Waikato Regional Transport Model

Four Step Model Validation 2013

Technical Note No 35

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1. Purpose

The purpose of this note is to document the procedure followed for checking the validation of the 2013 Four Step model (version 101) as part of the 2013 census update. Technical Notes 26, 33 and 29 have covered Generation, Distribution and Mode Split respectively.

This note covers the validation of the re-estimated model at 2013. It builds on Technical Note 34 which covers the application of the four step model using the 2006 census data as the land use data inputs, and its resulting bus vehicle and passenger volumes. This note covers the 2013 modelled outputs using 2013 input land use data and the 2013 networks (road and public transport).

2. Introduction

Once the trip matrices by mode have been formed, the final step is the assignment of the public transport trips to the bus services, at which time a number of validation checks can be performed. The 2013 public transport services have been coded onto the 2500 zone vehicle network, and the loaded network speeds and times have been used to determine bus running speeds.

The 2013 Bus Routes map is shown in **Appendix A** as Figure A1 for those within Hamilton, and Figure A2 and Figure A3 for the regional service between Hamilton to and from Te Awamutu and Cambridge. The corresponding timetables for both modelled periods are included as **Appendix B**.

The 2013 four step model has been converted based on the 2006 four step model but with 2013 land use, road network, and bus services. The bus survey data as supplied is only partially complete; there are a few routes that have been omitted, for example, regional service routes and CBD cordon counts.

When the original WRTM was built, there was the bus passenger survey data against which the model could be validated. The equivalent data provided for 2013 is not fully complete so the validation checks at 2013 are more limited.

The 2013 fare structure is presented in **Table 1**.

No.	Location and Provider	Fare	
1	Hamilton (Hamilton Urban Services)	$2.20	
2	Cambridge (Cambridge Travel Lines)	1 section	$2.20
		2 sections	$3.65
		3 sections	$4.90
		4 sections	$5.70
3	Te Awamutu (Go-bus Hodgsons)	$4.90	
4	Orbiter Hamilton	$2.20	
5	CBD Shuttle	Free	

Table 1: Modelled Waikato Region Bus Services and Fares

3. Public Transport Assignment

The following section briefly details the development of the public transportation model.

This description is identical to the text in Technical Note 34 (validation of the four step model for the year 2006). It is reproduced here so that the technical note can be read as a stand-alone document.

3.1 The Assignment Process

The PT assignment model is analogous to the vehicle assignment and is used for assigning PT trips onto the network.

Unlike conventional vehicle assignment, PT assignment assigns the bus passenger matrix onto a fixed set of routes. Similar to vehicle assignment the decision of which route is taken is based on least cost algorithm. The main difference between the vehicle and public transport assignment is in the way the matrix is loaded.

Public transport represents a dynamic assignment model where the modelled period and the matrix are divided into slices and passengers are released in intervals starting from the beginning of the modelled period. A dynamic assignment approach is necessary because of the way that buses run following a fixed timetable. The decision is made by each passenger as to which service or services will be taken, given the time that a service is available, and the time between two or more services connecting.

(i) The single ride trip will occur if:

$$T^1_A > T^i_S + T_F + T_C$$

Where:

T^1_A = the time at which the first available bus arrives at the bus stop A

T^i_S = slice release time where the number of slices is i

T_F = access and egress time by foot

T_C = access time by car to/from the park'n'ride station

The difference between the left and right hand side in the inequality above represents the waiting time T_W:

$$T_W = T^1_A - T^i_S + T_F + T_C$$

The waiting time has to be greater or equal to 0 and less or equal to maximum waiting time otherwise the trip cannot occur.

$$T_{W(max)} \geq T_W \geq 0$$

(ii) The multi ride trip will occur if the single ride trip condition is satisfied for the first bus service used, and

$$T^2_B \geq T^1_B + 30\text{sec}$$

Where:

T^1_B is the time at which the first bus arrives at the bus stop B

T^2_B is the time at which the second bus departs at the bus stop B

30sec is the minimum time allowed for the passenger transfer

The difference between the first bus arrival and the second bus departure represents the waiting time:

$$T_W = T^2_B - T^1_B$$

Therefore T_W and has to be greater or equal to 30 seconds and less or equal to maximum waiting time $T_{W(max)}$ for the trip to occur:

$$T_{W(max)} \geq T_W \geq 30\text{sec}$$

If the maximum number of transfers is 3, then another condition has to be met for the trip to occur:

$$T^3_C > T^2_C + 30, \text{ and}$$

$$T_{W(max)} \geq T_W \geq 30\text{sec}$$

Where:

T^2_C = *the time at which the second bus arrives at the bus stop* C

T^3_C = *the time at which the third bus departs at the bus stop* C

T_W = $T^3_C - T^2_C$

$T_{W(max)}$ = *the maximum waiting time*

Further constraints are the maximum inter-zonal cost and the maximum number of transfers. They cannot exceed values specified in the parameter file.

The inter-zonal cost for PT trips is derived as the weighted sum of several components:

- Wait time cost
- Walking time cost at each end of the trip
- Park'n'ride cost (if used)
- Fare cost
- A penalty for transferring between services

All bus routes are divided into a number of fare sections and the bus fare is derived depending of which fare section crossed. In the base model, a new ticket has to be purchased if a transfer is needed.

If a car is used as part of a PT trip (for example a park'n'ride trip) then the car cost is added and it consists of:

- In vehicle time cost, and
- In vehicle distance cost
- Parking cost

Time and distance costs are derived from the loaded vehicle network. During the assignment the link time is multiplied by 1.3 to allow for the time lost at bus stops where the boarding and alighting of buses occurs. The route file defines express routes where passengers can board buses only on certain stations, and no additional allowance is made for pick up times.

3.2 Public Transport Model Outputs

The public transport assignment outputs a series of matrices representing various time and cost components, and are a weighted average of the cost of all trips between each zone pair.

- In vehicle time
- Average walk time
- Average wait time
- Average car cost
- Average fare cost

Other matrices output by the public transport assignment are:

- Average number of fare sections crossed
- Average number of transfers

It is also possible to establish the services used between each zone pair for each slice of loading. Also available are the origin and destination nodes for each bus service used and the park'n ride nodes if these facilities are used to complete the trip. The path file also contains information about each of the slices loaded, the release time and the cost in dollars for that trip portion. If the trip happens to be the one where passengers transferred from one bus to another, then the node at which the transfer occurs is recorded.

Passenger patronage per service with the time component included is reported in a separate file, which lists all services and the number of passengers getting on and off the buses along the route.

Similar to vehicle assignment a loaded network is produced at the end of each run, and depending on the switch used in the parameter file loaded network will contain either PT passenger numbers or the number of buses. The number of buses is a graphical check on the coding and is a direct reflection of input.

