
	With Mitigation			
Arm A	91.59	152.29	1.09	F
Arm B	77.85	218.87	1.13	F
Arm C	98	119.73	1.07	F

A133 Colchester Rd / Tendring Park Services

	AM			
	Queue (Veh)	Delay (s)	RFC	LOS
	With Mitigation			
Arm A	0.17	1.96	0.14	A
Arm C	0.06	1.78	0.06	A
Arm D	0	0	0	A
Arm E	3.72	5.9	0.79	A

	PM			
	Queue (Veh)	Delay (s)	RFC	LOS
	With Mitigation			
Arm A	0.25	1.64	0.2	A
Arm C	0.07	1.44	0.06	A
Arm D	0	0	0	A
Arm E	3.17	5.13	0.76	A

B1033 Thorpe Rd / B1033 Frinton Rd / B1032 Kirby Rd

	AM			
	Queue (Veh)	Delay (s)	RFC	LOS
	With Mitigation			
Arm A	2.03	14.52	0.68	B

Arm B	99.34	672.66	1.37	F
Arm C	5.1	39.89	0.85	E

	PM			
	Queue (Veh)	**Delay (s)**	**RFC**	**LOS**
	With Mitigation			
Arm A	0.93	8.97	0.48	A
Arm B	118.1	700.84	1.35	F
Arm C	46.74	302.36	1.13	F

A133 / St Osyth Rd / Progress Way

	AM			
	Queue (Veh)	**Delay (s)**	**RFC**	**LOS**
	With Mitigation			
Arm A	1.27	5.06	0.56	A
Arm B	3.39	9.88	0.78	A
Arm C	1.96	12.95	0.67	B
Arm D	2.17	5.27	0.69	A

	PM			
	Queue (Veh)	**Delay (s)**	**RFC**	**LOS**
	With Mitigation			
Arm A	1.59	4.29	0.62	A
Arm B	1.24	4.72	0.56	A
Arm C	0.45	4.5	0.31	A
Arm D	1.07	5.11	0.52	A

A133 / B1027 St Johns Rd / A133 London Rd

	AM			
	Queue (Veh)	**Delay (s)**	**RFC**	**LOS**
	With Mitigation			
Arm A	2.69	13.75	0.74	B
Arm B	2.24	8.29	0.69	A
Arm C	4.53	11.33	0.82	B
Arm D	2.18	5.99	0.69	A
Arm E	1.62	12.2	0.62	B

	PM			
	Queue (Veh)	Delay (s)	RFC	LOS
	With Mitigation			
Arm A	5.24	28.12	0.85	D
Arm B	16.91	52.91	0.97	F
Arm C	1.6	5	0.62	A
Arm D	1.47	4.28	0.6	A
Arm E	7.61	34.52	0.9	D

A137 Cox's Hill/A137/B1352 Station Road/Cotman Avenue

	AM			
	Queue (Veh)	Delay (s)	RFC	LOS
	With Mitigation			
Arm A	0.46	3.26	0.32	A
Arm B	0.34	4.81	0.25	A
Arm C	0.91	3.41	0.48	A
Arm D	0.53	2	0.35	A

	PM			
	Queue (Veh)	Delay (s)	RFC	LOS
	With Mitigation			
Arm A	0.9	5.31	0.48	A
Arm B	0.23	6.02	0.18	A
Arm C	0.87	3.23	0.47	A
Arm D	1.27	3.03	0.56	A

A133 Main Road/B1029 Great Bentley Road/B1029 Bromley Road

With Mitigation, AM	Deg Sat (%)	Max Queue (PCU)
B1029 Bromley Road N Left Ahead Right	96.6%	9.5
A133 Colchester Road E Left Ahead	96.0%	21.6
A133 Colchester Road E Right Ahead	95.8%	21.5
Great Bentley Road S Ahead Right	97.0%	31.3

Left		
A133 Main Road W Left Ahead	94.1%	16.8
A133 Main Road W Ahead Right	94.1%	16.8

With Mitigation, PM	Deg Sat (%)	Max Queue (PCU)
B1029 Bromley Road N Left Ahead Right	93.1%	14.3
A133 Colchester Road E Left Ahead	95.2%	26.3
A133 Colchester Road E Right Ahead	95.0%	26.1
Great Bentley Road S Ahead Right Left	95.0%	16.9
A133 Main Road W Left Ahead	91.2%	15.1
A133 Main Road W Ahead Right	91.2%	15.1

A133 Main Road/B1029 Great Bentley Road/B1029 Bromley Road

With Mitigation, AM	Deg Sat (%)	Mean Max Queue (PCU)
B1033	104.3%	44.1
Halstead Road	74.5%	4.0
Frinton Road	108.8%	63.6

With Mitigation, PM	Deg Sat (%)	Mean Max Queue (PCU)
B1033	122.3%	128.2
Halstead Road	63.8%	3.1
Frinton Road	80.8%	11.6