

# DUNDEE MICROSIMULATION MODEL

## LEZ OPTION TESTING NOTE

### SUMMARY TABLE

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# 1. INTRODUCTION

1.1.1 SYSTRA Ltd (SYSTRA) were commissioned by Dundee City Council (DCC) to develop a microsimulation model of the Greater Dundee City Centre area for the purpose of assessing scenarios associated with the proposed Dundee Low Emission Zone. The project has been managed by Dundee City Council (DCC).

1.1.2 The initial Base Model development is detailed in the report *Dundee Greater City Centre Base Paramics Model Development Report (SYSTRA, November 2019)* and the development of the 2023 reference case model is detailed in the technical note *Dundee Greater City Centre Reference Case Note (SYSTRA, February 2020)*.

1.1.3 This technical note outlines the development of each of the LEZ option models, as defined by DCC and identified in the *National Low Emission Framework - Stage 2 Assessment Report (SYSTRA, July 2019)*. It assesses the impact of trips completed by vehicles with non-compliant engine standards, as defined by the Transport (Scotland) Act 2019, being displaced to outside the LEZ. Along with the operational results presented in this report, model outputs have been provided to SEPA for input to the air quality modelling, which will be reported separately by SEPA.

## 1.2 Model Testing Programme

1.2.1 The 2023 Reference Case, as defined by DCC, reflects infrastructure changes and committed Local Development Plan forecasts to 2023. The 2023 Reference Case Model was used as a basis to develop three core inner ring road LEZ option tests, namely the three all vehicle LEZ options identified through the NLEF high level appraisal:

- LEZ Option 1 (NLEF Ref 2A) - Inner Ring Road area, including all car parks
- LEZ Option 2 (NLEF Ref 2B) - Inner Ring Road area, excluding Bell Street and West Marketgait NCP car parks
- LEZ Option 3 (LEZ Ref 2C) - Inner Ring Road area, excluding Bell Street, West Marketgait NCP and Wellgate car parks

1.2.2 In addition to these three core inner ring road options, two further variants were tested where the LEZ was extended along the Lochee Road corridor, as identified through the NLEF public and stakeholder consultation. The Lochee Road option tests were:

- LEZ Option 1/2/3 (above) plus West Marketgait between West Port Roundabout and Dudhope Roundabout and Lochee Road to Tullideph Road
- LEZ Option 1/2/3 (above) plus West Marketgait between West Port Roundabout and Dudhope Roundabout and Lochee Road to Loon's Road

1.2.3 During this LEZ model testing, it was identified that the assessment of the Lochee Road corridor options was hindered by network congestion primarily resulting from the inclusion of West Marketgait between West Port Roundabout and Dudhope Roundabout in the LEZ area. To ensure a robust LEZ option testing programme, it was agreed with DCC to model further variants of the Lochee Road options, excluding West Marketgait, as follows:

- LEZ Option 1/2/3 (above) plus Lochee Road to Tullideph Road (excluding West Marketgait between West Port Roundabout and Dudhope Roundabout)
- LEZ Option 1/2/3 (above) plus Lochee Road to Loon's Road (excluding West Marketgait between West Port Roundabout and Dudhope Roundabout)

### **1.3 LEZ Post Covid-19 Uncertainty**

- 1.3.1 The Covid-19 pandemic has had a dramatic impact on travel across all modes and specifically travel in Scotland's city centres. To assist in the development of the LEZs across Scotland, Transport Scotland commissioned a study to apply the principals of modelling in considering the uncertainty over what travel will look like after the pandemic has ended.
- 1.3.2 The study set out a framework for embracing uncertainty by consulting with stakeholders on 'what will travel look like post Covid-19'. This framework set out the rationale for any additional modelling required to provide evidence to support the introduction of any LEZ. To assist this process, workshops were held with the local authorities, including DCC, to agree the key metrics to measure against the current LEZ objectives and identify the key disruptors which are likely to have the greatest impact on travel activities within each city centre.
- 1.3.3 A Scenario Planning Process was developed to allow a range of plausible future scenarios to be defined using important and likely disruptors. These scenarios were used as a reference case against which the anticipated LEZ impacts were applied to understand how an LEZ performs in the context of plausible future scenarios.
- 1.3.4 The outcomes from the study are detailed in the *LEZ Post-Covid Uncertainty Summary Note (SYSTRA Ref. GB01T20E86/11024112/005, January 2021)*. The study concluded that the impact of the LEZs will vary between each city introducing a LEZ, depending on their specific traffic levels and fleet composition. But importantly, the LEZ will protect the city centres by preventing non-compliant vehicles from entering them. Whilst the impact of the LEZ may vary across each city in terms of emissions, the outcome is likely to be very similar with the level of emissions limited to a reduced value compared to pre-LEZ levels.
- 1.3.5 For Dundee, plausible futures were considered against the core model assessments undertaken (outlined above) and further sensitivity testing of the proposed LEZ schemes was proposed. The reason for undertaking the sensitivity tests is to provide evidence that the LEZ schemes are robust to variations in network conditions that may occur in a post-pandemic world.
- 1.3.6 As noted above, the core traffic modelling results in this report were developed from one plausible future scenario, defined as the 2023 Reference Case. The LEZ Post-Covid-19 uncertainty study recommended that a sensitivity test was undertaken on one other further plausible future, to ensure a robust set of modelling results to inform Dundee's LEZ.
- 1.3.7 The sensitivity scenario was defined as "Coping as Best We Can" where, following an economic downturn, the projected rate of change towards a cleaner fleet is lower than pre-Covid-19 forecasts (as provided by SEPA) and traffic shrinkage is experienced, similar to the 2010 economic downturn. The outcomes from this sensitivity testing are detailed in Chapter 8.

## 2. INNER RING ROAD LEZ OPTION BOUNDARIES

2.1.1 The NLEF process identified three LEZ boundary options to be compared with the 2023 Reference Case model, as follows:

- LEZ Option 1 (NLEF Ref 2A) - Inner Ring Road area, including all car parks (Figure 2.1)
- LEZ Option 2 (NLEF Ref 2B) - Inner Ring Road area, excluding Bell Street and West Marketgait NCP car parks (Figure 2.2)
- LEZ Option 3 (LEZ Ref 2C) - Inner Ring Road area, excluding Bell Street, West Marketgait NCP and Wellgate car parks (Figure 5.2Figure 2.3)

2.1.2 A LEZ, as defined in the Transport (Scotland) Act 2019, prohibits vehicles with petrol and diesel engines that are below Euro 4 and Euro 6/VI, respectively. For each option, model restrictions along the LEZ boundary are put in place prohibiting non-compliant vehicles to enter the LEZ.

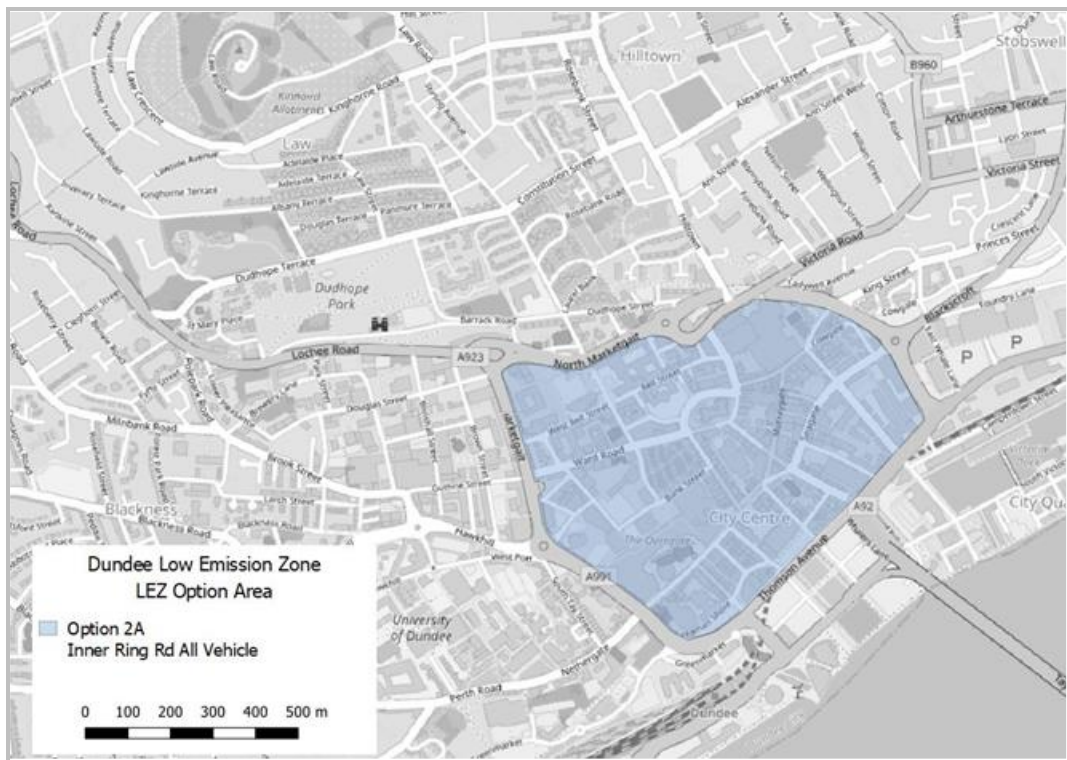


Figure 2.1 : LEZ Option 1 (NLEF Ref. 2A)



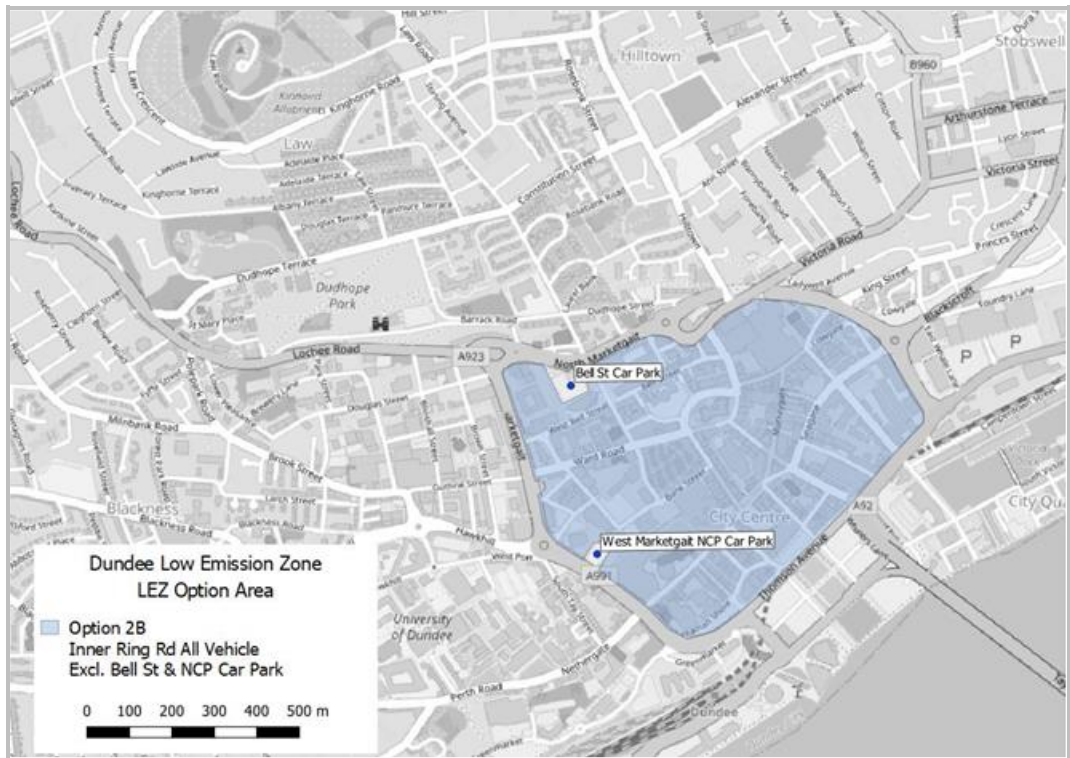


Figure 2.2 : LEZ Option 2 (NLEF Ref. 2B)

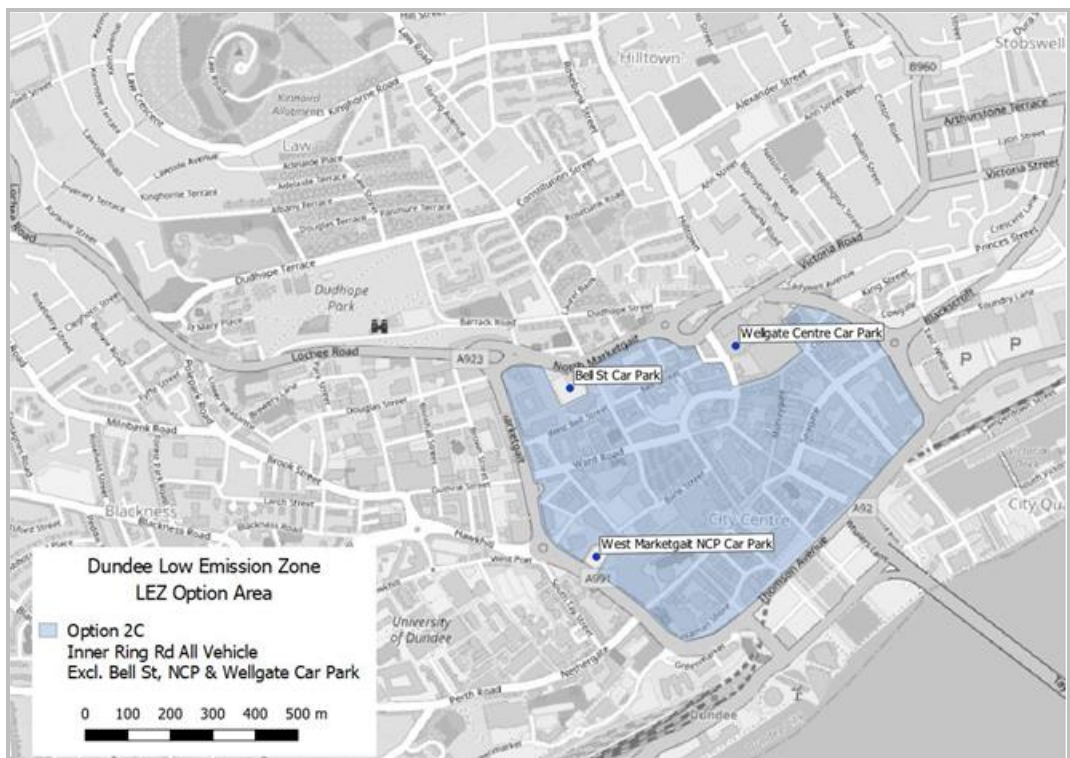


Figure 2.3 : LEZ Option 3 (NLEF Ref. 2C)

### 3. LEZ OPTION MODEL DEVELOPMENT

#### 3.1 LEZ Assumptions

3.1.1 For all the LEZ Option models the following assumptions were made, following discussions with DCC and Transport Scotland:

- The base year (2017) vehicle fleet has been used to provide a worst case with regards to displaced traffic volumes and resulting impact on emissions.
- No mode shift, or destination shift, reflecting a worst case in terms of vehicles to be displaced.
- Non-compliant cars destinating in the LEZ boundary assumed to move to park out-with the LEZ boundary in the nearest car park available.
- All taxis assumed to be compliant.
- All HGVs originating or destinating within the boundary assumed to be compliant.
- All LGVs originating or destinating the LEZ boundary assumed to be compliant.

3.1.2 In order to prohibit the relevant number of non-compliant vehicles from the LEZ, the proportion of compliant and non-compliant cars, LGVs and HGVs was provided by SEPA, as identified through ANPR traffic surveys. The split for each vehicle type is outlined below in Table 3.1.

Table 3.1 : Engine Type Split

Vehicle Type	Status	Fuel type	Percentage by vehicle class
Car	Compliant	Petrol	51%
		Diesel	17%
	Non-Compliant	Petrol	3%
		Diesel	29%
LGV	Compliant	Petrol	0%
		Diesel	16%
	Non-Compliant	Petrol	1%
		Diesel	83%
HGV	Compliant	Petrol	0%
		Diesel	26%
	Non-Compliant	Petrol	0%
		Diesel	74%

3.1.3 It is assumed that for the LGV and HGV trips that arrived or departed from within the LEZ in the Reference Case model, any non-compliant vehicles would be replaced with compliant ones, as agreed with DCC. The non-compliant cars are assumed to divert to a nearby carpark outside of the LEZ.