4. Validation Criteria

The checks on the public transport model as included in the Model Specification report are:

4.1 Public Transport Distribution and Assignment

Model Output:	Bus numbers
Check:	That the number of buses on each link matches observed. This is essentially a check on service coding.
Criteria:	Absolute match
Model Output:	Bus journey times
Check:	That the journey time for each service matches observed. In part a check on timetable coding and in part that the stopped and network travel times are correct.
Criteria:	Journey times within $\pm$ 5% of expected for each service
Model Output:	Passenger numbers per service
Check:	That the number of passengers on and off for each service match observed
Criteria:	Overall within +/- 10%, R^2 >0.6, and +/- 40% on most services
Model Output:	Screenline link passenger volumes
Check:	That the number of passengers on each and all links in a screenline match observed
Criteria:	That each screenline is within $\pm$ 20% of observed and most individual links are within $\pm$ 50% of observed
Model Output:	Elasticities
Check:	That the modelled response to changes is in accordance with international experience
Criteria:	Fare change has an elasticity of - 0.3, and frequencies -0.1 in peak periods and slightly higher elasticities off peak
Model Output:	Three step vs Four Step traffic volume comparison
Check:	That the two models are consistently replicate traffic volumes
Criteria:	Overall R^2 > 0.95 for counts and R^2 > 0.95 for sector to sector trip totals Most screenline GEH statistics < 4

These checks were specified during the model build and stipulated in the Model Specification Report. At that time, NZTA's Economic Evaluation Manual (EEM) did not provide any guidance on criteria for validating the public transport assignment. Since then, the NZTA Transport Model Development Guidelines have been released, which does include criteria for public transport assignment validation. The criteria in the NZTA Guideline have been taken on board and results are reported on this basis in this technical note.

5. Model Convergence

5.1 Assignment and Validation Loop

Time and distance matrices are required as inputs for trip distribution. As assigning the trips to the network generates these matrices, after each assignment the trip distribution needs to be re-run and the trips re-assigned until the time and distances matrices converge.

In practice, it is unlikely that absolute convergence occurs. The assignment and distribution steps are run iteratively until the totals of both the time and distance matrices between successive runs remain close to each other and relatively constant.

The totals for the time and distance matrices for two successive Assignment/Distribution Loops (after many previous runs) are shown below in **Table 2** where:

TVM = Total Vehicle Minutes

TVK = Total Vehicle Kilometres

And the mode split convergence results for both morning peak and inter peak are presented in **Table 3**.

Period	AM Peak		Interpeak	
	TVM	TVK	TVM	TVK
Last Run	2,694,461	2,519,254	2,290,582	2,039,692
Difference from Previous Run	-327	-235	-77	-32
% Diff	0.01%	0.01%	0.00%	0.00%

Table 2: Model Convergence

Variable	Previous Iteration	This Iteration	Difference	%
AMP				
Active Trips	40,979	40,982	3	0.00%
Bus Passengers	4,440	4,441	1	0.00%
Car Passengers	116,428	116,424	-4	0.00%
Drivers	239,289	239,289	0	0.00%
INP				
Active Trips	37,662	37,656	-6	-0.00%
Bus Passengers	2,615	2,643	28	1.10%
Car Passengers	73,133	73,124	-9	-0.01%
Drivers	232,658	232,647	-11	-0.00%

Table 3: Mode Split Convergence

The percentage change in generalised user cost between consecutive loops should be less than 1%. As the total vehicle minutes and total vehicle kilometres change less than 1% between runs (shown above), and unit time and distance costs are constant between runs, generalised user cost also changes less than 1% between runs.

When validating the model it is difficult to get a long series of runs prior to convergence because of the continual changing of the model components to get a better fit, even though these changes were often small. In general the model re-converged after two or three iterations. The periods were then run several times after convergence and remained stable.

For any model, if the network is heavily congested, convergence may not occur. Although the model is currently stable, when any changes are made to the model (e.g. option testing or land use), then convergence must be checked to ensure the model is still stable. In the unlikely event of the model not stabilising, modifications will have to be made to the network so that it will converge. These modifications should then be incorporated into the option or year being tested.

Another check on the assignment convergence stability is that the proportion of links in the entire network with flows changing less than 5% from the previous iteration, and consecutive iterations with proportions greater than 95% (EEM Worksheet 8.4). This is reported in the next section.

5.2 Link Flow Convergence

The EEM requirement for link flow stability details that 95% of all links should not change by more than 5% between the ultimate and penultimate distribution/assignment convergence loops. The percentage of total links with changes of less than 5% for the three modelled periods is shown in **Table 4** below.

Period	Criteria	Links	Percentage	Less than 5%
AMP	0% - 2.5%	22714	99.75	99.96%
	2.5% - 5%	48	0.21	
	> 5%	8	0.04	
Total		**22770**	**100**	
INP	0% - 2.5%	22726	99.81	99.89%
	2.5% - 5%	18	0.08	
	> 5%	26	0.11	
Total		**22770**	**100**	

Table 4: Model Convergence

6. Model Validation

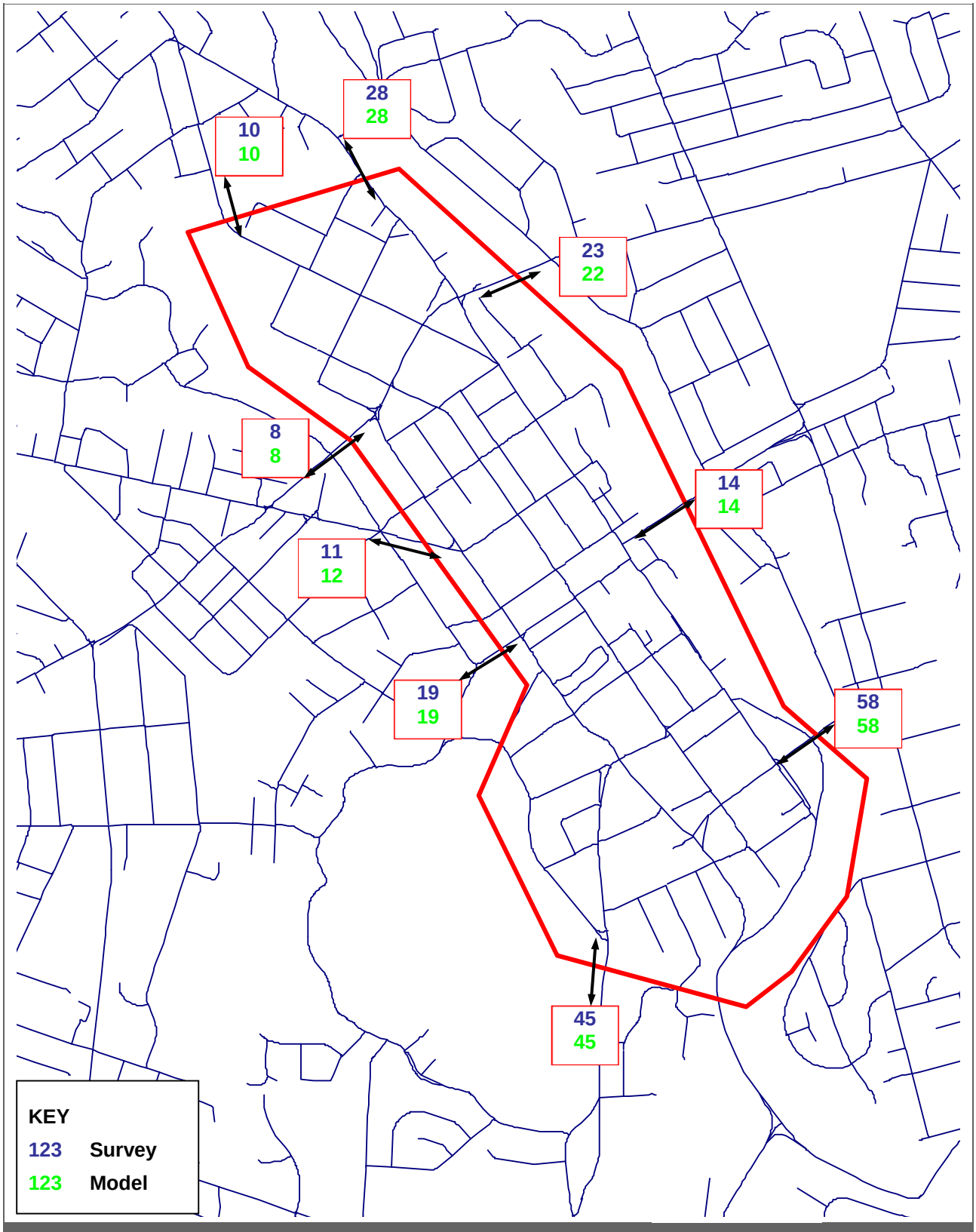
6.1 Bus Numbers

The number of buses passing a particular point during the modelled time period is a function of the service routes, the frequency of the service, and the extent to which a bus driver has managed to keep to the timetable.