3.1.4 In order to facilitate this in the model, the model demands have been split into 9 matrix levels;

- Matrix 1 – Car Compliant
- Matrix 2 – Car Non-Compliant
- Matrix 3 – LGV Compliant
- Matrix 4 – LGV Non-Compliant
- Matrix 5 – HGV Compliant
- Matrix 6 – HGV Non-Compliant



- Matrix 7 – Taxi
- Matrix 8 – Development Cars Compliant
- Matrix 9 – Development Cars Non-Compliant

3.1.5 Table 3.2, Table 3.3 and Table 3.4 details the vehicle numbers by matrix level for the Reference Case and each of the options. The total number of compliant and non-compliant vehicles differs slightly between each LEZ option due to the inclusion or exclusion of city centre car parks, as detailed in Chapter 2.

**Table 3.2 : AM Demand Summary by matrix level**

Matrix	AM (07:00-10:00)			
	Ref Case	Option 1	Option 2	Option 3
1	51513	51513	51513	51513
2	25012	24905	24911	24908
3	1957	2226	2226	2226
4	10399	10130	10130	10130
5	893	945	945	945
6	2542	2489	2489	2489
7	2111	2111	2111	2111
8	989	989	989	989
9	480	475	479	479

**Table 3.3 : IP Demand Summary by matrix level**

Matrix	IP (10:00-16:00)			
	Ref Case	Option 1	Option 2	Option 3
1	111001	111001	111001	111001
2	53883	53418	53418	53429
3	4036	4784	4784	4802
4	21438	20690	20690	20672
5	1938	2026	2026	2027
6	5515	5426	5426	5426
7	6457	6457	6457	6457
8	1705	1705	1705	1705
9	828	822	822	826

**Table 3.4 : PM Demand Summary by matrix level**

Matrix	PM (16:00-19:00)			
	Ref Case	Option 1	Option 2	Option 3
1	71573	71573	71573	71573
2	34744	34468	34468	34480
3	1472	1629	1629	1629
4	7823	7666	7666	7666
5	376	388	388	388
6	1071	1059	1059	1059
7	2373	2373	2373	2373
8	1211	1211	1211	1211
9	588	584	584	587

## **3.2 LEZ Trip Displacement**

- 3.2.1 Separate matrix levels were used for trips made by non-compliant cars. Trips arriving and departing from zones identified as inside the LEZ in the non-compliant OD Matrix were removed and re-distributed to nearby carparks outside of the LEZ. For each LEZ zone, the nearest carpark zone is defined and the identified non-compliant trips are reassigned to this zone.
- 3.2.2 Table 3.5, Table 3.6 and Table 3.7 detail the number of non-compliant trips being displaced by the LEZ and the adopted distribution to nearby carparks for each LEZ option based on its proximity to each Paramics zone within the LEZ.
- 3.2.3 It should be noted that compliant cars access the LEZ area and city centre car parks as normal without restriction. In LEZ Option 3, no additional non-compliant vehicles are redistributed to Bell Street car park, as shown, but existing compliant and non-compliant cars trips assigned here in the Reference Case model access the car park as normal.

**Table 3.5 : LEZ Option 1 – New Car Park Trips**

LEZ Option 1	AM		IP		PM	
	From	To	From	To	From	To
Greenmarket Carpark	333	803	1552	1655	1123	787
Olympia CarPark	148	268	516	534	322	192
Marketgait Carpark	0	0	0	0	0	0
Bell Street Carpark	0	0	0	0	0	0
Wellgate Carpark	0	0	0	0	0	0
TOTAL	480	1072	2069	2189	1444	978

**Table 3.6 : LEZ Option 2 – New Car Park Trips**

LEZ Option 2	AM		IP		PM	
	From	To	From	To	From	To
Greenmarket Carpark	19	94	248	288	195	155
Olympia CarPark	50	119	263	226	172	87
Marketgait Carpark	309	519	1158	1109	815	571
Bell Street Carpark	89	193	177	304	131	89
Wellgate Carpark	0	0	0	0	0	0
TOTAL	466	925	1845	1927	1312	902

**Table 3.7 : LEZ Option 3 – New Car Park Trips**

LEZ Option 3	AM		IP		PM	
	From	To	From	To	From	To
Greenmarket Carpark	19	94	248	288	195	155
Olympia CarPark	30	60	162	210	57	75
Marketgait Carpark	309	519	1158	1109	815	571
Bell Street Carpark	0	0	0	0	0	0
Wellgate Carpark	106	113	185	102	179	45
TOTAL	464	786	1752	1708	1246	846

### 3.3 Reference Case Network Changes

- 3.3.1 An issue was identified at the Moffat Road Roundabout on the Kingsway which caused runs to crash sporadically. In order to prevent this, Clear Exit Adherence was added at this location in the Reference Case and all Option models.

## 4. INNER RING ROAD OPTION PERFORMANCE COMPARISON

4.1.1 The three inner ring road option models were run 10 times each for the three time periods AM (07:00-10:00), IP (10:00-16:00), PM (16:00-19:00) and results averaged across the 10 runs.

### 4.2 General Model Observations

4.2.1 For the most part, the Option models operate without noticeable difference from the Reference Case model. The notable exception to this is the East Dock Street/East Marketgait junction which sees an increase in congestion, particularly in the AM, as a result of non-compliant vehicles being reassigned to car parks on the periphery of the LEZ inner ring road area. This congestion is worst in Option 1 which has the highest number of displaced vehicles.

### 4.3 Journey Time Comparisons

4.3.1 Journey Times were collected over 11 routes which were specified by DCC and represent key routes that may be impacted by the LEZ proposals, as shown in Figure 4.1.

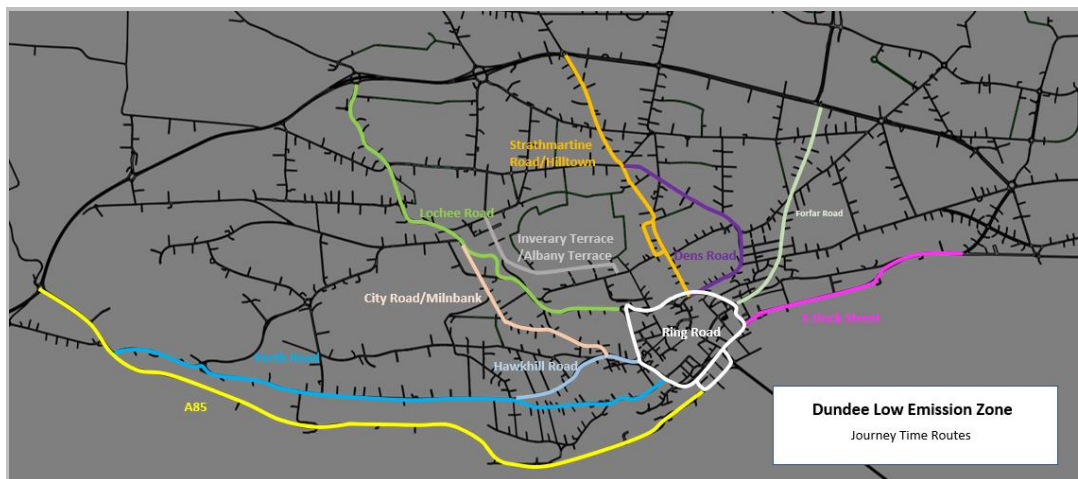


Figure 4.1 : Journey Time Routes

4.3.2 Table 4.1 and Table 4.2 show the average journey time in seconds during the peak hours, 08:00-09:00 and 17:00-18:00 respectively, along these routes for the reference case model and the three LEZ option models.

**Table 4.1 : Journey Time Comparison (seconds) 08:00 – 09:00**

Route	Ref Case	Op1	Difference (Op1-Ref)	Op2	Difference (Op2-Ref)	Op3	Difference (Op3-Ref)
A85 EB	404	406	1	403	-1	406	2
A85 WB	435	431	-4	433	-2	437	1
City Road/Milnbank Road NB	154	153	-1	154	0	155	1
City Road/Milnbank Road SB	152	150	-3	150	-3	151	-1
Dens Road NB	242	242	0	246	4	242	0
Dens Road SB	253	250	-3	253	1	253	0
East Dock Street EB	177	178	1	177	-1	177	0
East Dock Street WB	199	272	74	230	31	226	27
Forfar Road NB	304	304	0	301	-3	299	-5
Forfar Road SB	278	289	10	277	-1	283	5
Hawkhill Road EB	118	117	-1	118	0	118	0
Hawkhill Road WB	126	129	3	128	1	126	-1
Inverary/Albany/Gardner NB	123	123	1	123	0	123	0
Inverary/Albany/Gardner SB	107	107	0	107	0	107	0
Lochee Road NB	392	390	-2	387	-5	390	-1
Lochee Road SB	400	399	-1	400	0	400	0
Perth Road EB	489	423	-66	459	-31	461	-29
Perth Road WB	419	432	13	428	9	434	15
Ring Road Anticlockwise	373	384	11	376	3	367	-6
Ring Road Clockwise	462	490	29	477	15	474	12
Strathmartine Road SB	343	337	-6	349	6	346	3
Hilltown NB	350	353	3	350	0	347	-3

**Table 4.2 : Journey Time Comparison (seconds) 17:00 – 18:00**

Route	Ref Case	Op1	Difference (Op1-Ref)	Op2	Difference (Op2-Ref)	Op3	Difference (Op3-Ref)
A85 EB	439	444	5	449	10	447	7
A85 WB	436	440	4	440	3	439	3
City Road/Milnbank Road NB	163	165	2	163	0	161	-2
City Road/Milnbank Road SB	157	156	-1	155	-2	155	-2
Dens Road NB	270	277	7	277	7	275	5
Dens Road SB	315	316	2	314	-1	312	-3
East Dock Street EB	216	236	20	229	13	215	-1
East Dock Street WB	214	278	64	186	-28	199	-14
Forfar Road NB	434	428	-7	431	-3	418	-16
Forfar Road SB	311	327	17	302	-9	306	-4
Hawkhill Road EB	127	126	-1	125	-2	125	-2
Hawkhill Road WB	126	127	1	124	-1	125	0
Inverary/Albany/Gardner NB	164	171	7	173	9	164	0
Inverary/Albany/Gardner SB	111	111	0	111	0	111	0
Lochee Road NB	608	610	3	607	-1	591	-17
Lochee Road SB	450	449	-1	460	10	441	-8
Perth Road EB	468	455	-13	453	-15	471	2
Perth Road WB	459	447	-12	438	-21	455	-4
Ring Road Anticlockwise	415	428	13	431	16	442	27
Ring Road Clockwise	479	499	20	480	2	494	15
Strathmartine Road SB	363	373	10	365	3	364	1
Hilltown NB	373	373	1	365	-7	372	0

4.3.3 In general, the comparisons show that the LEZ proposals have little impact on the average journey time on the majority of routes.

4.3.4 The largest increases in journey time are on East Dock Street Westbound in both periods and the Ring Road in the clockwise direction in the AM which is caused by non-compliant vehicles utilising alternative parking locations on the periphery of the LEZ area, as noted in Section 3.2 above. There is particularly notable queueing around the East Dock Street/East Marketgait junction in Option 1 in in the AM period as noted above,

## 4.4 General Network Statistics

4.4.1 For the modelled area, average trip distances and speeds for the AM and PM periods were compared in order to assess the overall network impact resulting from the introduction of a LEZ, as shown in Table 4.3

**Table 4.3 : Speed and distance comparisons**

07:00-10:00	Units	RefCase	Option 1	Option 2	Option 3
Total Compliant Vehicles	vehs	55502	55735	55793	55819
Total Non- Compliant Vehicles	vehs	37091	36548	36667	36638
Compliant Speed	mph	23.2	23.0	23.2	23.3
Non-Compliant Speed	mph	23.7	23.4	23.7	23.7
Compliant Av. Distance	m	4602	4602	4599	4604
Non-Compliant Av. Distance	m	4813	4830	4829	4832

16:00-19:00	Units	RefCase	Option 1	Option 2	Option 3
Total Compliant Vehicles	vehs	75307	75362	75439	75397
Total Non- Compliant Vehicles	vehs	43243	42809	42823	42820
Compliant Speed	mph	21.4	21.0	21.3	21.2
Non-Compliant Speed	mph	22.0	21.6	22.0	21.9
Compliant Av. Distance	m	3984	3985	3982	3984
Non-Compliant Av. Distance	m	4169	4202	4198	4199

4.4.2 The results show that although there is little overall difference in average speed of vehicles across the options, there is a small increase in trip distance for non-compliant vehicles as a result of the LEZ proposals. This increase in trip distance, assuming the same average speed as for the rest of the journey, will lead to a direct increase in carbon emissions for the non-compliant vehicles of between 0.3% and 0.8%. This will be quantified in detail by the SEPA air quality modelling.

## 4.5 Link Flow Comparisons

4.5.1 Modelled link flows were compared for selected locations on the inner ring road for each inner ring road LEZ option. This was undertaken to understand the localised impact of each option in restricting non-compliant vehicles from accessing the area inside the inner ring road and redistributing trips to car parks on the periphery of the proposed option area.

4.5.2 Table 4.4 shows 12 hour two-way modelled flows at 10 locations on the inner ring road for the Reference Case and each LEZ Option. 12 hour two-way flow is presented to assist with the NLEF appraisal process to identify a preferred LEZ option through, amongst other criteria, potential impacts on NO<sub>2</sub> emissions.



**Table 4.4 : 12 Hour Two-Way Flow Comparisons on Inner Ring Road (All Vehicles)**

Site	Location	Ref Case	Op1	Difference (Op1-Ref)	% Diff
West Marketgait	North of West Bell St	17386	16269	-1118	-6.4%
North Marketgait	West of Ladywell Rbt	23535	22158	-1377	-5.9%
Victoria Road	South of Ladywell Rbt	13344	13014	-330	-2.5%
North Marketgait	North of East Port Rbt	17470	16549	-920	-5.3%
East Marketgait	North of East Dock St	13950	14236	286	2.1%
Dock Street	West of Trades Lane	30051	30804	753	2.5%
Thomson Ave	At Slessor Grdns (1-way)	13609	13989	379	2.8%
Riverside Esplanade	At Slessor Grdns (1-way)	15209	15679	470	3.1%
West Marketgait	South of Nethergate	11901	13815	1915	16.1%
West Marketgait	South of West Port Rbt	12779	13931	1152	9.0%

Site	Location	Ref Case	Op2	Difference (Op2-Ref)	% Diff
West Marketgait	North of West Bell St	17386	16014	-1372	-7.9%
North Marketgait	West of Ladywell Rbt	23535	22972	-562	-2.4%
Victoria Road	South of Ladywell Rbt	13344	12840	-504	-3.8%
North Marketgait	North of East Port Rbt	17470	16977	-493	-2.8%
East Marketgait	North of East Dock St	13950	14308	358	2.6%
Dock Street	West of Trades Lane	30051	30558	507	1.7%
Thomson Ave	At Slessor Grdns (1-way)	13609	14201	592	4.3%
Riverside Esplanade	At Slessor Grdns (1-way)	15209	15395	186	1.2%
West Marketgait	South of Nethergate	11901	13694	1793	15.1%
West Marketgait	South of West Port Rbt	12779	14289	1510	11.8%

Site	Location	Ref Case	Op3	Difference (Op3-Ref)	% Diff
West Marketgait	North of West Bell St	17386	15894	-1492	-8.6%
North Marketgait	West of Ladywell Rbt	23535	22498	-1037	-4.4%
Victoria Road	South of Ladywell Rbt	13344	12977	-367	-2.8%
North Marketgait	North of East Port Rbt	17470	17556	86	0.5%
East Marketgait	North of East Dock St	13950	14313	363	2.6%
Dock Street	West of Trades Lane	30051	30642	591	2.0%
Thomson Ave	At Slessor Grdns (1-way)	13609	14254	645	4.7%
Riverside Esplanade	At Slessor Grdns (1-way)	15209	15402	192	1.3%
West Marketgait	South of Nethergate	11901	13717	1816	15.3%
West Marketgait	South of West Port Rbt	12779	14222	1443	11.3%

4.5.3

The modelled flow comparisons show there to be some redistribution of traffic on the inner ring road as a result of each LEZ option. In all options there is a decrease in traffic flow on West Marketgait north of West Port roundabout due to a reduction in non-compliant vehicles accessing the city centre using West Bell Street and Ward Road. Conversely there is an increase in traffic flow on West Marketgait south of West Port roundabout, primarily due to an increase in non-compliant vehicles, displaced from the city centre to car parks on the periphery of the LEZ area (e.g. Greenmarket or West Marketgait NCP). At all locations the changes in traffic flows are not considered significant for the class of road (dual carriageway) for the two-way 12 hour time period represented.

## 5. LOCHEE ROAD LEZ OPTION VARIANTS

### 5.1 Background

5.1.1 In addition to the three core inner ring road options described above, two further variants were tested where the LEZ was extended along the Lochee Road corridor, as identified through the NLEF public and stakeholder consultation. The Lochee Road options tests were:

- Variant 1: LEZ Option 1/2/3 (above) plus West Marketgait between West Port Roundabout and Dudhope Roundabout and Lochee Road to Tullideph Road
- Variant 2: LEZ Option 1/2/3 (above) plus West Marketgait between West Port Roundabout and Dudhope Roundabout and Lochee Road to Loon's Road

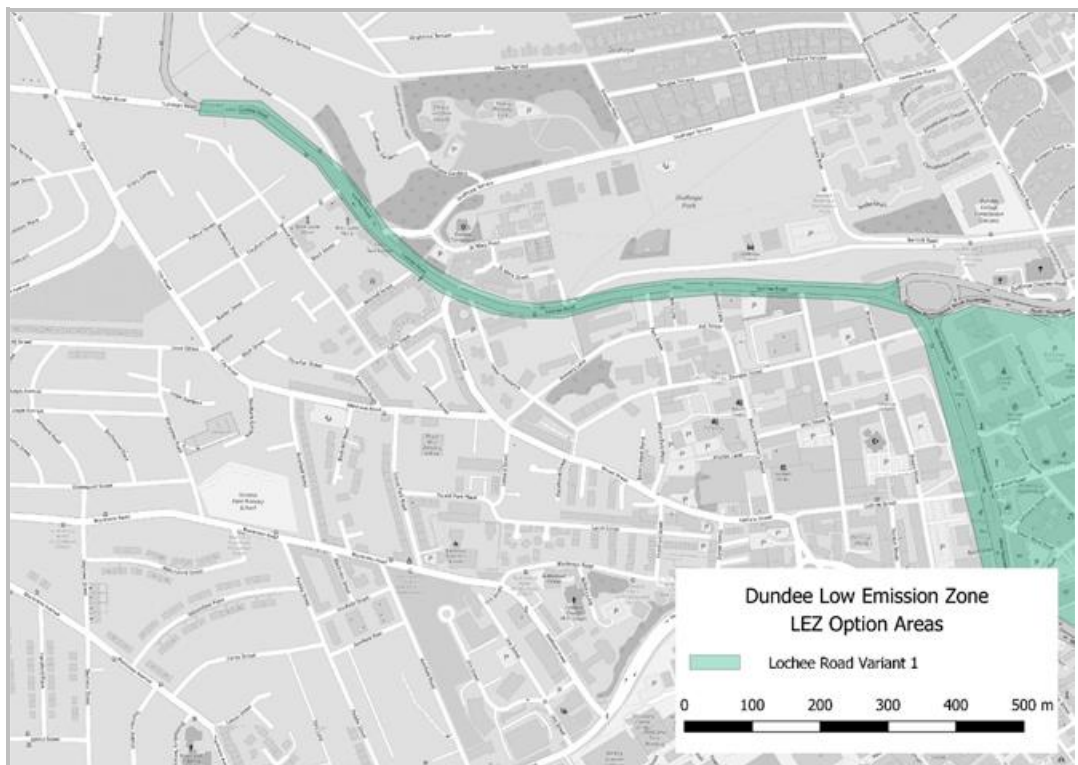
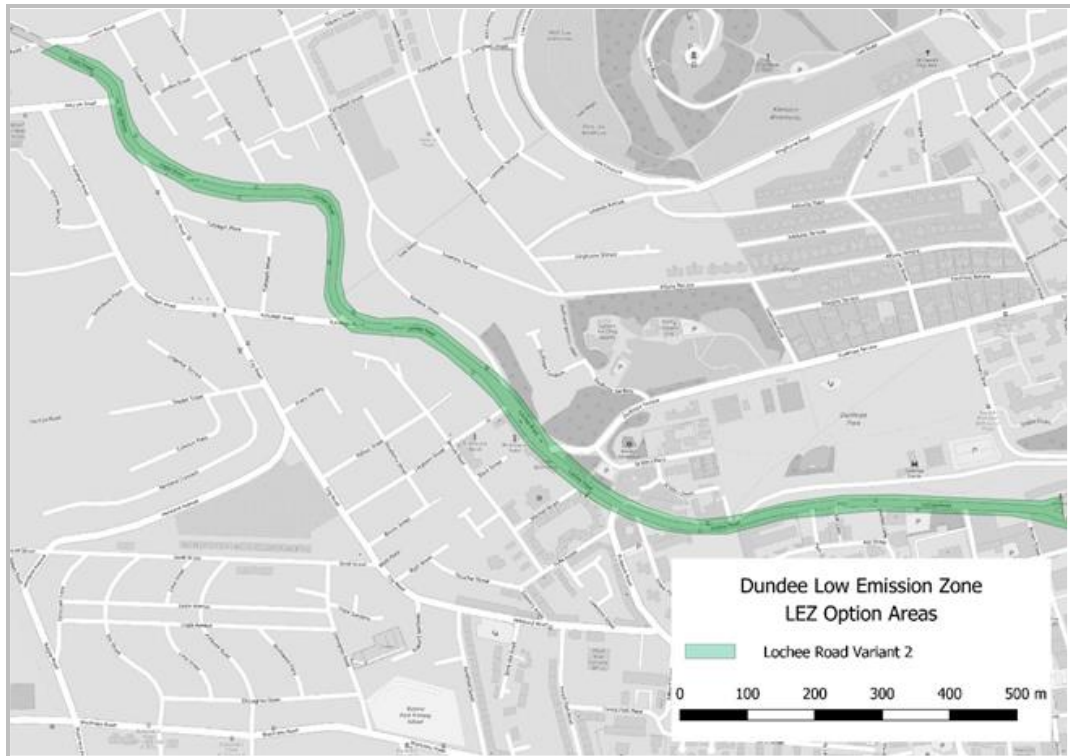


Figure 5.1 : Lochee Road Option Variant 1



**Figure 5.2 : Lochee Road Option Variant 2**

## **5.2 Option Performance Comparisons – Lochee Road Variants**

5.2.1 Each of the Lochee Road variants was run 10 times each for the three time periods AM (07:00-10:00), IP (10:00-16:00), PM (16:00-19:00) and results averaged across the 10 runs.

## **5.3 General Model Observations**

5.3.1 The Lochee Road Variant 1 shows increased levels of congestion originating from the East Dock Street/East Marketgait junction, in the PM period the queueing can extend along the waterfront area and past the East Dock Street/Tay Bridge junction and on to the bridge itself. In the PM, there is also an increase in queueing at the High Street/Loon’s Road junction where queueing can extend back on to Ancrum Road and on to Gardner Street northbound on approach to Loon’s Road. In general, this option variant has a more localised impact on the road network, due to the shorter extent of the Lochee Road corridor influenced by the LEZ

5.3.2 Extending the LEZ option to incorporate Lochee Road to Loon’s Road (variant 2) results in a more significant strategic shift of non-compliant traffic away from the Lochee Road corridor to other key routes in and out of the city such as Riverside Drive, Perth Road/Hawkhill and Strathmartine Road/Hilltown. Variant 2 shows increased congestion compared to the Variant 1 models, however again this is most notable around the East Dock Street/East Marketgait junction with queueing in the PM period extending back on to the Tay Bridge. The queueing at the Loon’s Road/High Street junction and Loon’s Road/Gardner Street is not present in these models, as non-compliant vehicles utilise more strategic routes to routes around the city.

## 5.4 Journey Time Comparisons

5.4.1 Journey Times were collected over the same 11 routes assessed for the core inner ring road options, as specified by DCC and shown in Figure 5.2.

5.4.2 Table 5.1 to Table 5.6 below show the journey time comparisons for the Lochee Road LEZ option variants compared against the 2023 Reference Case.

**Table 5.1 : AM Journey Time Comparison for Option 1 Lochee Road Variants (seconds) 08:00-09:00**

Route	Ref Case	Op1	Difference (Op1-Ref)	Op1v1	Difference (Op1v1-Ref)	Op1v2	Difference (Op1v2-Ref)
A85 EB	404	406	1	406	2	406	2
A85 WB	435	431	-4	431	-4	432	-4
City Road/Milnbank Road NB	154	153	-1	155	1	148	-6
City Road/Milnbank Road SB	152	150	-3	156	4	149	-4
Dens Road NB	242	242	0	247	5	245	4
Dens Road SB	253	250	-3	244	-9	251	-2
East Dock Street EB	177	178	1	178	1	178	0
East Dock Street WB	199	272	74	355	156	387	188
Forfar Road NB	304	304	0	303	-2	304	0
Forfar Road SB	278	289	10	369	91	570	292
Hawkhill Road EB	118	117	-1	116	-2	116	-2
Hawkhill Road WB	126	129	3	126	0	127	1
Inverary/Albany/Gardner NB	123	123	1	132	10	118	-4
Inverary/Albany/Gardner SB	107	107	0	108	1	108	0
Lochee Road NB	392	390	-2	392	0	357	-34
Lochee Road SB	400	399	-1	381	-19	373	-28
Perth Road EB	489	423	-66	449	-41	468	-21
Perth Road WB	419	432	13	428	9	422	3
Ring Road Anticlockwise	373	384	11	358	-15	359	-14
Ring Road Clockwise	462	490	29	558	96	572	110
Strathmartine Road SB	343	337	-6	349	5	346	2
Hilltown NB	350	353	3	356	6	353	3

**Table 5.2 : PM Journey Time Comparison for Option 1 Lochee Road Variants (seconds) 17:00-18:00**

Route	Ref Case	Op1	Difference (Op1-Ref)	Op1v1	Difference (Op1v1-Ref)	Op1v2	Difference (Op1v2-Ref)
A85 EB	439	444	5	511	72	694	255
A85 WB	436	440	4	436	0	440	3
City Road/Milnbank Road NB	163	165	2	182	19	152	-11
City Road/Milnbank Road SB	157	156	-1	160	3	158	1
Dens Road NB	270	277	7	285	15	288	18
Dens Road SB	315	316	2	312	-3	329	14
East Dock Street EB	216	236	20	187	-29	177	-39
East Dock Street WB	214	278	64	479	265	504	291
Forfar Road NB	434	428	-7	382	-52	368	-66
Forfar Road SB	311	327	17	622	312	917	606
Hawkhill Road EB	127	126	-1	126	-1	130	3
Hawkhill Road WB	126	127	1	128	2	125	0
Inverary/Albany/Gardner NB	164	171	7	264	100	157	-7
Inverary/Albany/Gardner SB	111	111	0	115	4	112	1
Lochee Road NB	608	610	3	630	22	566	-41
Lochee Road SB	450	449	-1	420	-30	411	-39
Perth Road EB	468	455	-13	505	36	497	28
Perth Road WB	459	447	-12	453	-6	450	-9
Ring Road Anticlockwise	415	428	13	497	82	566	151
Ring Road Clockwise	479	499	20	580	101	615	136
Strathmartine Road SB	363	373	10	385	23	402	39
Hilltown NB	373	373	1	389	16	374	1

**Table 5.3 : AM Journey Time Comparison for Option 2 Lochee Road Variants (seconds) 08:00-09:00**

Route	Ref Case	Op2	Difference (Op1-Ref)	Op2v1	Difference (Op1v1-Ref)	Op2v2	Difference (Op1v2-Ref)
A85 EB	404	403	-1	405	0	408	3
A85 WB	435	433	-2	433	-2	434	-1
City Road/Milnbank Road NB	154	154	0	156	2	149	-5
City Road/Milnbank Road SB	152	150	-3	155	2	149	-3
Dens Road NB	242	246	4	243	1	245	3
Dens Road SB	253	253	1	244	-9	247	-5
East Dock Street EB	177	177	-1	181	3	181	4
East Dock Street WB	199	230	31	263	64	304	105
Forfar Road NB	304	301	-3	299	-5	300	-4
Forfar Road SB	278	277	-1	304	26	350	72
Hawkhill Road EB	118	118	0	119	1	119	1
Hawkhill Road WB	126	128	1	126	0	127	1
Inverary/Albany/Gardner NB	123	123	0	132	10	119	-3
Inverary/Albany/Gardner SB	107	107	0	108	1	107	0
Lochee Road NB	392	387	-5	395	3	355	-36
Lochee Road SB	400	400	0	379	-21	370	-30
Perth Road EB	489	459	-31	455	-34	433	-56
Perth Road WB	419	428	9	430	11	433	14
Ring Road Anticlockwise	373	376	3	360	-13	363	-11
Ring Road Clockwise	462	477	15	506	44	528	66
Strathmartine Road SB	343	349	6	343	0	344	1
Hilltown NB	350	350	0	357	7	352	3

**Table 5.4 : PM Journey Time Comparison for Option 2 Lochee Road Variants (seconds) 17:00-18:00**

Route	Ref Case	Op2	Difference (Op1-Ref)	Op2v1	Difference (Op1v1-Ref)	Op2v2	Difference (Op1v2-Ref)
A85 EB	439	449	10	552	113	666	227
A85 WB	436	440	3	445	9	447	11
City Road/Milnbank Road NB	163	163	0	190	27	153	-10
City Road/Milnbank Road SB	157	155	-2	161	4	156	-1
Dens Road NB	270	277	7	284	14	286	16
Dens Road SB	315	314	-1	306	-9	323	8
East Dock Street EB	216	229	13	193	-23	181	-35
East Dock Street WB	214	186	-28	362	149	453	239
Forfar Road NB	434	431	-3	388	-46	375	-60
Forfar Road SB	311	302	-9	426	116	780	469
Hawkhill Road EB	127	125	-2	129	2	133	6
Hawkhill Road WB	126	124	-1	125	0	125	-1
Inverary/Albany/Gardner NB	164	173	9	280	117	160	-4
Inverary/Albany/Gardner SB	111	111	0	115	4	113	2
Lochee Road NB	608	607	-1	637	30	563	-45
Lochee Road SB	450	460	10	431	-19	420	-30
Perth Road EB	468	453	-15	464	-4	462	-7
Perth Road WB	459	438	-21	472	13	448	-11
Ring Road Anticlockwise	415	431	16	516	101	609	194
Ring Road Clockwise	479	480	2	552	73	596	118
Strathmartine Road SB	363	365	3	388	26	394	32
Hilltown NB	373	365	-7	390	18	377	4

**Table 5.5 : AM Journey Time Comparison for Option 3 Lochee Road Variants (seconds) 08:00-09:00**

Route	Ref Case	Op3	Difference (Op1-Ref)	Op3v1	Difference (Op1v1-Ref)	Op3v2	Difference (Op1v2-Ref)
A85 EB	404	406	2	405	0	408	3
A85 WB	435	437	1	433	-2	434	-1
City Road/Milnbank Road NB	154	155	1	156	2	149	-5
City Road/Milnbank Road SB	152	151	-1	155	2	149	-3
Dens Road NB	242	242	0	243	1	245	3
Dens Road SB	253	253	0	244	-9	247	-5
East Dock Street EB	177	177	0	181	3	181	4
East Dock Street WB	199	226	27	263	64	304	105
Forfar Road NB	304	299	-5	299	-5	300	-4
Forfar Road SB	278	283	5	304	26	350	72
Hawkhill Road EB	118	118	0	119	1	119	1
Hawkhill Road WB	126	126	-1	126	0	127	1
Inverary/Albany/Gardner NB	123	123	0	132	10	119	-3
Inverary/Albany/Gardner SB	107	107	0	108	1	107	0
Lochee Road NB	392	390	-1	395	3	355	-36
Lochee Road SB	400	400	0	379	-21	370	-30
Perth Road EB	489	461	-29	455	-34	433	-56
Perth Road WB	419	434	15	430	11	433	14
Ring Road Anticlockwise	373	367	-6	360	-13	363	-11
Ring Road Clockwise	462	474	12	506	44	528	66
Strathmartine Road SB	343	346	3	343	0	344	1
Hilltown NB	350	347	-3	357	7	352	3