The check that the model is assigning buses to the correct routes and in the correct numbers is a check on input service coding, and can be derived from an analysis of the timetables. Alternatively, the number of buses on a link can be derived directly from a classified count.

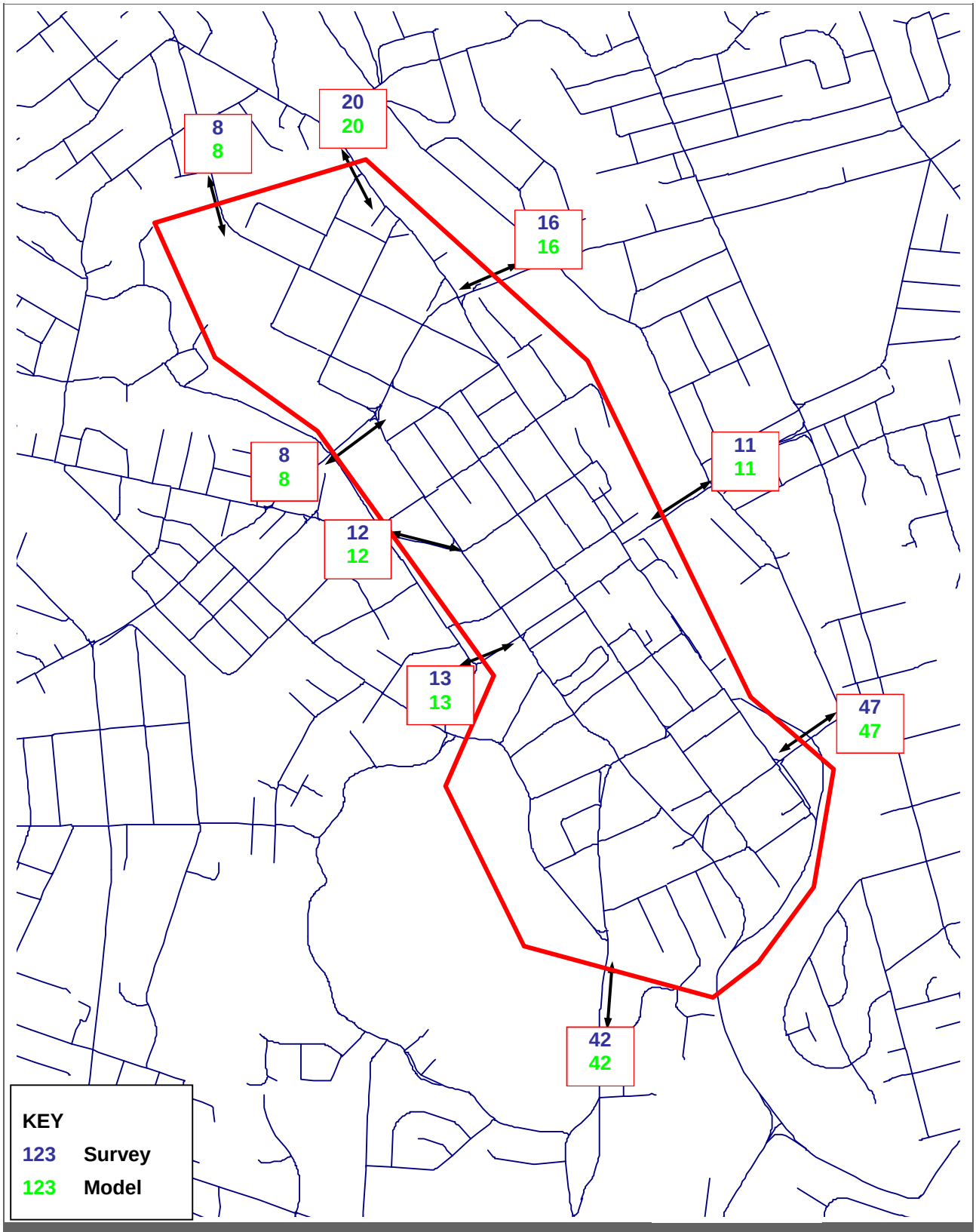
In Hamilton, the latter course was not followed as the automatic classified counts available to the study identified buses as a vehicle class, but these do not distinguish between buses, coaches and school buses, with only scheduled public services included in the model.

Accordingly, the number of buses that should have been on the links around a CBD cordon was calculated from the timetables and checked back against the modelled bus vehicle assignment. The CBD cordon used in this analysis and the AM peak and inter peak bus number validation is shown in **Figure 1** and **Figure 2**. These figures indicate that the model is replicating the timetables correctly.



Hamilton CBD Cordon
AM Peak Bus Vehicle Validation

1



Hamilton CBD Cordon
Inter Peak Bus Vehicle Validation

2

6.2 Bus Journey Time

The model specification report suggested a check against bus journey times. It was initially intended that this data be extracted from the Environment Waikato electronic bus data and it was understood that this would be readily available. Unfortunately time-specific data, which is available from EW is limited to the time at which patrons boarded services, therefore it is not possible to extract an arrival time for the bus reaching the last stop. It is also evident that patrons may board the service at the first stop a number of minutes prior to the start of a run.

The WRTM assumes that bus travel times in urban areas are 30% longer than travel times in private vehicles when no bus priority measures are imposed. The 30% is an allowance for the time taken for boarding and alighting the service. This value was calibrated in 1971 in Christchurch and has recently been confirmed using real-time GPS data in each of Dunedin, Christchurch and Kuala Lumpur. Analysis of the public transport assignment outputs confirmed that the model is accurately calculating bus travel times on this basis.