**Table 5.6 : PM Journey Time Comparison for Option 3 Lochee Road Variants (seconds) 17:00-18:00**

Route	Ref Case	Op3	Difference (Op1-Ref)	Op3v1	Difference (Op1v1-Ref)	Op3v2	Difference (Op1v2-Ref)
A85 EB	439	447	7	566	127	866	427
A85 WB	436	439	3	443	7	447	11
City Road/Milnbank Road NB	163	161	-2	188	25	153	-10
City Road/Milnbank Road SB	157	155	-2	160	3	156	-1
Dens Road NB	270	275	5	282	12	278	8
Dens Road SB	315	312	-3	312	-2	362	47
East Dock Street EB	216	215	-1	191	-25	175	-40
East Dock Street WB	214	199	-14	390	176	435	221
Forfar Road NB	434	418	-16	385	-49	364	-70
Forfar Road SB	311	306	-4	532	222	935	625
Hawkhill Road EB	127	125	-2	129	2	147	20
Hawkhill Road WB	126	125	0	125	0	127	1
Inverary/Albany/Gardner NB	164	164	0	305	141	167	3
Inverary/Albany/Gardner SB	111	111	0	113	2	116	5
Lochee Road NB	608	591	-17	647	39	565	-43
Lochee Road SB	450	441	-8	428	-22	419	-31
Perth Road EB	468	471	2	455	-13	483	14
Perth Road WB	459	455	-4	464	5	451	-8
Ring Road Anticlockwise	415	442	27	523	108	692	277
Ring Road Clockwise	479	494	15	558	79	639	160
Strathmartine Road SB	363	364	1	395	33	425	62
Hilltown NB	373	372	0	392	20	378	5

- 5.4.3 The comparisons for Lochee Road Variant 1 show decreases in average journey time on Lochee Road Southbound in the AM and PM as non-compliant trips are moved off this route. The inner ring road option 1 model variants see the largest increases in journey times though increases are also reported in options 2 and 3. In the AM period there are notable increases in average journey time on Forfar Road southbound, the Ring Road in a clockwise direction and East Dock Street westbound. The maximum increase is noted in the Option 1 Variant 1 model of over 2 minutes 30 seconds on East Dock Street Westbound. In the PM there are significant notable increases are on A85 Eastbound, East Dock Street Westbound, Forfar Road Southbound, Gardner Street Northbound and the Ring Road in both directions, representing significant network congestion. The maximum increase is noted in the Option 1 Variant 1 model of over 5 minutes on Forfar Road southbound.
- 5.4.4 The increase in journey times on Forfar Road Southbound, East Dock Street westbound and the Ring Road is a result of the increase in congestion at East Dock Street/Marketgait, which is exacerbated in the Lochee Road Variant 1 models by the inclusion of Lochee Road and West Marketgait in the LEZ. This forces non-compliant vehicles which previously used these routes to find alternative routes. In particular the inclusion of West Marketgait in the LEZ effectively closes a section of the ring road to non-compliant vehicles, causing increased queueing on other routes.
- 5.4.5 The increase in journey times on Gardner Street Northbound is caused by vehicles rerouting along Inverary Terrace/Gardner Street to avoid the LEZ section of Lochee Road. This causes a queue on Gardner Street at the junction with Loon's Road.
- 5.4.6 The comparisons for Lochee Road Variant 2 also show decreases in average journey time on Lochee Road Northbound and Southbound in the AM and PM as non-compliant trips are moved off this route. In the AM there are notable increases in average journey time on Forfar Road Southbound, the Ring Road in a clockwise direction and East Dock Street Westbound. In the PM the notable increases are on A85 Eastbound, East Dock Street Westbound, Forfar Road Southbound, Northbound and the Ring Road in both directions. The maximum increase is noted in the Option 1 Variant 2 models approximately 5 minutes

in AM period and over 10 minutes in the PM period. In general, the scale of the increases is larger in the variant 2 models due to the wider displacement of non-compliant vehicles.

- 5.4.7 Again, the increase in journey times on Forfar Road Southbound and East Dock Street westbound and the Ring Road is a result of the increase in congestion at East Dock Street/Marketgait, this is exacerbated in the Lochee Road Variant 2 models compared to the Variant 1 models as longer section of Lochee Road is included in the LEZ which forces wider rerouting of vehicles. It is noticeable that increases are on routes separate from the Lochee Road corridor and show that the inclusion of Lochee Road in any LEZ has wide ranging implications on the Dundee road network.

## **5.5 General Network Statistics**

- 5.5.1 For the modelled area, average trip distances and speeds for the AM and PM were compared in order to assess the overall network impact.
- 5.5.2 Table 5.7 shows average trip distances and speeds for these variants compared with the Reference Case.
- 5.5.3 The inclusion of Lochee Road in the LEZ leads to a reduction in average speed for all three options, with the Variant 2 models showing the largest decrease in average speed due to the resulting congestion being worse. The average distance driven by non-compliant cars does increase with Lochee Road included in the LEZ boundary, as these vehicles are forced to reroute to avoid Lochee Road. This increase is larger in the Variant 2 models. This suggests that including Lochee Road in the LEZ may in fact result in greater overall CO2 emissions than without due to the additional displacement of the non-compliant traffic. This increase in trip distance, assuming a consistent average speed with the rest of a vehicle trip, will lead to a direct increase in carbon emissions for the non-compliant vehicles of between 1.2% and 2.4% for the Lochee Road Variant 1 models and 2.5% and 4.0% for the Lochee Road Variant 2 models..

**Table 5.7 : Speed and Distance comparison for Lochee Road Variants**

<b>07:00-10:00</b>	<b>Units</b>	<b>RefCase</b>	<b>Option 1</b>	<b>Option 1 v1</b>	<b>Option 1 v2</b>
Total Compliant Vehicles	vehs	55502	55735	55535	55290
Total Non- Compliant Vehicles	vehs	37091	36548	36460	36328
Compliant Speed	mph	23.2	23.0	22.4	22.1
Non-Compliant Speed	mph	23.7	23.4	22.7	22.5
Compliant Av. Distance	m	4602	4602	4594	4577
Non-Compliant Av. Distance	m	4813	4830	4875	4936

<b>16:00-19:00</b>	<b>Units</b>	<b>RefCase</b>	<b>Option 1</b>	<b>Option 1 v1</b>	<b>Option 1 v2</b>
Total Compliant Vehicles	vehs	75307	75362	75275	75174
Total Non- Compliant Vehicles	vehs	43243	42809	42729	42639
Compliant Speed	mph	21.4	21.0	20.0	19.5
Non-Compliant Speed	mph	22.0	21.6	20.3	19.8
Compliant Av. Distance	m	3984	3985	3995	3992
Non-Compliant Av. Distance	m	4169	4202	4267	4329

<b>07:00-10:00</b>	<b>Units</b>	<b>RefCase</b>	<b>Option 2</b>	<b>Option 2 v1</b>	<b>Option 2 v2</b>
Total Compliant Vehicles	vehs	55502	55793	55770	55677
Total Non- Compliant Vehicles	vehs	37091	36667	36566	36486
Compliant Speed	mph	23.2	23.2	22.7	22.5
Non-Compliant Speed	mph	23.7	23.7	23.0	23.0
Compliant Av. Distance	m	4602	4599	4603	4593
Non-Compliant Av. Distance	m	4813	4829	4883	4947

<b>16:00-19:00</b>	<b>Units</b>	<b>RefCase</b>	<b>Option 2</b>	<b>Option 2 v1</b>	<b>Option 2 v2</b>
Total Compliant Vehicles	vehs	75307	75439	75297	75196
Total Non- Compliant Vehicles	vehs	43243	42823	42780	42643
Compliant Speed	mph	21.4	21.3	20.1	19.6
Non-Compliant Speed	mph	22.0	22.0	20.5	20.0
Compliant Av. Distance	m	3984	3982	3993	3989
Non-Compliant Av. Distance	m	4169	4198	4268	4335

<b>07:00-10:00</b>	<b>Units</b>	<b>RefCase</b>	<b>Option 3</b>	<b>Option 3 v1</b>	<b>Option 3 v2</b>
Total Compliant Vehicles	vehs	55502	55819	55734	55391
Total Non- Compliant Vehicles	vehs	37091	36638	36580	36479
Compliant Speed	mph	23.2	23.3	22.6	22.3
Non-Compliant Speed	mph	23.7	23.7	23.0	22.8
Compliant Av. Distance	m	4602	4604	4603	4586
Non-Compliant Av. Distance	m	4813	4832	4882	4946

<b>16:00-19:00</b>	<b>Units</b>	<b>RefCase</b>	<b>Option 3</b>	<b>Option 3 v1</b>	<b>Option 3 v2</b>
Total Compliant Vehicles	vehs	75307	75397	75303	75090
Total Non- Compliant Vehicles	vehs	43243	42820	42762	42712
Compliant Speed	mph	21.4	21.2	20.0	19.5
Non-Compliant Speed	mph	22.0	21.9	20.4	19.7
Compliant Av. Distance	m	3984	3984	3997	3991
Non-Compliant Av. Distance	m	4169	4199	4266	4337

## 5.6 Link Flow Comparisons

- 5.6.1 Modelled link flow were compared for selected locations on the inner ring road, on Lochee Road and on local routes (as defined by DCC) for each LEZ Lochee Road option variant. This was undertaken to understand fully the impact of each option in restricting non-compliant vehicles from the Lochee Road corridor as well as from accessing the area inside the inner ring road and redistributing trips to car parks on the periphery of the proposed option area.
- 5.6.2 12 hour two-way modelled flows are presented in this section with directional AM and PM peak hour flows presented in Appendix A. 12 hour two-way flow is presented here to assist with the NLEF appraisal process to identify a preferred LEZ option through, amongst other criteria, potential impacts on NO<sub>2</sub> emissions.
- 5.6.3 Table 5.8 and Table 5.9 show the 12 hour two-way modelled flows at 10 locations on the inner ring road for the Reference Case and each LEZ Lochee Road option variant.
- 5.6.4 The flow comparisons show there to be significant changes in traffic flows on the inner ring road as a result of incorporating Lochee Road in any LEZ option. The largest increase in vehicle flows are on East Marketgait, Dock Street, West Marketgait (south of West Port roundabout) and the waterfront area of between approximately 3000 vehicles and 5300 vehicles over 12 hours. There is a significant reduction in traffic on West Marketgait (north of West Port roundabout) as a result of non-compliant vehicles restricted from this section of the inner ring road. North Marketgait sees as a significant drop in vehicles, primarily due to the restrictions for non-compliant vehicles on the adjacent Lochee Road corridor. While such a reduction here may be welcome, the resultant opposing increases on the southern and eastern sections of the inner ring road result in significant congestion, as noted above, with queues extending along the waterfront area, East Dock Street and the Tay Road Bridge and journey times significantly increasing on the routes approaching these locations (Forfar Road and East Dock Street).

**Table 5.8 : 12 Hour Two-Way Flow Comparisons on Inner Ring Road (All Vehicles) – Variant 1**

Site	Location	Ref Case	Op1 & Lochee Rd - Tullideph Rd	Difference (Op-Ref)	% Diff
West Marketgait	North of West Bell St	17386	12309	-5078	-29.2%
North Marketgait	West of Ladywell Rbt	23535	18278	-5256	-22.3%
Victoria Road	South of Ladywell Rbt	13344	12491	-852	-6.4%
North Marketgait	North of East Port Rbt	17470	16633	-836	-4.8%
East Marketgait	North of East Dock St	13950	16326	2376	17.0%
Dock Street	West of Trades Lane	30051	34049	3998	13.3%
Thomson Ave	At Slessor Grdns (1-way)	13609	16218	2609	19.2%
Riverside Esplanade	At Slessor Grdns (1-way)	15209	17686	2477	16.3%
West Marketgait	South of Nethergate	11901	13978	2077	17.5%
West Marketgait	South of West Port Rbt	12779	13635	856	6.7%

Site	Location	Ref Case	Op2 & Lochee Rd - Tullideph Rd	Difference (Op-Ref)	% Diff
West Marketgait	North of West Bell St	17386	12532	-4854	-27.9%
North Marketgait	West of Ladywell Rbt	23535	20124	-3410	-14.5%
Victoria Road	South of Ladywell Rbt	13344	12871	-472	-3.5%
North Marketgait	North of East Port Rbt	17470	17754	284	1.6%
East Marketgait	North of East Dock St	13950	17280	3330	23.9%
Dock Street	West of Trades Lane	30051	35463	5412	18.0%
Thomson Ave	At Slessor Grdns (1-way)	13609	16581	2972	21.8%
Riverside Esplanade	At Slessor Grdns (1-way)	15209	18543	3334	21.9%
West Marketgait	South of Nethergate	11901	16112	4211	35.4%
West Marketgait	South of West Port Rbt	12779	16111	3332	26.1%

Site	Location	Ref Case	Op3 & Lochee Rd - Tullideph Rd	Difference (Op-Ref)	% Diff
West Marketgait	North of West Bell St	17386	12558	-4829	-27.8%
North Marketgait	West of Ladywell Rbt	23535	19372	-4163	-17.7%
Victoria Road	South of Ladywell Rbt	13344	12900	-443	-3.3%
North Marketgait	North of East Port Rbt	17470	18270	801	4.6%
East Marketgait	North of East Dock St	13950	17276	3326	23.8%
Dock Street	West of Trades Lane	30051	35336	5285	17.6%
Thomson Ave	At Slessor Grdns (1-way)	13609	16553	2944	21.6%
Riverside Esplanade	At Slessor Grdns (1-way)	15209	18416	3207	21.1%
West Marketgait	South of Nethergate	11901	16106	4206	35.3%
West Marketgait	South of West Port Rbt	12779	16098	3319	26.0%

**Table 5.9 : 12 Hour Two-Way Flow Comparisons on Inner Ring Road (All Vehicles) – Variant 2**

Site	Location	Ref Case	Op1 & Lochee Rd - Loon's Rd	Difference (Op-Ref)	% Diff
West Marketgait	North of West Bell St	17386	12344	-5042	-29.0%
North Marketgait	West of Ladywell Rbt	23535	18503	-5032	-21.4%
Victoria Road	South of Ladywell Rbt	13344	12929	-415	-3.1%
North Marketgait	North of East Port Rbt	17470	17312	-158	-0.9%
East Marketgait	North of East Dock St	13950	17190	3240	23.2%
Dock Street	West of Trades Lane	30051	34888	4837	16.1%
Thomson Ave	At Slessor Grdns (1-way)	13609	16612	3003	22.1%
Riverside Esplanade	At Slessor Grdns (1-way)	15209	18221	3012	19.8%
West Marketgait	South of Nethergate	11901	14409	2509	21.1%
West Marketgait	South of West Port Rbt	12779	14127	1347	10.5%

Site	Location	Ref Case	Op2 & Lochee Rd - Loon's Rd	Difference (Op-Ref)	% Diff
West Marketgait	North of West Bell St	17386	12338	-5049	-29.0%
North Marketgait	West of Ladywell Rbt	23535	19802	-3733	-15.9%
Victoria Road	South of Ladywell Rbt	13344	12974	-370	-2.8%
North Marketgait	North of East Port Rbt	17470	18007	537	3.1%
East Marketgait	North of East Dock St	13950	17615	3665	26.3%
Dock Street	West of Trades Lane	30051	35247	5196	17.3%
Thomson Ave	At Slessor Grdns (1-way)	13609	16579	2970	21.8%
Riverside Esplanade	At Slessor Grdns (1-way)	15209	18304	3095	20.3%
West Marketgait	South of Nethergate	11901	16320	4419	37.1%
West Marketgait	South of West Port Rbt	12779	16408	3629	28.4%

Site	Location	Ref Case	Op3 & Lochee Rd - Loon's Rd	Difference (Op-Ref)	% Diff
West Marketgait	North of West Bell St	17386	12627	-4759	-27.4%
North Marketgait	West of Ladywell Rbt	23535	19369	-4165	-17.7%
Victoria Road	South of Ladywell Rbt	13344	13450	107	0.8%
North Marketgait	North of East Port Rbt	17470	18930	1461	8.4%
East Marketgait	North of East Dock St	13950	18111	4161	29.8%
Dock Street	West of Trades Lane	30051	36160	6109	20.3%
Thomson Ave	At Slessor Grdns (1-way)	13609	16811	3202	23.5%
Riverside Esplanade	At Slessor Grdns (1-way)	15209	18851	3642	23.9%
West Marketgait	South of Nethergate	11901	16785	4885	41.0%
West Marketgait	South of West Port Rbt	12779	16909	4130	32.3%

5.6.5 Table 5.10 shows the 12 hour two-way modelled flows at 18 locations on the Lochee Road corridor and adjacent local roads for the Reference Case and LEZ core option 3 with Lochee Road option variants 1 and 2. The comparisons for LEZ core options 1 and 2 are presented in Appendix B, with the changes in flows patterns considered consistent between all three core inner ring road options.



**Table 5.10 : 12 Hour Two-Way Flow Comparisons on Lochee Rd and adjacent routes (All Vehicles) – Core Option 3, Lochee Rd variants 1 & 2**

Site	Location	Ref Case	Op3 & Lochee Rd - Tullideph Rd	Difference (Op-Ref)	% Diff
Lochee Road	North of Loon's Road	10171	9834	-337	-3.3%
Lochee Road	South of City Road	8223	5700	-2523	-30.7%
Lochee Road	North of Dudhope Terr	15905	11324	-4580	-28.8%
Lochee Road	West of Dudhope Rbt	13764	9875	-3889	-28.3%
Dudhope Terrace	At Lochee Road	3120	2143	-977	-31.3%
Inverary Terrace	South of Rankine Street	2631	3640	1008	38.3%
Rankine Street	South of Inverary Terr	4420	3036	-1384	-31.3%
Tullideph Road	At Lochee Road	3535	2542	-992	-28.1%
City Road	South of Tullideph Road	5756	8289	2533	44.0%
Milnbank Road	At Polepark Road	3627	4830	1202	33.2%
Gardner Street	South of Loon's Road	6284	6221	-62	-1.0%
Loon's Road	At Lochee Road	7358	9623	2265	30.8%
Brook Street	East of Edward Street	4437	5409	972	21.9%
Ancrum Road	At Lochee Road	5920	5869	-51	-0.9%
Hawkhill	East of Hunter Street Rbt	11847	12651	805	6.8%
Blackness Road	East of Forest Park Road	3273	3354	81	2.5%
Bellfield Street	At Hawkhill	2391	2501	111	4.6%
Balfield Road	North of Loon's Road	6500	6083	-418	-6.4%

Site	Location	Ref Case	Op3 & Lochee Rd - Loon's Rd	Difference (Op-Ref)	% Diff
Lochee Road	North of Loon's Road	10171	9335	-836	-8.2%
Lochee Road	South of City Road	8223	5671	-2552	-31.0%
Lochee Road	North of Dudhope Terr	15905	11286	-4618	-29.0%
Lochee Road	West of Dudhope Rbt	13764	9830	-3934	-28.6%
Dudhope Terrace	At Lochee Road	3120	2139	-981	-31.4%
Inverary Terrace	South of Rankine Street	2631	3504	872	33.1%
Rankine Street	South of Inverary Terr	4420	3215	-1205	-27.3%
Tullideph Road	At Lochee Road	3535	2400	-1134	-32.1%
City Road	South of Tullideph Road	5756	6731	975	16.9%
Milnbank Road	At Polepark Road	3627	4420	793	21.9%
Gardner Street	South of Loon's Road	6284	6253	-31	-0.5%
Loon's Road	At Lochee Road	7358	7615	257	3.5%
Brook Street	East of Edward Street	4437	5128	690	15.6%
Ancrum Road	At Lochee Road	5920	4688	-1231	-20.8%
Hawkhill	East of Hunter Street Rbt	11847	12931	1084	9.2%
Blackness Road	East of Forest Park Road	3273	3447	174	5.3%
Bellfield Street	At Hawkhill	2391	2588	197	8.2%
Balfield Road	North of Loon's Road	6500	5842	-659	-10.1%

#### 5.6.6

The flow comparisons in Table 5.10 show there to be significant reductions in vehicle flow on Lochee Road, as expected, with non-compliant vehicles restricted from utilising the corridor. The results show however, that non-compliant vehicles shift from Lochee Road to a number of other adjacent routes. When the LEZ is extended along Lochee Road to Tullideph Road (variant 1), the largest increases in vehicles are seen on City Road and Loon's Road, of over 2000 vehicles over 12 hours. This represents a 44% increase in traffic on City Road and a 30% increase on Loon's Road. When the LEZ is extended to Loon's

Road (variant 2), the impact on local routes is dampened somewhat as the larger LEZ results in a more strategic shift of trips to routes such as Perth Road/Hawkhill, where flows increase by over 1000 vehicles over 12 hours. Analysis of the vehicles switching routes from Lochee Road confirm these to be non-compliant vehicles meaning the local adjacent routes are seeing a significant increase in the most polluting vehicles.

## **6. WEST MARKETGAIT VARIANTS**

### **6.1 Background**

- 6.1.1 During the LEZ model testing, it was identified that the performance of the Lochee Road corridor options was hindered by network congestion primarily resulting from the inclusion of West Marketgait between West Port Roundabout and Dudhope Roundabout in the LEZ area. With West Marketgait included in the LEZ area, non-compliant vehicles using the inner ring road are forced either clockwise or anti-clockwise around the ring road, away from West Marketgait, resulting in significant congestion at the junctions on the eastern side of the inner ring road, primarily East Marketgait/Dock Street. With West Marketgait excluded from the LEZ area, the full inner ring road is available to non-compliant vehicles and thus less displacement results to key junctions on the eastern side of the inner ring road, and therefore less network congestion stemming from this location. To ensure a robust LEZ option testing programme, it was agreed with DCC to model further variants of the Lochee Road options, excluding West Marketgait from the LEZ area.
- 6.1.2 To assess this, six additional test models were created based on each of the Lochee Road variants above, but excluding West Marketgait from the LEZ. This effectively means that in these models there are two LEZs, one covering Lochee Road and a second covering the area inside the inner ring road.
- 6.1.3 Appendix C details the outcomes from these model option tests and concludes that while the options operate with less congestion around the inner ring road area due to the full inner ring road route being available to non-compliant vehicles, the continued inclusion of the Lochee Road corridor still results in a shift of non-compliant vehicles from Lochee Road to adjacent local routes. The largest increases in traffic flow are recorded on Perth Road/Hawkhill of over 2000 vehicles over 12 hours.

## **7. OUTCOMES FROM TRAFFIC MODELLING OF PROPOSED LEZ OPTIONS**

### **7.1 Summary of Results**

7.1.1 15 LEZ options were tested in the Dundee City Paramics traffic model and the model results clearly show there to be considerable impacts on the Dundee Road network if Lochee Road is included in any LEZ option.

7.1.2 The modelling of the three core inner ring road LEZ option boundaries, has shown that, in general the LEZ options operate similarly to the Reference Case but there are some impacts of the proposals on traffic conditions in the city, most notably around the East Dock Street East Marketgait junction, particularly in LEZ Option 1 (including all car parks). This is a result of non-compliant vehicles being reassigned to car parks on the periphery of the LEZ inner ring road area. In Option 2 and 3, where fewer vehicles are displaced due to greater car park availability in these options, general network conditions are similar to Reference Case conditions.

7.1.3 The model results clearly show there to be considerable impacts on the Dundee Road network if Lochee Road is included in any LEZ option. Flow comparisons show there to be significant changes in traffic flows on the inner ring road and on local routes adjacent to as a result of incorporating Lochee Road in any LEZ option. The Lochee Road options also show there are large increases in network modelled journey times when the corridor is included.

7.1.4 The core boundaries do not result in significant extra distance being driven within the city, suggesting that CO2 emissions should remain broadly consistent. Including Lochee Road within the boundary does however result in a small additional distance due to the wider displacement introduced, suggesting a small increase in CO2 emissions would result.

### **7.2 NLEF Outcomes**

7.2.1 The modelling results presented in this report have been used to inform the NLEF appraisal process to help identify the final proposed LEZ for Dundee. From the modelling results, the NLEF process recommended that the core inner ring road LEZ Options 1, 2, and 3 be progressed to further detailed appraisal. All option variants including Lochee Road have been removed and not recommended for further appraisal based on the model outcomes summarised above.

7.2.2 Following the progression of LEZ Option 1, 2 and 3 in the NLEF process, Option 3 has been identified as the final preferred LEZ Option. Full details on this outcome can be found in the NLEF Stage 2 Report.

## 8. POST COVID-19 UNCERTAINTY (SCENARIO PLANNING)

### 8.1 Background

8.1.1 The Covid-19 pandemic has had a dramatic impact on travel across all modes and specifically travel in Scotland's city centres. To assist in the development of the LEZs across Scotland, Transport Scotland commissioned a Scenario Planning study to apply the principals of modelling in considering the uncertainty over what travel will look like after the pandemic has ended.

8.1.2 The outcomes from the study are detailed in the *LEZ Post-Covid Uncertainty Summary Note (SYSTRA Ref. GB01T20E86/11024112/005, January 2021)*. The core traffic modelling results presented in Chapters 2 to 7 in this report are undertaken based on one plausible future scenario, as defined as the 2023 Reference Case. The Covid-19 study recommended that a sensitivity test was undertaken on one other further plausible future, to ensure a robust set of modelling results to inform Dundee's LEZ.

8.1.3 The sensitivity scenario was defined as "Coping as Best We Can" where, following an economic downturn, the projected rate of change towards a cleaner fleet is lower than pre-Covid-19 forecasts (as provided by SEPA) and traffic shrinkage is experienced, similar to the 2010 economic downturn.

8.1.4 To inform a reduction in traffic, DCC's Road Traffic Reduction Act monitoring data was utilised. The data provides surveyed AM and PM peak and Annual Average Daily Traffic (AADT) flows from the city from 1996 to 2020. The data shows a reduction in traffic from pre financial crisis in 2006 to a lowest point in 2012 of around 9% in the AM peak hour and 7.5% in the PM Peak Hour. It was agreed with DCC that a 10% reduction would be applied to the traffic model demands for the 2023 Reference Case and appropriate LEZ Option models.

8.1.5 Following the NLEF process identifying LEZ Option 3 as the preferred final LEZ option for Dundee, it was agreed with DCC that this option would be assessed under the alternative forecast sensitivity test. Although the NLEF process did not recommend any Lochee Road option variants, it was considered important to assess the Lochee Road variants using the lower demand forecasts to understand their impacts in a network with lower levels of traffic. As such, it was agreed with DDC that Covid-19 sensitivity tests were undertaken on the following models:

- Reference Case
- LEZ Option 3 - Inner Ring Road area, excluding Bell Street, West Marketgait NCP and Wellgate car parks
- LEZ Option 3 Lochee Road Variant 1 – Op3 plus West Marketgait between West Port Roundabout and Dudhope Roundabout and Lochee Road to Tullideph Road
- LEZ Option 3 Lochee Road Variant 2 – Op3 plus West Marketgait between West Port Roundabout and Dudhope Roundabout and Lochee Road to Loon's Road

8.1.6 To create the sensitivity test models, the demand matrices in each of scenario models developed for the core testing (outlined in Chapters 2 to 7) were simply reduced globally by 10%. No other changes were made to the models.

### 8.2 General Network Observations

8.2.1 For the most part, the Option models operate without noticeable difference from the Reference Case model. With the reduction in demand, the increase in congestion at East

Dock Street/East Marketgait while still present in the Option models is less significant in all variants.

### 8.3 Journey Time Comparisons

8.3.1 Journey Times were collected over the same 11 routes assessed in the core testing above, as specified by DCC and which represent the relevant routes relating to the LEZ proposals.

8.3.2 Table 8.1 and Table 8.2 show the average journey time in seconds during the peak hours, 08:00-09:00 and 17:00-18:00 respectively, along these routes for the reference case model and the Covid-19 sensitivity test models.

**Table 8.1 : AM Journey Time Comparison for Scenario Planning Variants (seconds) 08:00-09:00**

	AM (08:00-09:00)			
	Ref Case	Option 3	Option 3 v1	Option 3 v2
A85 EB	400	401	403	403
A85 WB	411	412	412	415
City Road/Milnbank Road NB	152	152	154	147
City Road/Milnbank Road SB	149	147	152	148
Dens Road NB	240	238	241	241
Dens Road SB	239	239	237	244
East Dock Street EB	171	170	172	174
East Dock Street WB	170	170	189	210
Forfar Road NB	289	290	289	294
Forfar Road SB	266	267	273	290
Hawkhill Road EB	116	116	117	118
Hawkhill Road WB	128	126	126	126
Inverary/Albany/Gardner NB	118	119	122	116
Inverary/Albany/Gardner SB	106	107	106	107
Lochee Road NB	368	366	374	351
Lochee Road SB	388	387	371	368
Perth Road EB	455	427	468	444
Perth Road WB	428	429	424	432
Ring Road Anticlockwise	347	353	344	348
Ring Road Clockwise	431	435	463	480
Strathmartine Road SB	332	334	336	338
Hilltown NB	345	342	340	344

**Table 8.2 : AM Journey Time Comparison for Scenario Planning Variants (seconds) 08:00-09:00**

	PM (17:00-18:00)			
	Ref Case	Option 3	Option 3 v1	Option 3 v2
A85 EB	414	414	425	440
A85 WB	409	409	415	416
City Road/Milnbank Road NB	157	156	162	152
City Road/Milnbank Road SB	153	153	156	150
Dens Road NB	262	263	263	267
Dens Road SB	294	283	286	284
East Dock Street EB	174	183	177	174
East Dock Street WB	154	179	167	177
Forfar Road NB	343	347	333	340
Forfar Road SB	283	288	288	297
Hawkhill Road EB	120	120	120	123
Hawkhill Road WB	125	123	124	125
Inverary/Albany/Gardner NB	139	140	174	133
Inverary/Albany/Gardner SB	109	108	109	109
Lochee Road NB	463	454	464	426
Lochee Road SB	413	410	396	386
Perth Road EB	465	453	443	437
Perth Road WB	429	436	431	431
Ring Road Anticlockwise	375	393	425	474
Ring Road Clockwise	424	434	449	464
Strathmartine Road SB	343	343	349	338
Hilltown NB	333	342	342	337

8.3.3 In general, the comparisons show that the Option 3 model operates with similar journey times on these routes to the Reference Case. The Option 3 Lochee Road Variant 1 model has increases in journey time of over 30 seconds in the AM on the Ring Road in a clockwise direction and in the PM on the Ring Road in both directions. The Option 3 Lochee Road Variant 2 model has increases in journey time of over 30 seconds in the AM on the Ring Road in a clockwise direction and East Dock Street Westbound and in the PM on the Ring Road in both directions.

## 8.4 General Network Statistics

8.4.1 For the modelled area, average trip distances and speeds for the AM and PM were compared in order to assess the overall network impact.

8.4.2 Table 8.3 shows average trip distances and speeds for these variants compared with the Reference Case.

**Table 8.3 : Speed and Distance Comparison – Scenario Planning Variants**

<b>07:00-10:00</b>	<b>Units</b>	<b>RefCase</b>	<b>Option 3</b>	<b>Option 3 v1</b>	<b>Option 3 v2</b>
Total Compliant Vehicles	vehs	50073	50328	50348	50323
Total Non- Compliant Vehicles	vehs	33453	33076	33035	33010
Compliant Speed	mph	25.9	25.9	25.7	25.6
Non-Compliant Speed	mph	26.5	26.6	26.2	26.2
Compliant Av. Distance	m	4592	4589	4590	4589
Non-Compliant Av. Distance	m	4801	4819	4869	4937

<b>16:00-19:00</b>	<b>Units</b>	<b>RefCase</b>	<b>Option 3</b>	<b>Option 3 v1</b>	<b>Option 3 v2</b>
Total Compliant Vehicles	vehs	67810	67995	67953	67910
Total Non- Compliant Vehicles	vehs	38917	38596	38525	38541
Compliant Speed	mph	24.6	24.5	24.1	23.9
Non-Compliant Speed	mph	25.2	25.1	24.7	24.4
Compliant Av. Distance	m	3963	3962	3963	3965
Non-Compliant Av. Distance	m	4137	4167	4226	4289

8.4.3 The comparisons show that the network average speeds are consistent between the Reference Case and Option 3 model. The Lochee variants show a reduction in in average speed for compliant and non-compliant vehicles and an increase in average trip distance for non-compliant vehicles.