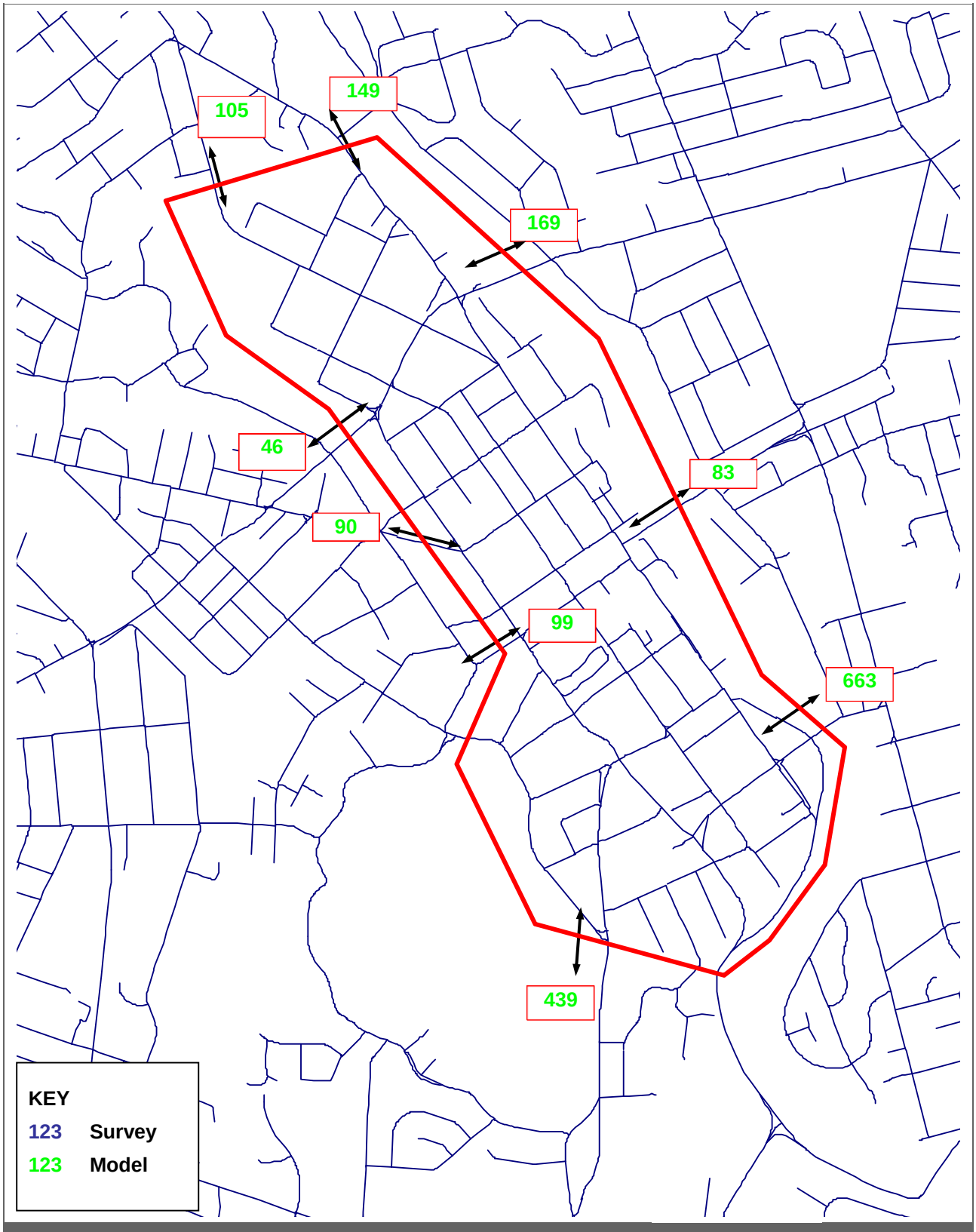
Unfortunately there was insufficient recorded data from the GPS data collected by Environment Waikato to verify the 30% figure on the local services. However, this assumption could be tested using GPS units on a selection of Hamilton City bus services if required. In any event, this assumption has invariably held when it has been tested in urban areas.

6.3 Screenline Link Passenger Volumes

The number of bus passengers passing a particular point during the modelled time period is again a function of the service routes, the frequency of the service, and the extent to which a bus driver has managed to keep to the timetable. The check that the model is assigning bus passengers to the correct routes and in the correct numbers is a check on input service coding and the ability of the model to replicate observed.

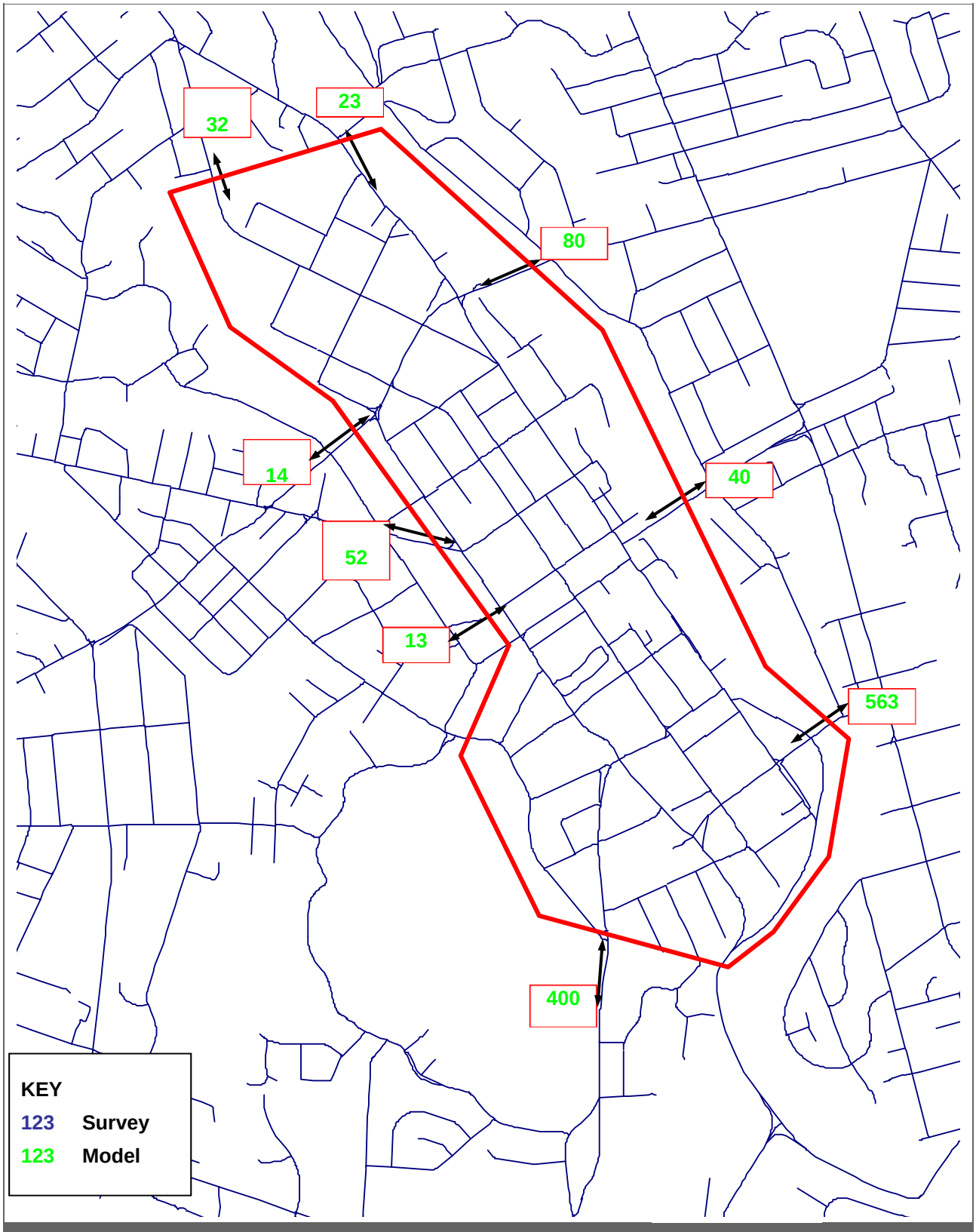
The number of bus passengers that should have been on the links around a CBD cordon was calculated from the bus intercept survey data in 2008. However, in 2013, no such survey was undertaken. As a result, it is not possible to compare the GEH statistics against the NZTA Guideline (the EEM has no criteria) or test r^2 values to check the correlation between surveyed data and modelled results. Only modelled patronage is therefore reported.