## 8.5 Link Flow Comparisons

8.5.1 Modelled link flow were compared for selected locations on Lochee Road and on local adjacent routes (as defined by DCC) for each Covid-19 test model. Link flows have been extracted for the AM (08:00-09:00) and PM (17:00-18:00) peak hours and presented in Appendix D.

8.5.2 Although the general network conditions are considered comparable between the Covid-19 sensitivity Reference Case and option models, the flow comparisons highlight that there remains significant changes to localised traffic flows as a result of the Lochee Road corridor being included in any LEZ. In a similar manner to the “full” forecast scenarios reported above, significant increases in traffic flow is recorded on routes such as City Road (up to approximately 60% increase), Loon’s Road (up to approximately 50% increase) and Brook Street (up to approximately 80% increase). Clearly, even under a future where traffic demand is at the lower end of forecast predictions, the inclusion of Lochee Road in any LEZ will still result in localised rerouting of non-compliant vehicles.



## 9. SUMMARY AND CONCLUSIONS

### 9.1 Summary

9.1.1 Dundee City Council commissioned the development of a traffic microsimulation model of the Dundee Greater City Centre area for the purpose of assessing the LEZ options identified through the NLEF appraisal process.

9.1.2 An 2019 Base Model was developed (as detailed in the report *Dundee Greater City Centre Base Paramics Model Development Report (SYSTRA, November 2019)* and from this a future year 2023 Reference Case Model was created (as detailed in the technical note *Dundee Greater City Centre Reference Case Note (SYSTRA, February 2020)*). The 2023 Reference Case, as defined by DCC, reflects infrastructure changes and committed Local Development Plan forecasts to 2023.

9.1.3 The 2023 Reference Case Model was used as a basis to develop three LEZ option tests, namely the three all vehicle LEZ options identified through the NLEF high level appraisal:

- LEZ Option 1 (NLEF Ref 2A) - Inner Ring Road area, including all car parks
- LEZ Option 2 (NLEF Ref 2B) - Inner Ring Road area, excluding Bell Street and West Marketgait NCP car parks
- LEZ Option 3 (LEZ Ref 2C) - Inner Ring Road area, excluding Bell Street, West Marketgait NCP and Wellgate car parks

9.1.4 In addition to these three core inner ring road options, two further variants were tested where the LEZ was extended along the Lochee Road corridor, as identified through the public and stakeholder consultation. The Lochee Road options tests were:

- LEZ Option 1/2/3 (above) plus West Marketgait between West Port Roundabout and Dudhope Roundabout and Lochee Road to Tullideph Road
- LEZ Option 1/2/3 (above) plus West Marketgait between West Port Roundabout and Dudhope Roundabout and Lochee Road to Loon's Road

9.1.5 During the LEZ model testing, it was identified that the performance of the Lochee Road corridor options was hindered by network congestion primarily resulting from the inclusion of West Marketgait between West Port Roundabout and Dudhope Roundabout in the LEZ area. To ensure a robust LEZ option testing programme, it was agreed with DCC to model further variants of the Lochee Road options, excluding West Marketgait, as follows:

- LEZ Option 1/2/3 (above) plus Lochee Road to Tullideph Road (excluding West Marketgait between West Port Roundabout and Dudhope Roundabout)
- LEZ Option 1/2/3 (above) plus Lochee Road to Loon's Road (excluding West Marketgait between West Port Roundabout and Dudhope Roundabout)

9.1.6 A Transport Scotland study assessing the uncertainties around future traffic demand in Scotland, as reported in *LEZ Post-Covid Uncertainty Summary Note (SYSTRA Ref. GB01T20E86/11024112/005, January 2021)*, recommended that sensitivity testing was undertaken against another further plausible future scenario, to ensure a robust set of modelling results to inform Dundee's LEZ.

9.1.7 It was agreed with DCC that a 10% reduction would be applied to the traffic model demands for the 2023 Reference Case and appropriate LEZ Option models to create a set

of Covid-19 alternative scenario models. It was agreed with DDC that Covid-19 sensitivity tests were undertaken on the following model:

- Reference Case
- LEZ Option 3 - Inner Ring Road area, excluding Bell Street, West Marketgait NCP and Wellgate car parks
- LEZ Option 3 Lochee Road Variant 1 – Op3 plus West Marketgait between West Port Roundabout and Dudhope Roundabout and Lochee Road to Tullideph Road
- LEZ Option 3 Lochee Road Variant 2 – Op3 plus West Marketgait between West Port Roundabout and Dudhope Roundabout and Lochee Road to Loon's Road

## **9.2 Conclusions**

- 9.2.1 The modelling of the three core inner ring road LEZ option boundaries has shown that, in general, the LEZ options operate similarly to the Reference Case but there are some impacts of the proposals on traffic conditions in the city, most notably around the East Dock Street East Marketgait junction, particularly in LEZ Option 1 (including all car parks). This is a result of non-compliant vehicles being reassigned to car parks on the periphery of the LEZ inner ring road area. In Option 2 and 3, where fewer vehicles are displaced due to greater car park availability in these options, general network conditions are more similar to Reference Case conditions.
- 9.2.2 The model results show there to be considerable impacts on the Dundee Road network if Lochee Road is included in any LEZ option. Flow comparisons show there to be significant changes in traffic flows on the inner ring road and on local routes adjacent to Lochee Road as a result of incorporating Lochee Road in any LEZ option. The Lochee Road options also show there are large increase in network modelled journey times when the corridor is included.
- 9.2.3 Although the general network conditions are considered comparable between the Covid-19 sensitivity Reference Case and option models, the flow comparisons highlight that there remains significant changes to localised traffic flows as a result of the Lochee Road corridor being included in any LEZ. It is concluded that even under a future where traffic demand is at the lower end of forecast predictions, the inclusion of Lochee Road in any LEZ will still result in localised rerouting of non-compliant vehicles.

## APPENDIX A – LINK FLOW COMPARISONS

The link flow comparisons presented in Table A.1 to Table A.6 are for the following models

- Reference Case
  
- Op1 - Inner Ring Road area, including all car parks
- Op1v1– Op1 plus West Marketgait between West Port Roundabout and Dudhope Roundabout and Lochee Road to Tullideph Road
- Op1v1a - Op1 plus Lochee Road to Tullideph Road (excluding West Marketgait between West Port Roundabout and Dudhope Roundabout)
- Op1v2– Op1 plus West Marketgait between West Port Roundabout and Dudhope Roundabout and Lochee Road to Loon’s Road
- Op1v2a - Op1 plus Lochee Road to Loon’s Road (excluding West Marketgait between West Port Roundabout and Dudhope Roundabout)
  
- Op2 - Inner Ring Road area, excluding Bell Street and West Marketgait NCP car parks
- Op2v1– Op2 plus West Marketgait between West Port Roundabout and Dudhope Roundabout and Lochee Road to Tullideph Road
- Op2v1a – Op2 plus Lochee Road to Tullideph Road (excluding West Marketgait between West Port Roundabout and Dudhope Roundabout)
- Op2v2– Op2 plus West Marketgait between West Port Roundabout and Dudhope Roundabout and Lochee Road to Loon’s Road
- Op2v2a – Op2 plus Lochee Road to Loon’s Road (excluding West Marketgait between West Port Roundabout and Dudhope Roundabout)
  
- Op3 - Inner Ring Road area, excluding Bell Street, West Marketgait NCP and Wellgate car parks
- Op3v1– Op3 plus West Marketgait between West Port Roundabout and Dudhope Roundabout and Lochee Road to Tullideph Road
- Op3v1a – Op3 plus Lochee Road to Tullideph Road (excluding West Marketgait between West Port Roundabout and Dudhope Roundabout)
- Op3v2– Op3 plus West Marketgait between West Port Roundabout and Dudhope Roundabout and Lochee Road to Loon’s Road
- Op3v2a – Op3 plus Lochee Road to Loon’s Road (excluding West Marketgait between West Port Roundabout and Dudhope Roundabout)

**Table A.1 : Link Flow Comparisons Option 1 AM**

Site	Location	Direction	AM (08:00-09:00)					
			Ref Case	Op1	Op1 v1	Op1 v1a	Op1 v2	Op1 v2a
Lochee Road	North of Loons Road	Northbound	372	366	315	330	325	299
		Southbound	547	538	513	519	460	454
Lochee Road	South of City Road	Northbound	383	370	266	255	244	252
		Southbound	430	425	280	289	281	280
Lochee Road	North of Dudhope Terrace	Northbound	755	746	507	502	462	506
		Southbound	790	784	564	571	569	570
Lochee Road	West of Dudhope Roundabout	Westbound	715	691	484	499	460	489
		Eastbound	619	609	438	447	449	452
Dudhope Terrace	At Lochee Road	Westbound	168	167	114	110	95	110
		Eastbound	148	149	101	105	97	97
Inverary Terrace	South of Rankine Street	Northbound	121	117	139	142	146	162
		Southbound	121	118	139	142	146	162
Rankine Street	South of Inverary Terrace	Northbound	151	149	102	109	96	97
		Southbound	226	232	166	163	174	175
Tullideph Road	At Lochee Road	Westbound	178	181	126	124	112	125
		Eastbound	179	173	125	126	125	125
City Road	South of Tullideph Road	Northbound	269	261	318	306	248	254
		Southbound	288	283	446	375	313	292
Milnbank Road	At Polepark Road	Westbound	125	113	145	159	133	156
		Eastbound	221	226	295	258	256	252
Gardner Street	South of Loon's Road	Northbound	204	206	228	221	195	194
		Southbound	312	312	286	289	306	320
Loon's Road	At Lochee Road	Westbound	338	334	430	380	312	270
		Eastbound	374	363	447	419	335	337
Brook Street	East of Edward Street	Westbound	113	112	130	146	124	152
		Eastbound	307	318	376	336	336	331
Ancrum Road	At Lochee Road	Westbound	343	339	316	316	252	234
		Eastbound	269	270	260	262	175	176
Hawkhill	East of Hunter Street	Westbound	569	571	575	698	603	737
		Eastbound	540	535	616	594	614	641
Blackness Road	East of Forest Park Road	Westbound	133	133	123	150	139	165
		Eastbound	189	189	205	205	216	217
Bellfield Street	At Hawkhill	Northbound	108	110	106	133	121	147
		Southbound	120	123	139	138	142	142
Ballfield Road	North of Loon's Road	Northbound	246	246	250	246	195	209
		Southbound	273	278	248	249	245	258

**Table A.2 : Link Flow Comparisons Option 1 PM**

Site	Location	Direction	PM (17:00-18:00)					
			Ref Case	Op1	Op1 v1	Op1 v1a	Op1 v2	Op1 v2a
Lochee Road	North of Loons Road	Northbound	557	549	478	502	498	481
		Southbound	597	593	633	601	609	535
Lochee Road	South of City Road	Northbound	471	462	298	336	329	350
		Southbound	435	422	287	282	299	282
Lochee Road	North of Dudhope Terrace	Northbound	873	871	564	602	582	626
		Southbound	809	811	619	606	663	601
Lochee Road	West of Dudhope Roundabout	Westbound	723	706	480	518	491	531
		Eastbound	583	584	448	436	482	432
Dudhope Terrace	At Lochee Road	Westbound	175	179	116	122	121	118
		Eastbound	311	309	223	211	242	213
Inverary Terrace	South of Rankine Street	Northbound	135	138	222	186	208	184
		Southbound	135	138	222	186	207	184
Rankine Street	South of Inverary Terrace	Northbound	150	151	81	102	107	119
		Southbound	213	212	143	153	160	163
Tullideph Road	At Lochee Road	Westbound	209	199	149	141	122	135
		Eastbound	194	200	140	140	155	139
City Road	South of Tullideph Road	Northbound	320	319	439	376	320	313
		Southbound	303	296	383	360	320	308
Milnbank Road	At Polepark Road	Westbound	232	223	306	289	241	278
		Eastbound	207	210	216	217	211	220
Gardner Street	South of Loon's Road	Northbound	244	248	215	230	243	255
		Southbound	331	328	369	341	366	348
Loon's Road	At Lochee Road	Westbound	375	370	424	391	361	328
		Eastbound	494	493	627	549	497	446
Brook Street	East of Edward Street	Westbound	315	310	353	336	301	339
		Eastbound	233	233	247	255	245	266
Ancrum Road	At Lochee Road	Westbound	315	304	282	302	275	247
		Eastbound	365	352	301	317	255	236
Hawkhill	East of Hunter Street	Westbound	691	646	656	721	644	758
		Eastbound	782	760	877	857	957	925
Blackness Road	East of Forest Park Road	Westbound	206	197	190	200	191	217
		Eastbound	234	218	244	239	246	251
Bellfield Street	At Hawkhill	Northbound	152	146	137	151	144	159
		Southbound	169	164	179	184	185	196
Ballfield Road	North of Loon's Road	Northbound	366	361	340	353	307	314
		Southbound	266	253	183	221	225	233

**Table A.3 : Link Flow Comparisons Option 2 AM**

Site	Location	Direction	AM (08:00-09:00)					
			Ref Case	Op2	Op2 v1	Op2 v1a	Op2 v2	Op2 v2a
Lochee Road	North of Loons Road	Northbound	372	360	342	330	334	304
		Southbound	547	543	575	510	451	440
Lochee Road	South of City Road	Northbound	383	362	282	258	257	259
		Southbound	430	432	307	281	281	278
Lochee Road	North of Dudhope Terrace	Northbound	755	738	562	511	487	505
		Southbound	790	790	628	563	573	571
Lochee Road	West of Dudhope Roundabout	Westbound	715	683	549	495	485	485
		Eastbound	619	627	494	444	450	459
Dudhope Terrace	At Lochee Road	Westbound	168	174	114	112	95	111
		Eastbound	148	149	111	101	94	95
Inverary Terrace	South of Rankine Street	Northbound	121	122	154	151	146	167
		Southbound	121	122	154	151	146	168
Rankine Street	South of Inverary Terrace	Northbound	151	146	113	106	97	99
		Southbound	226	226	182	160	173	172
Tullideph Road	At Lochee Road	Westbound	178	178	143	123	114	122
		Eastbound	179	183	143	125	123	122
City Road	South of Tullideph Road	Northbound	269	274	352	309	248	248
		Southbound	288	287	478	380	325	293
Milnbank Road	At Polepark Road	Westbound	125	124	155	162	138	160
		Eastbound	221	245	325	255	258	247
Gardner Street	South of Loon's Road	Northbound	204	206	255	219	194	199
		Southbound	312	314	315	296	306	317
Loon's Road	At Lochee Road	Westbound	338	334	473	387	309	269
		Eastbound	374	365	506	415	332	326
Brook Street	East of Edward Street	Westbound	113	119	140	151	130	150
		Eastbound	307	327	403	331	338	322
Ancrum Road	At Lochee Road	Westbound	343	338	352	324	254	244
		Eastbound	269	267	284	255	184	182
Hawkhill	East of Hunter Street	Westbound	569	553	636	660	588	709
		Eastbound	540	557	679	624	613	654
Blackness Road	East of Forest Park Road	Westbound	133	131	139	144	126	153
		Eastbound	189	190	221	213	216	224
Bellfield Street	At Hawkhill	Northbound	108	105	122	126	112	135
		Southbound	120	122	141	143	143	147
Ballfield Road	North of Loon's Road	Northbound	246	251	281	242	194	211
		Southbound	273	281	260	258	237	256