The number of bus passengers from the bus vehicle assignment on the links around a CBD cordon for the AM peak and inter peak is shown in **Figure 3** and **Figure 4**. The volume plots of bus passengers for all bus routes within Hamilton for both the morning peak and inter peak are shown **Figure 5** and **Figure 6**.



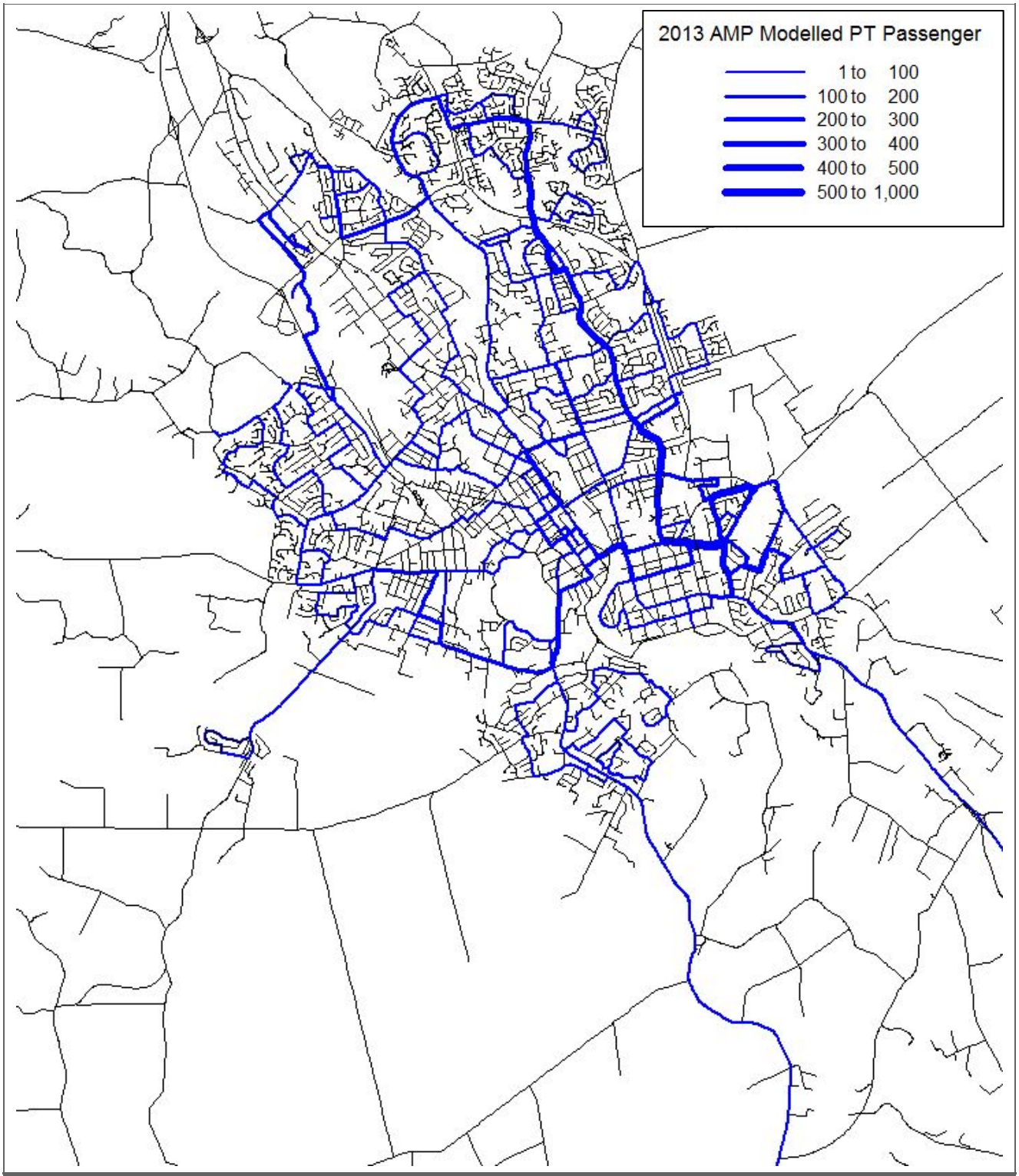
Hamilton CBD Cordon
AM Peak Bus Passengers

3



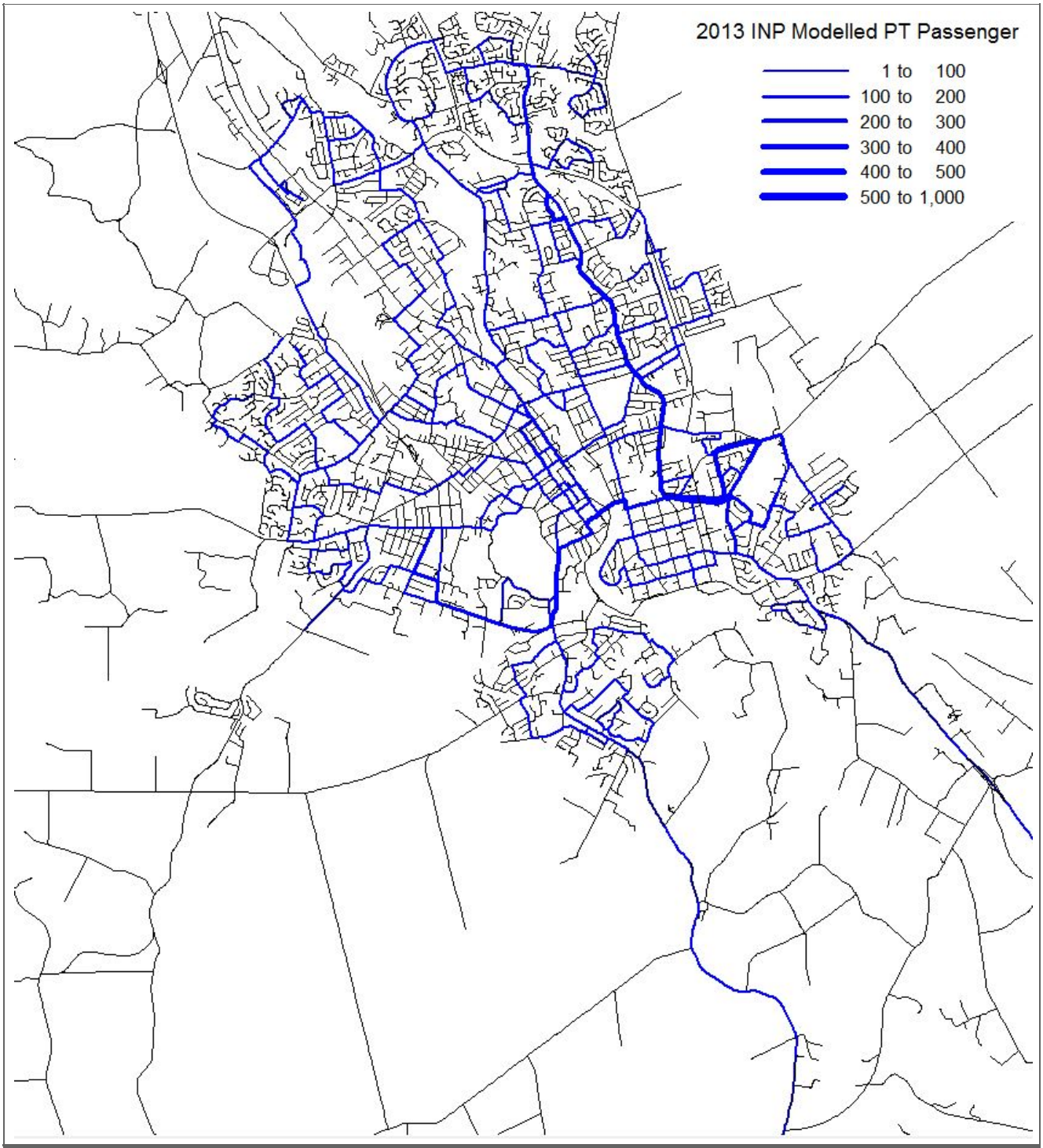
Hamilton CBD Cordon
Inter Peak Bus Passengers

4



Hamilton Bus Patronage
AM Peak Bus Passengers

5



Hamilton Bus Patronage
Inter Peak Bus Passengers

6

6.4 Passenger Numbers per Service

Another check is a comparison of surveyed service use against modelled service use. In this instance the total number of passengers for all services during each period was compared as well as the number of passengers on each route during each period. **Table 5** details the total passenger numbers by route and overall for each period. **Table 6** highlights GEH statistical comparison against NZTA Transport Model Development Guidelines.

A scatterplot of surveyed versus modelled patronage by route for each time period is also presented in Figure 7. The R-Squared measure of fit is R^2 = 0.83and 0.53 for the AM Peak and interpeak respectively. Note that the AM Peak is a better fit than the application of the model using the 2006 (2500 zone) system but not as good for the interpeak period.

Route	Route Name	Morning Peak			Inter Peak		
		Survey	Model	Difference	Survey	Model	Difference
1	Pukete In	126	83	-43	21	22	1
1a	Pukete Out	19	55	36	17	7	-11
2	Silverdale In	134	264	130	50	79	29
2a	Silverdale Out	194	239	45	36	66	30
3	Dinsdale In	151	98	-53	34	19	-15
3a	Dinsdale Out	12	34	22	26	4	-22
4	Flagstaff In	102	54	-48	24	17	-8
4a	Flagstaff Out	30	67	37	27	7	-21
5	Chartwell In	80	5	-75	14	2	-13
5a	Chartwell Out	21	13	-8	12	1	-11
6	Mahoe In	108	56	-53	33	21	-12
6a	Mahoe Out	39	58	19	33	9	-24
7	Glenview In	74	35	-39	35	46	11
7a	Glenview Out	25	43	18	30	30	0
8	Frankton In	172	158	-14	48	32	-16
8a	Frankton Out	54	72	18	59	47	-12
9	Nawton-TC IN	99	27	-73	25	11	-14
9a	Nawton-TC OUT	65	55	-10	27	13	-14
10	Hillcrest-TC IN	74	88	14	33	31	-2
10a	Hillcrest-TC OUT	139	88	-51	24	14	-10
11	Fairfield-TC IN	83	28	-55	26	3	-23
11a	Fairfield-TC OUT	10	36	26	28	2	-26
12	Fitzroy-TC IN	109	46	-63	26	30	4
12a	Fitzroy-TC OUT	32	47	15	21	6	-15
13	University-TC IN	61	38	-24	57	59	2
13a	University-TC OUT	75	62	-13	57	57	0
14	Claudelands-TC IN	88	82	-6	24	6	-19
14a	Claudelands-TC OUT	23	36	13	29	3	-26
15	Ruakura-TC IN	97	93	-4	45	75	30
15a	Ruakura-TC OUT	148	173	25	48	111	63
16	Rotoruna-TC IN	197	120	-78	65	89	24
16a	Rotoruna-TC OUT	36	85	49	66	25	-41
17	Hamilton East Uni-TC IN	68	122	54	76	82	6
17a	Hamilton East Uni-TC OUT	109	190	81	59	111	52

Route	Route Name	Morning Peak			Inter Peak		
		Survey	Model	Difference	Survey	Model	Difference
18	Te Rapa-TC IN	138	119	-19	42	42	0
18a	Te Rapa-TC OUT	41	115	74	24	19	-5
26	Bremworth/Temple View-TC IN	77	38	-39	22	3	-20
26a	Bremworth/Temple View-TC OUT	20	36	16	13	2	-11
30	Northerner-TC IN	N/A	14	14	3	5	2
30a	Northerner-TC OUT	N/A	8	8	14	12	-2
16rd	Rototuna Direct East	54	53	-1			
16rda	Rototuna Direct West	43	24	-19			
51	CBD Shuttle	N/A	117	-360	N/A	258	258
20	Hamilton to Cambridge	82	95	13			
20	Cambridge to Hamilton	N/A	216	216	N/A	81	81
24	Hamilton to Te Awamutu	31	29	-2	N/A	1	1
24a	Te Awamutu to Hamilton	62	73	11	N/A	6	6
52	OrbiterC: Base to Base	699	594	-105	N/A	588	588
52	OrbiterA: Base to Base	494	384	-110	N/A	581	581
Trips with no transfer			4144			2485	
Trips with transfer			260			121	
TOTAL TRIPS		4595	4664	-69	1353	2728	1375
TOTAL TRIPS excluding N/A		4595	4309	-286	1353	1215	-138