**Table A.4 : Link Flow Comparisons Option 2 PM**

Site	Location	Direction	PM (17:00-18:00)					
			Ref Case	Op2	Op2 v1	Op2 v1a	Op2 v2	Op2 v2a
Lochee Road	North of Loon's Road	Northbound	557	549	474	515	514	493
		Southbound	597	593	646	579	592	525
Lochee Road	South of City Road	Northbound	471	458	308	341	343	352
		Southbound	435	438	281	276	301	288
Lochee Road	North of Dudhope Terrace	Northbound	873	863	576	611	598	630
		Southbound	809	815	617	604	654	613
Lochee Road	West of Dudhope Roundabout	Westbound	723	711	494	524	493	539
		Eastbound	583	586	448	431	462	432
Dudhope Terrace	At Lochee Road	Westbound	175	174	116	116	130	116
		Eastbound	311	318	233	229	252	222
Inverary Terrace	South of Rankine Street	Northbound	135	144	234	186	218	200
		Southbound	135	145	233	186	218	199
Rankine Street	South of Inverary Terrace	Northbound	150	154	75	98	105	120
		Southbound	213	200	143	148	154	165
Tullideph Road	At Lochee Road	Westbound	209	209	149	142	122	138
		Eastbound	194	202	135	155	150	137
City Road	South of Tullideph Road	Northbound	320	336	426	381	322	314
		Southbound	303	293	382	363	324	298
Milnbank Road	At Polepark Road	Westbound	232	239	294	290	247	277
		Eastbound	207	196	211	209	207	209
Gardner Street	South of Loon's Road	Northbound	244	240	219	230	239	254
		Southbound	331	324	375	338	377	362
Loon's Road	At Lochee Road	Westbound	375	365	429	399	356	334
		Eastbound	494	492	626	537	495	448
Brook Street	East of Edward Street	Westbound	315	318	345	336	309	333
		Eastbound	233	213	239	240	241	255
Ancrum Road	At Lochee Road	Westbound	315	306	293	307	253	244
		Eastbound	365	362	299	325	260	241
Hawkhill	East of Hunter Street	Westbound	691	659	658	735	631	752
		Eastbound	782	771	893	861	946	914
Blackness Road	East of Forest Park Road	Westbound	206	198	186	213	190	215
		Eastbound	234	231	250	241	237	245
Bellfield Street	At Hawkhill	Northbound	152	148	139	157	137	160
		Southbound	169	165	180	183	183	194
Ballfield Road	North of Loon's Road	Northbound	366	371	327	346	293	316
		Southbound	266	260	186	226	227	244

**Table A.5 : Link Flow Comparisons Option 3 AM**

Site	Location	Direction	AM (08:00-09:00)					
			Ref Case	Op3	Op3 v1	Op3 v1a	Op3 v2	Op3 v2a
Lochee Road	North of Loons Road	Northbound	372	363	339	319	368	302
		Southbound	547	543	586	508	514	450
Lochee Road	South of City Road	Northbound	383	375	283	255	283	249
		Southbound	430	432	315	282	307	279
Lochee Road	North of Dudhope Terrace	Northbound	755	735	569	511	538	498
		Southbound	790	789	641	579	626	570
Lochee Road	West of Dudhope Roundabout	Westbound	715	695	557	486	517	483
		Eastbound	619	621	505	457	496	459
Dudhope Terrace	At Lochee Road	Westbound	168	166	115	116	115	110
		Eastbound	148	146	108	100	106	95
Inverary Terrace	South of Rankine Street	Northbound	121	129	157	147	161	164
		Southbound	121	129	156	147	161	164
Rankine Street	South of Inverary Terrace	Northbound	151	143	112	102	109	96
		Southbound	226	215	181	165	190	169
Tullideph Road	At Lochee Road	Westbound	178	174	145	128	118	122
		Eastbound	179	182	141	133	130	123
City Road	South of Tullideph Road	Northbound	269	262	350	302	279	250
		Southbound	288	283	495	382	356	294
Milnbank Road	At Polepark Road	Westbound	125	121	150	150	154	171
		Eastbound	221	225	337	262	291	249
Gardner Street	South of Loon's Road	Northbound	204	198	258	212	228	196
		Southbound	312	306	315	293	339	314
Loon's Road	At Lochee Road	Westbound	338	331	473	382	342	276
		Eastbound	374	371	495	418	376	327
Brook Street	East of Edward Street	Westbound	113	105	137	138	147	160
		Eastbound	307	313	424	332	376	321
Ancrum Road	At Lochee Road	Westbound	343	345	356	326	290	239
		Eastbound	269	278	282	259	202	173
Hawkhill	East of Hunter Street	Westbound	569	539	637	666	661	732
		Eastbound	540	546	676	605	686	646
Blackness Road	East of Forest Park Road	Westbound	133	132	140	144	146	159
		Eastbound	189	197	224	203	231	212
Bellfield Street	At Hawkhill	Northbound	108	105	122	127	129	139
		Southbound	120	125	150	131	151	136
Ballfield Road	North of Loon's Road	Northbound	246	241	277	239	226	204
		Southbound	273	265	261	249	272	253



**Table A.6 : Link Flow Comparisons Option 3 PM**

Site	Location	Direction	PM (17:00-18:00)					
			Ref Case	Op3	Op3 v1	Op3 v1a	Op3 v2	Op3 v2a
Lochee Road	North of Loons Road	Northbound	557	543	474	509	517	484
		Southbound	597	597	644	595	596	537
Lochee Road	South of City Road	Northbound	471	454	310	336	336	348
		Southbound	435	440	283	284	294	280
Lochee Road	North of Dudhope Terrace	Northbound	873	858	579	613	593	613
		Southbound	809	828	629	603	660	607
Lochee Road	West of Dudhope Roundabout	Westbound	723	706	497	532	510	524
		Eastbound	583	604	456	432	495	445
Dudhope Terrace	At Lochee Road	Westbound	175	170	119	115	132	117
		Eastbound	311	314	236	223	242	212
Inverary Terrace	South of Rankine Street	Northbound	135	137	238	190	203	186
		Southbound	135	137	237	190	202	186
Rankine Street	South of Inverary Terrace	Northbound	150	147	75	105	112	111
		Southbound	213	205	145	149	162	162
Tullideph Road	At Lochee Road	Westbound	209	201	159	142	120	131
		Eastbound	194	196	144	143	152	145
City Road	South of Tullideph Road	Northbound	320	320	435	367	319	324
		Southbound	303	299	401	367	314	299
Milnbank Road	At Polepark Road	Westbound	232	228	302	277	253	270
		Eastbound	207	196	226	226	200	225
Gardner Street	South of Loon's Road	Northbound	244	241	208	234	252	250
		Southbound	331	326	381	344	367	353
Loon's Road	At Lochee Road	Westbound	375	368	431	396	370	335
		Eastbound	494	484	644	545	499	454
Brook Street	East of Edward Street	Westbound	315	304	344	324	312	331
		Eastbound	233	217	252	257	236	268
Ancrum Road	At Lochee Road	Westbound	315	307	282	301	276	248
		Eastbound	365	354	308	325	264	234
Hawkhill	East of Hunter Street	Westbound	691	643	645	727	604	758
		Eastbound	782	758	899	896	904	938
Blackness Road	East of Forest Park Road	Westbound	206	197	192	208	193	210
		Eastbound	234	230	241	240	249	257
Bellfield Street	At Hawkhill	Northbound	152	143	139	155	136	151
		Southbound	169	171	183	187	191	198
Ballfield Road	North of Loon's Road	Northbound	366	356	331	340	321	315
		Southbound	266	247	185	218	234	247

## APPENDIX B – LINK FLOW COMPARISON LOCHEE ROAD VARIANTS (OP1 & OP2)

**Table B.1 : 12 Hour Two-Way Flow Comparisons on Lochee Rd and adjacent routes (All Vehicles) – Core Option 1, Lochee Rd variants 1 & 2**

Site	Location	Ref Case	Op1 & Lochee Rd - Tullideph Rd	Difference (Op-Ref)	% Diff
Lochee Road	North of Loon's Road	10171	9528	-643	-6.3%
Lochee Road	South of City Road	8223	5509	-2714	-33.0%
Lochee Road	North of Dudhope Terr	15905	10953	-4952	-31.1%
Lochee Road	West of Dudhope Rbt	13764	9488	-4277	-31.1%
Dudhope Terrace	At Lochee Road	3120	2087	-1033	-33.1%
Inverary Terrace	South of Rankine Street	2631	3509	877	33.3%
Rankine Street	South of Inverary Terr	4420	3006	-1414	-32.0%
Tullideph Road	At Lochee Road	3535	2454	-1081	-30.6%
City Road	South of Tullideph Road	5756	8022	2266	39.4%
Milnbank Road	At Polepark Road	3627	4675	1048	28.9%
Gardner Street	South of Loon's Road	6284	6106	-178	-2.8%
Loon's Road	At Lochee Road	7358	9313	1955	26.6%
Brook Street	East of Edward Street	4437	5291	853	19.2%
Ancrum Road	At Lochee Road	5920	5695	-225	-3.8%
Hawkhill	East of Hunter Street Rbt	11847	12333	486	4.1%
Blackness Road	East of Forest Park Road	3273	3270	-3	-0.1%
Bellfield Street	At Hawkhill	2391	2446	56	2.3%
Balfield Road	North of Loon's Road	6500	6005	-495	-7.6%

Site	Location	Ref Case	Op1 & Lochee Rd - Loon's Rd	Difference (Op-Ref)	% Diff
Lochee Road	North of Loon's Road	10171	9030	-1142	-11.2%
Lochee Road	South of City Road	8223	5469	-2754	-33.5%
Lochee Road	North of Dudhope Terr	15905	10952	-4953	-31.1%
Lochee Road	West of Dudhope Rbt	13764	9476	-4289	-31.2%
Dudhope Terrace	At Lochee Road	3120	2047	-1073	-34.4%
Inverary Terrace	South of Rankine Street	2631	3449	818	31.1%
Rankine Street	South of Inverary Terr	4420	3164	-1256	-28.4%
Tullideph Road	At Lochee Road	3535	2371	-1163	-32.9%
City Road	South of Tullideph Road	5756	6543	787	13.7%
Milnbank Road	At Polepark Road	3627	4253	626	17.3%
Gardner Street	South of Loon's Road	6284	6137	-147	-2.3%
Loon's Road	At Lochee Road	7358	7367	9	0.1%
Brook Street	East of Edward Street	4437	4984	547	12.3%
Ancrum Road	At Lochee Road	5920	4537	-1383	-23.4%
Hawkhill	East of Hunter Street Rbt	11847	12632	786	6.6%
Blackness Road	East of Forest Park Road	3273	3379	106	3.2%
Bellfield Street	At Hawkhill	2391	2559	168	7.0%
Balfield Road	North of Loon's Road	6500	5725	-775	-11.9%

**Table B.2 : 12 Hour Two-Way Flow Comparisons on Lochee Rd and adjacent routes (All Vehicles) – Core Option 2, Lochee Rd variants 1 & 2**

Site	Location	Ref Case	Op2 & Lochee Rd - Tullideph Rd	Difference (Op-Ref)	% Diff
Lochee Road	North of Loon's Road	10171	9825	-346	-3.4%
Lochee Road	South of City Road	8223	5644	-2579	-31.4%
Lochee Road	North of Dudhope Terr	15905	11251	-4654	-29.3%
Lochee Road	West of Dudhope Rbt	13764	9789	-3975	-28.9%
Dudhope Terrace	At Lochee Road	3120	2143	-977	-31.3%
Inverary Terrace	South of Rankine Street	2631	3703	1071	40.7%
Rankine Street	South of Inverary Terr	4420	3046	-1375	-31.1%
Tullideph Road	At Lochee Road	3535	2533	-1002	-28.3%
City Road	South of Tullideph Road	5756	8221	2465	42.8%
Milnbank Road	At Polepark Road	3627	4797	1170	32.2%
Gardner Street	South of Loon's Road	6284	6302	19	0.3%
Loon's Road	At Lochee Road	7358	9609	2251	30.6%
Brook Street	East of Edward Street	4437	5403	966	21.8%
Ancrum Road	At Lochee Road	5920	5836	-84	-1.4%
Hawkhill	East of Hunter Street Rbt	11847	12704	857	7.2%
Blackness Road	East of Forest Park Road	3273	3335	62	1.9%
Bellfield Street	At Hawkhill	2391	2505	114	4.8%
Balfield Road	North of Loon's Road	6500	6089	-411	-6.3%

Site	Location	Ref Case	Op2 & Lochee Rd - Loon's Rd	Difference (Op-Ref)	% Diff
Lochee Road	North of Loon's Road	10171	9092	-1079	-10.6%
Lochee Road	South of City Road	8223	5539	-2684	-32.6%
Lochee Road	North of Dudhope Terr	15905	10991	-4914	-30.9%
Lochee Road	West of Dudhope Rbt	13764	9557	-4208	-30.6%
Dudhope Terrace	At Lochee Road	3120	2078	-1042	-33.4%
Inverary Terrace	South of Rankine Street	2631	3491	859	32.7%
Rankine Street	South of Inverary Terr	4420	3107	-1314	-29.7%
Tullideph Road	At Lochee Road	3535	2354	-1181	-33.4%
City Road	South of Tullideph Road	5756	6619	863	15.0%
Milnbank Road	At Polepark Road	3627	4309	682	18.8%
Gardner Street	South of Loon's Road	6284	6116	-168	-2.7%
Loon's Road	At Lochee Road	7358	7364	6	0.1%
Brook Street	East of Edward Street	4437	4989	552	12.4%
Ancrum Road	At Lochee Road	5920	4556	-1363	-23.0%
Hawkhill	East of Hunter Street Rbt	11847	12649	802	6.8%
Blackness Road	East of Forest Park Road	3273	3330	57	1.7%
Bellfield Street	At Hawkhill	2391	2510	119	5.0%
Balfield Road	North of Loon's Road	6500	5644	-856	-13.2%

## **APPENDIX C – RESULTS FOR WEST MARKETGAIT VARIANTS**

### **C1 - General Network Observations**

For the most part, the Option models operate without noticeable difference from the Reference Case model. The notable exception to this is the East Dock Street/East Marketgait junction which sees an increase in congestion, particularly in the AM. This congestion is worst in Option 1 which has the highest number of displaced vehicles.

### **C2 - Journey Time Comparisons**

Journey Times were collected over 11 routes which were specified by DCC and which represent the relevant routes relating to the LEZ proposals. The without West Marketgait variants are:

- Option 1 v1a
- Option 1 v2a
- Option 2 v1a
- Option 2 v2a
- Option 3 v1a
- Option 3 v2a

Journey time comparisons are shown in Table C.1 to Table C.6.