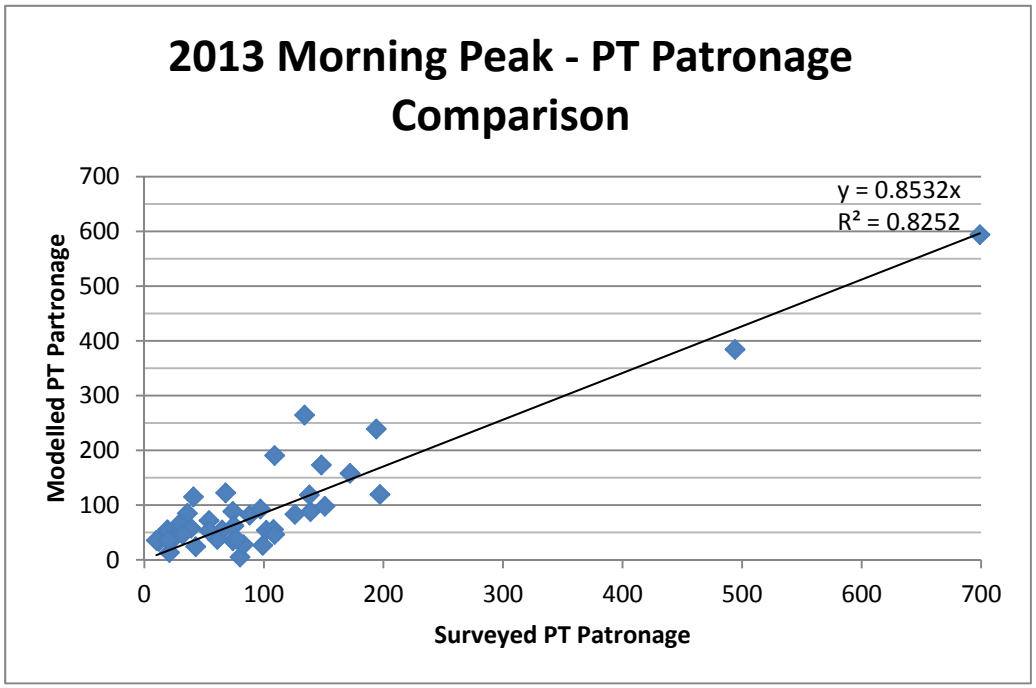
Table 5: Total PT Boarding Comparison

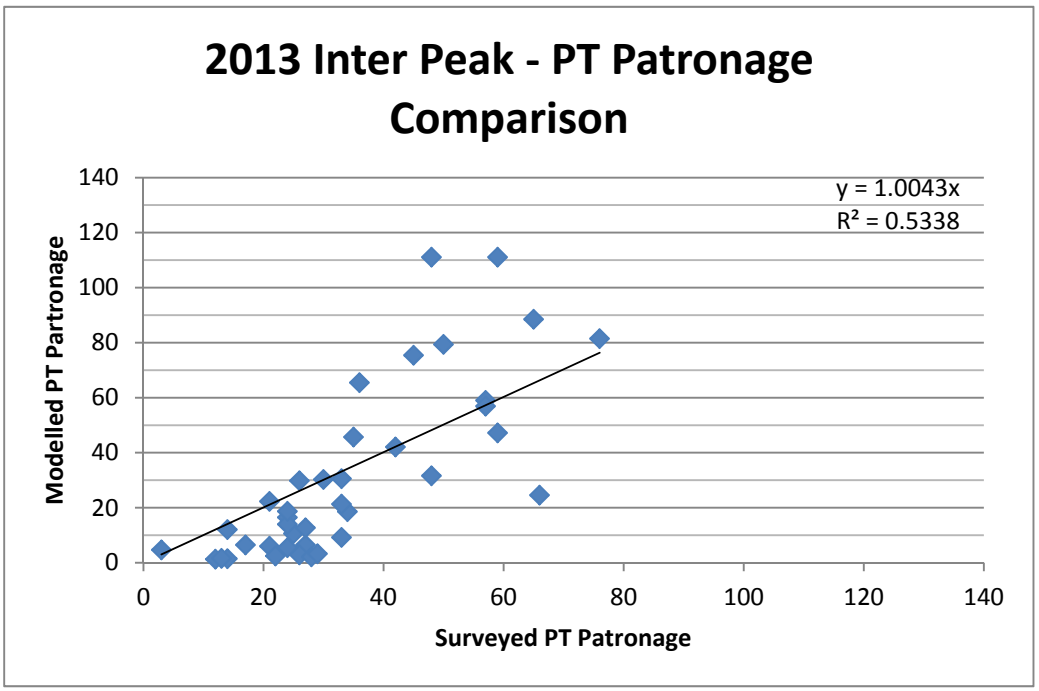
While there is some considerable variation on a route by route basis, this is typical when reproducing relatively small figures.

PT BOARDING COMPARISON SUMMARY TO NZTA TRANSPORT MODEL GUIDELINES				
		Target	**Morning Peak**	**Inter Peak**
All Individual PT Routes	GEH < 5.0	>50%	60.0%	76.2%
	GEH < 7.5	>60%	91.1%	100%
	GEH < 10	>70%	97.8%	100%
	GEH < 12	>80%	100%	100%
Line of Best Fit		Y=0.85x-1.15x	Y=0.853	Y=1.004
R^2		>0.80	0.83	0.53

Table 6: PT Boarding Comparison Summary to NZTA Transport Model Development Guidelines

The model is within the NZTA guidelines with the exception of the inter peak R^2. Other metrics indicate that the inter peak meets the NZTA Guideline criteria. The results are considered acceptable given the small observed volumes that are being replicated.





Hamilton Service Patronage Validation by Route Scatterplot

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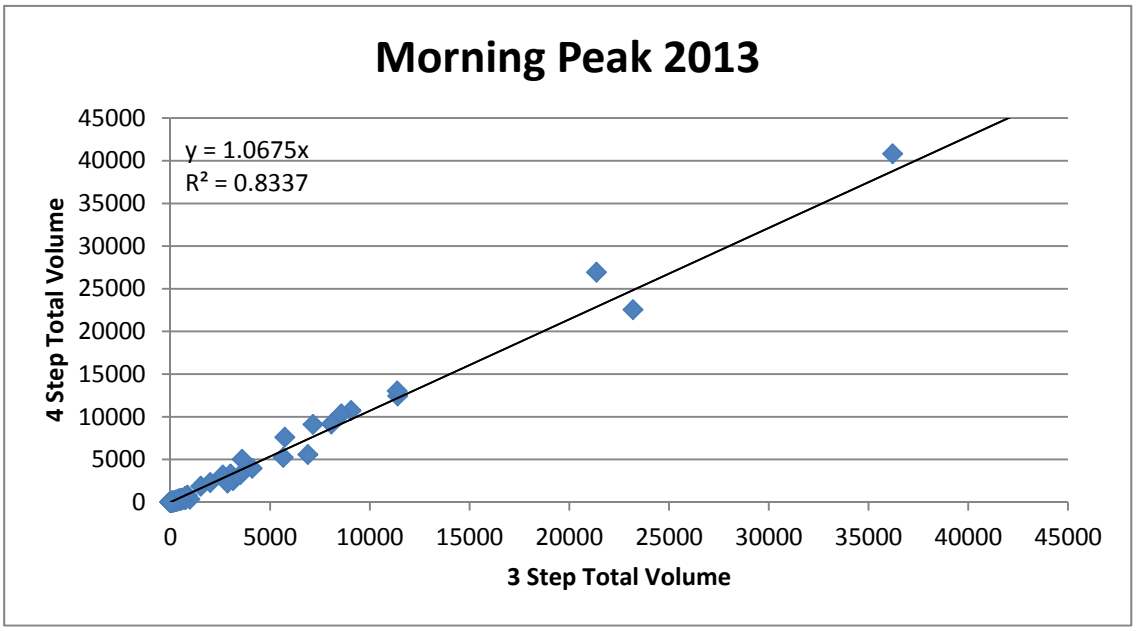
6.5 Correlation with the Three-Step Vehicle Driver Matrix