**Table C.1 : AM Journey Time Comparison for Option 1 West Marketgait Variants (seconds) 08:00-09:00**

	AM (08:00-09:00)					
	Ref Case	Option 1	Option 1	Option 1	Option 1	Option 1
			v1	v1a	v2	v2a
A85 EB	404	406	406	408	406	407
A85 WB	435	431	431	435	432	434
City Road/Milnbank Road NB	154	153	155	155	148	148
City Road/Milnbank Road SB	152	150	156	153	149	149
Dens Road NB	242	242	247	245	245	251
Dens Road SB	253	250	244	252	251	262
East Dock Street EB	177	178	178	178	178	180
East Dock Street WB	199	272	355	279	387	279
Forfar Road NB	304	304	303	303	304	303
Forfar Road SB	278	289	369	289	570	296
Hawkhill Road EB	118	117	116	117	116	118
Hawkhill Road WB	126	129	126	127	127	128
Inverary/Albany/Gardner NB	123	123	132	126	118	118
Inverary/Albany/Gardner SB	107	107	108	108	108	109
Lochee Road NB	392	390	392	383	357	360
Lochee Road SB	400	399	381	381	373	375
Perth Road EB	489	423	449	441	468	448
Perth Road WB	419	432	428	432	422	445
Ring Road Anticlockwise	373	384	358	377	359	386
Ring Road Clockwise	462	490	558	493	572	488
Strathmartine Road SB	343	337	349	349	346	350
Hilltown NB	350	353	356	355	353	354

**Table C.2 : PM Journey Time Comparison for Option 1 West Marketgait Variants (seconds) 17:00-18:00**

	PM (17:00-18:00)					
	Ref Case	Option 1	Option 1	Option 1	Option 1	Option 1
			v1	v1a	v2	v2a
A85 EB	439	444	511	444	694	453
A85 WB	436	440	436	442	440	439
City Road/Milnbank Road NB	163	165	182	164	152	154
City Road/Milnbank Road SB	157	156	160	159	158	156
Dens Road NB	270	277	285	293	288	307
Dens Road SB	315	316	312	330	329	337
East Dock Street EB	216	236	187	222	177	225
East Dock Street WB	214	278	479	262	504	310
Forfar Road NB	434	428	382	440	368	475
Forfar Road SB	311	327	622	314	917	351
Hawkhill Road EB	127	126	126	127	130	129
Hawkhill Road WB	126	127	128	126	125	126
Inverary/Albany/Gardner NB	164	171	264	191	157	158
Inverary/Albany/Gardner SB	111	111	115	112	112	112
Lochee Road NB	608	610	630	591	566	553
Lochee Road SB	450	449	420	420	411	416
Perth Road EB	468	455	505	470	497	466
Perth Road WB	459	447	453	468	450	455
Ring Road Anticlockwise	415	428	497	426	566	450
Ring Road Clockwise	479	499	580	492	615	535
Strathmartine Road SB	363	373	385	384	402	375
Hilltown NB	373	373	389	380	374	380

**Table C.3 : AM Journey Time Comparison for Option 2 West Marketgait Variants (seconds) 08:00-09:00**

AM (08:00-09:00)						
Ref Case	Option 2	Option 2 v1	Option 2 v1a	Option 2 v2	Option 2 v2a	
A85 EB	404	403	405	404	408	405
A85 WB	435	433	433	433	434	435
City Road/Milnbank Road NB	154	154	156	154	149	150
City Road/Milnbank Road SB	152	150	155	152	149	147
Dens Road NB	242	246	243	252	245	250
Dens Road SB	253	253	244	259	247	274
East Dock Street EB	177	177	181	179	181	177
East Dock Street WB	199	230	263	199	304	247
Forfar Road NB	304	301	299	301	300	301
Forfar Road SB	278	277	304	276	350	279
Hawkhill Road EB	118	118	119	118	119	120
Hawkhill Road WB	126	128	126	127	127	128
Inverary/Albany/Gardner NB	123	123	132	124	119	118
Inverary/Albany/Gardner SB	107	107	108	109	107	108
Lochee Road NB	392	387	395	381	355	356
Lochee Road SB	400	400	379	378	370	377
Perth Road EB	489	459	455	436	433	460
Perth Road WB	419	428	430	425	433	437
Ring Road Anticlockwise	373	376	360	366	363	375
Ring Road Clockwise	462	477	506	457	528	475
Strathmartine Road SB	343	349	343	353	344	348
Hilltown NB	350	350	357	354	352	352

**Table C.4 : PM Journey Time Comparison for Option 2 West Marketgait Variants (seconds) 17:00-18:00**

PM (17:00-18:00)						
Ref Case	Option 2	Option 2 v1	Option 2 v1a	Option 2 v2	Option 2 v2a	
A85 EB	439	449	552	440	666	464
A85 WB	436	440	445	447	447	438
City Road/Milnbank Road NB	163	163	190	163	153	154
City Road/Milnbank Road SB	157	155	161	158	156	157
Dens Road NB	270	277	284	303	286	301
Dens Road SB	315	314	306	329	323	341
East Dock Street EB	216	229	193	217	181	226
East Dock Street WB	214	186	362	243	453	249
Forfar Road NB	434	431	388	425	375	424
Forfar Road SB	311	302	426	307	780	309
Hawkhill Road EB	127	125	129	126	133	128
Hawkhill Road WB	126	124	125	125	125	126
Inverary/Albany/Gardner NB	164	173	280	179	160	159
Inverary/Albany/Gardner SB	111	111	115	112	113	112
Lochee Road NB	608	607	637	582	563	547
Lochee Road SB	450	460	431	422	420	421
Perth Road EB	468	453	464	456	462	448
Perth Road WB	459	438	472	470	448	470
Ring Road Anticlockwise	415	431	516	442	609	460
Ring Road Clockwise	479	480	552	483	596	506
Strathmartine Road SB	363	365	388	383	394	372
Hilltown NB	373	365	390	374	377	382

**Table C.5 : AM Journey Time Comparison for Option 3 West Marketgait Variants (seconds) 08:00-09:00**

	AM (08:00-09:00)					
	Ref Case	Option 3	Option 3	Option 3	Option 3	Option 3
			v1	v1a	v2	v2a
A85 EB	404	406	405	407	406	406
A85 WB	435	437	433	436	432	436
City Road/Milnbank Road NB	154	155	158	155	149	150
City Road/Milnbank Road SB	152	151	154	153	148	149
Dens Road NB	242	242	244	248	253	245
Dens Road SB	253	253	243	255	255	260
East Dock Street EB	177	177	178	179	180	177
East Dock Street WB	199	226	284	207	379	227
Forfar Road NB	304	299	303	300	306	300
Forfar Road SB	278	283	312	278	478	278
Hawkhill Road EB	118	118	119	118	118	120
Hawkhill Road WB	126	126	127	128	127	127
Inverary/Albany/Gardner NB	123	123	128	123	120	119
Inverary/Albany/Gardner SB	107	107	108	108	107	108
Lochee Road NB	392	390	394	381	361	358
Lochee Road SB	400	400	382	379	371	374
Perth Road EB	489	461	464	462	440	438
Perth Road WB	419	434	427	428	430	424
Ring Road Anticlockwise	373	367	362	368	358	373
Ring Road Clockwise	462	474	515	461	544	470
Strathmartine Road SB	343	346	345	350	350	350
Hilltown NB	350	347	354	354	351	351

**Table C.6 : PM Journey Time Comparison for Option 3 Lochee Road Variants (seconds) 17:00-18:00**

	PM (17:00-18:00)					
	Ref Case	Option 3	Option 3	Option 3	Option 3	Option 3
			v1	v1a	v2	v2a
A85 EB	439	447	566	452	866	455
A85 WB	436	439	443	444	447	435
City Road/Milnbank Road NB	163	161	188	160	153	153
City Road/Milnbank Road SB	157	155	160	160	156	155
Dens Road NB	270	275	282	286	278	293
Dens Road SB	315	312	312	316	362	360
East Dock Street EB	216	215	191	212	175	213
East Dock Street WB	214	199	390	236	435	282
Forfar Road NB	434	418	385	454	364	443
Forfar Road SB	311	306	532	326	935	325
Hawkhill Road EB	127	125	129	127	147	129
Hawkhill Road WB	126	125	125	126	127	125
Inverary/Albany/Gardner NB	164	164	305	182	167	149
Inverary/Albany/Gardner SB	111	111	113	113	116	112
Lochee Road NB	608	591	647	585	565	567
Lochee Road SB	450	441	428	422	419	415
Perth Road EB	468	471	455	452	483	460
Perth Road WB	459	455	464	448	451	462
Ring Road Anticlockwise	415	442	523	441	692	456
Ring Road Clockwise	479	494	558	494	639	499
Strathmartine Road SB	363	364	395	378	425	376
Hilltown NB	373	372	392	387	378	380

### C3 - General Network Statistics

For the modelled area, average trip distances and speeds for the AM and PM were compared in order to assess the overall network impact.

Table C.7 shows average trip distances and speeds for these variants compared with the Reference Case.

**Table C.7 : Speed and Distance Comparisons – Marketgait Variants**

07:00-10:00	Units	RefCase	Option 1	Option 1 v1	Option 1 v1a	Option 1 v2	Option 1 v2a
Total Compliant Vehicles	vehs	55502	55735	55535	55780	55290	55719
Total Non- Compliant Vehicles	vehs	37091	36548	36460	36599	36328	36612
Compliant Speed	mph	23.2	23.0	22.4	22.8	22.1	22.7
Non-Compliant Speed	mph	23.7	23.4	22.7	23.2	22.5	23.2
Compliant Av. Distance	m	4602	4602	4594	4599	4577	4598
Non-Compliant Av. Distance	m	4813	4830	4875	4865	4936	4916

16:00-19:00	Units	RefCase	Option 1	Option 1 v1	Option 1 v1a	Option 1 v2	Option 1 v2a
Total Compliant Vehicles	vehs	75307	75362	75275	75430	75174	55719
Total Non- Compliant Vehicles	vehs	43243	42809	42729	42823	42639	36612
Compliant Speed	mph	21.4	21.0	20.0	21.0	19.5	22.7
Non-Compliant Speed	mph	22.0	21.6	20.3	21.6	19.8	23.2
Compliant Av. Distance	m	3984	3985	3995	3959	3992	4598
Non-Compliant Av. Distance	m	4169	4202	4267	4208	4329	4916

07:00-10:00	Units	RefCase	Option 2	Option 2 v1	Option 2 v1a	Option 2 v2	Option 2 v2a
Total Compliant Vehicles	vehs	55502	55793	55770	55766	55677	55763
Total Non- Compliant Vehicles	vehs	37091	36667	36566	36566	36486	36613
Compliant Speed	mph	23.2	23.2	22.7	23.1	22.5	23.0
Non-Compliant Speed	mph	23.7	23.7	23.0	23.5	23.0	23.6
Compliant Av. Distance	m	4602	4599	4603	4604	4593	4599
Non-Compliant Av. Distance	m	4813	4829	4883	4866	4947	4908

16:00-19:00	Units	RefCase	Option 2	Option 2 v1	Option 2 v1a	Option 2 v2	Option 2 v2a
Total Compliant Vehicles	vehs	75307	75439	75297	75404	75196	75373
Total Non- Compliant Vehicles	vehs	43243	42823	42780	42824	42643	42781
Compliant Speed	mph	21.4	21.3	20.1	21.0	19.6	21.0
Non-Compliant Speed	mph	22.0	22.0	20.5	21.6	20.0	21.7
Compliant Av. Distance	m	3984	3982	3993	3961	3989	3979
Non-Compliant Av. Distance	m	4169	4198	4268	4211	4335	4275

07:00-10:00	Units	RefCase	Option 3	Option 3 v1	Option 3 v1a	Option 3 v2	Option 3 v2a
Total Compliant Vehicles	vehs	55502	55819	55734	55813	55391	55801
Total Non- Compliant Vehicles	vehs	37091	36638	36580	36594	36479	36584
Compliant Speed	mph	23.2	23.3	22.6	23.1	22.3	23.2
Non-Compliant Speed	mph	23.7	23.7	23.0	23.5	22.8	23.8
Compliant Av. Distance	m	4602	4604	4603	4601	4586	4596
Non-Compliant Av. Distance	m	4813	4832	4882	4860	4946	4913

16:00-19:00	Units	RefCase	Option 3	Option 3 v1	Option 3 v1a	Option 3 v2	Option 3 v2a
Total Compliant Vehicles	vehs	75307	75397	75303	75381	75090	75382
Total Non- Compliant Vehicles	vehs	43243	42820	42762	42810	42712	42788
Compliant Speed	mph	21.4	21.2	20.0	20.9	19.5	20.9
Non-Compliant Speed	mph	22.0	21.9	20.4	21.5	19.7	21.6
Compliant Av. Distance	m	3984	3984	3997	3984	3991	3953
Non-Compliant Av. Distance	m	4169	4199	4266	4234	4337	4245

The comparisons show that the ‘a’ options which exclude West Marketgait from the LEZ have increased network average speed for compliant and non-compliant vehicles when compared to the equivalent Lochee Road variants. The network average speed for the ‘a’ variants is similar to that shown in the city centre only LEZ options.



## **C4 - Link Flow Comparisons**

In order to assess the impact of the LEZ Lochee Road variants excluding West Marketgait, on local routes, link flows for selected locations have been extracted for the AM (08:00-09:00) and PM (17:00-18:00) peak hours. The results are presented in Table A.1 to Table A.6 in Appendix A.

The results show that while the options operate with less congestion around the inner ring road area due to the full inner ring road route being available to non-compliant vehicles, the continued inclusion of the Lochee Road corridor still results in a shift of non-compliant vehicles from Lochee Road to adjacent local routes. The largest increases in traffic flow are recorded on Perth Road/Hawkhill of over 2000 vehicles over 12 hours.

## APPENDIX D – LINK FLOW COMPARISONS (COVID-19 SENSITIVITY TESTS)

Table D.1 : Link Flow Comparisons Covid-19 Sensitivity Tests – Option 3 AM

Site	Location	Direction	AM (08:00-09:00)			
			Ref Case	Op3	Op3 v1	Op3v2
Lochee Road	North of Loons Road	Northbound	335	335	294	293
		Southbound	487	480	465	411
Lochee Road	South of City Road	Northbound	338	326	233	227
		Southbound	395	388	259	251
Lochee Road	North of Dudhope Terrace	Northbound	676	660	468	454
		Southbound	745	736	523	523
Lochee Road	West of Dudhope Roundabout	Westbound	647	628	455	450
		Eastbound	590	574	410	414
Dudhope Terrace	At Lochee Road	Westbound	140	138	99	82
		Eastbound	135	130	89	84
Inverary Terrace	South of Rankine Street	Northbound	107	105	133	137
		Southbound	107	106	133	138
Rankine Street	South of Inverary Terrace	Northbound	136	132	92	88
		Southbound	214	218	153	157
Tullideph Road	At Lochee Road	Westbound	160	165	119	116
		Eastbound	163	163	109	114
City Road	South of Tullideph Road	Northbound	231	235	281	230
		Southbound	256	255	399	295
Milnbank Road	At Polepark Road	Westbound	114	111	119	130
		Eastbound	196	198	267	229
Gardner Street	South of Loon's Road	Northbound	186	178	198	176
		Southbound	287	295	274	280
Loon's Road	At Lochee Road	Westbound	309	312	414	270
		Eastbound	334	329	414	313
Brook Street	East of Edward Street	Westbound	100	105	109	121
		Eastbound	268	282	338	293
Ancrum Road	At Lochee Road	Westbound	305	311	295	210
		Eastbound	252	251	244	157
Hawkhill	East of Hunter Street	Westbound	515	501	517	556
		Eastbound	480	487	543	542
Blackness Road	East of Forest Park Road	Westbound	118	124	120	122
		Eastbound	175	178	179	187
Bellfield Street	At Hawkhill	Northbound	100	103	102	111
		Southbound	109	113	119	126
Ballfield Road	North of Loon's Road	Northbound	223	216	215	184
		Southbound	257	259	244	224

**Table D.2 : Link Flow Comparisons Covid-19 Sensitivity Tests – Option 3 AM**

Site	Location	Direction	PM (17:00-18:00)			
			Ref Case	Op3	Op3 v1	Op3v2
Lochee Road	North of Loons Road	Northbound	503	509	456	452
		Southbound	479	477	496	449
Lochee Road	South of City Road	Northbound	425	423	295	309
		Southbound	369	365	251	245
Lochee Road	North of Dudhope Terrace	Northbound	799	798	555	571
		Southbound	744	736	558	542
Lochee Road	West of Dudhope Roundabout	Westbound	683	678	477	489
		Eastbound	559	561	415	409
Dudhope Terrace	At Lochee Road	Westbound	133	140	92	90
		Eastbound	251	250	178	171
Inverary Terrace	South of Rankine Street	Northbound	126	115	178	172
		Southbound	126	115	177	172
Rankine Street	South of Inverary Terrace	Northbound	170	171	112	136
		Southbound	192	196	136	146
Tullideph Road	At Lochee Road	Westbound	181	181	132	121
		Eastbound	191	186	134	131
City Road	South of Tullideph Road	Northbound	285	287	396	291
		Southbound	259	259	364	272
Milnbank Road	At Polepark Road	Westbound	213	202	268	239
		Eastbound	158	164	189	174
Gardner Street	South of Loon's Road	Northbound	260	265	236	260
		Southbound	309	303	321	330
Loon's Road	At Lochee Road	Westbound	334	338	404	292
		Eastbound	411	412	533	402
Brook Street	East of Edward Street	Westbound	283	275	317	296
		Eastbound	188	183	218	206
Ancrum Road	At Lochee Road	Westbound	281	282	260	197
		Eastbound	316	313	293	223
Hawkhill	East of Hunter Street	Westbound	591	566	559	573
		Eastbound	647	640	702	729
Blackness Road	East of Forest Park Road	Westbound	177	174	167	170
		Eastbound	193	196	206	208
Bellfield Street	At Hawkhill	Northbound	135	124	127	124
		Southbound	139	145	158	160
Ballfield Road	North of Loon's Road	Northbound	352	352	339	309
		Southbound	258	260	209	236

## APPROVAL

Version	Name		Position	Date	Comments
<b>1</b>	Author	Graham Smith	Senior Consultant	07/05/21	Draft for DCC Comment
	Checked by	Chris Shaw	Associate	10/05/21	
	Approved by	Chris Shaw	Associate	10/05/21	
<b>2</b>					
<b>3</b>					
<b>4</b>					