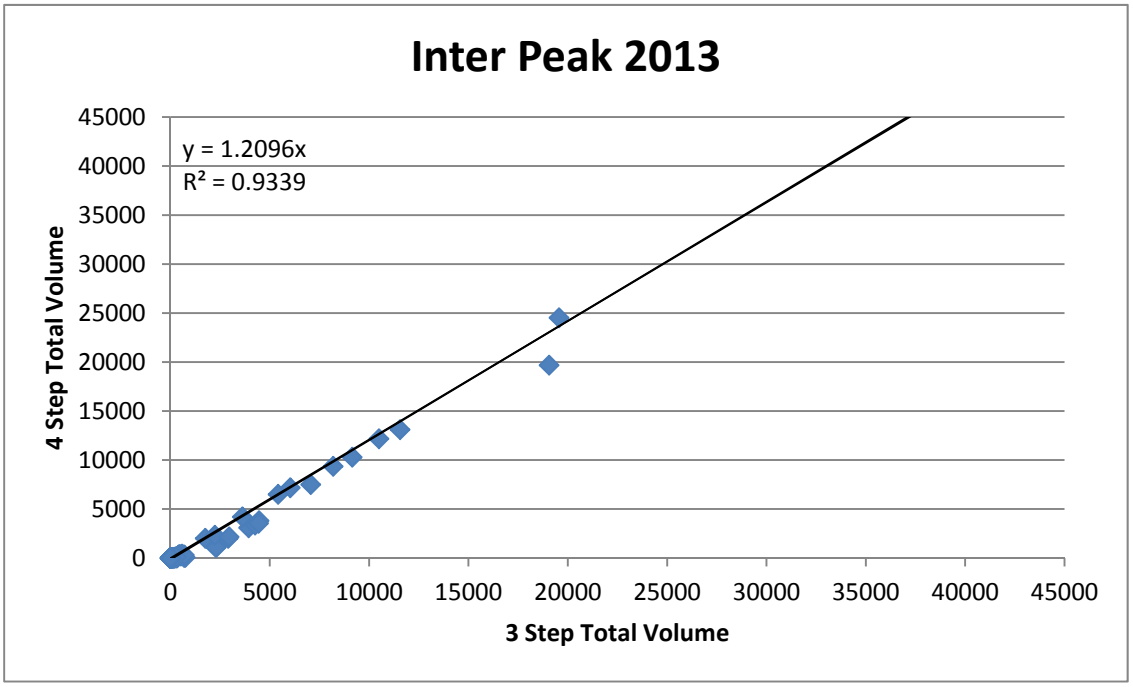
The intention of this section is to establish that the vehicle driver matrices resulting from the AM peak and the inter peak mode split processes are statistically similar to those produced in the three step processes. The three and four step vehicle driver matrices have been aggregated into Territorial Local Authority areas and compared on a sector-to-sector level. The results of those comparisons are shown in **Figure 8**, and yield correlation coefficients of R^2=0.8337 and 0.9339 for the AM and inter peak periods respectively.

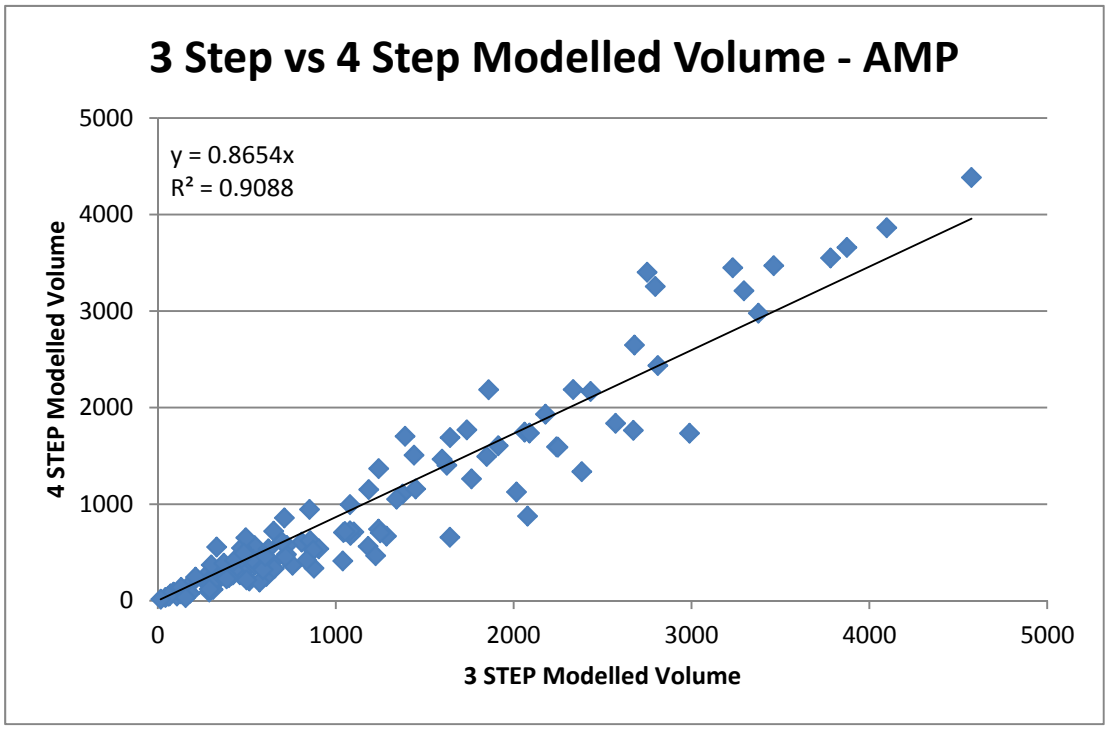
However, in comparison with the three step model the screenline GEH statistics are not as good as the three step model and as such we would expect that analysis of roading projects be carried out using the three step model while the four step model would generally only be used for public transport analysis.

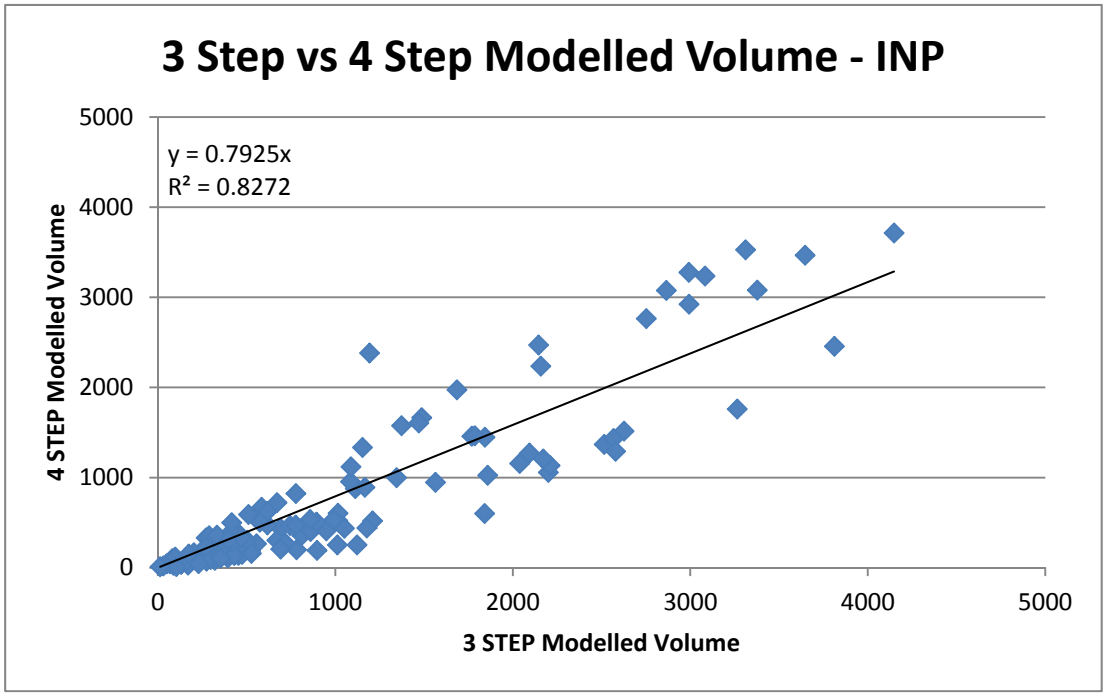
The correlation between the three and four step models is shown in a scatterplot of modelled verses observed counts as **Figure 9** with R-squared statistics of 0.91 and 0.83 for each period.

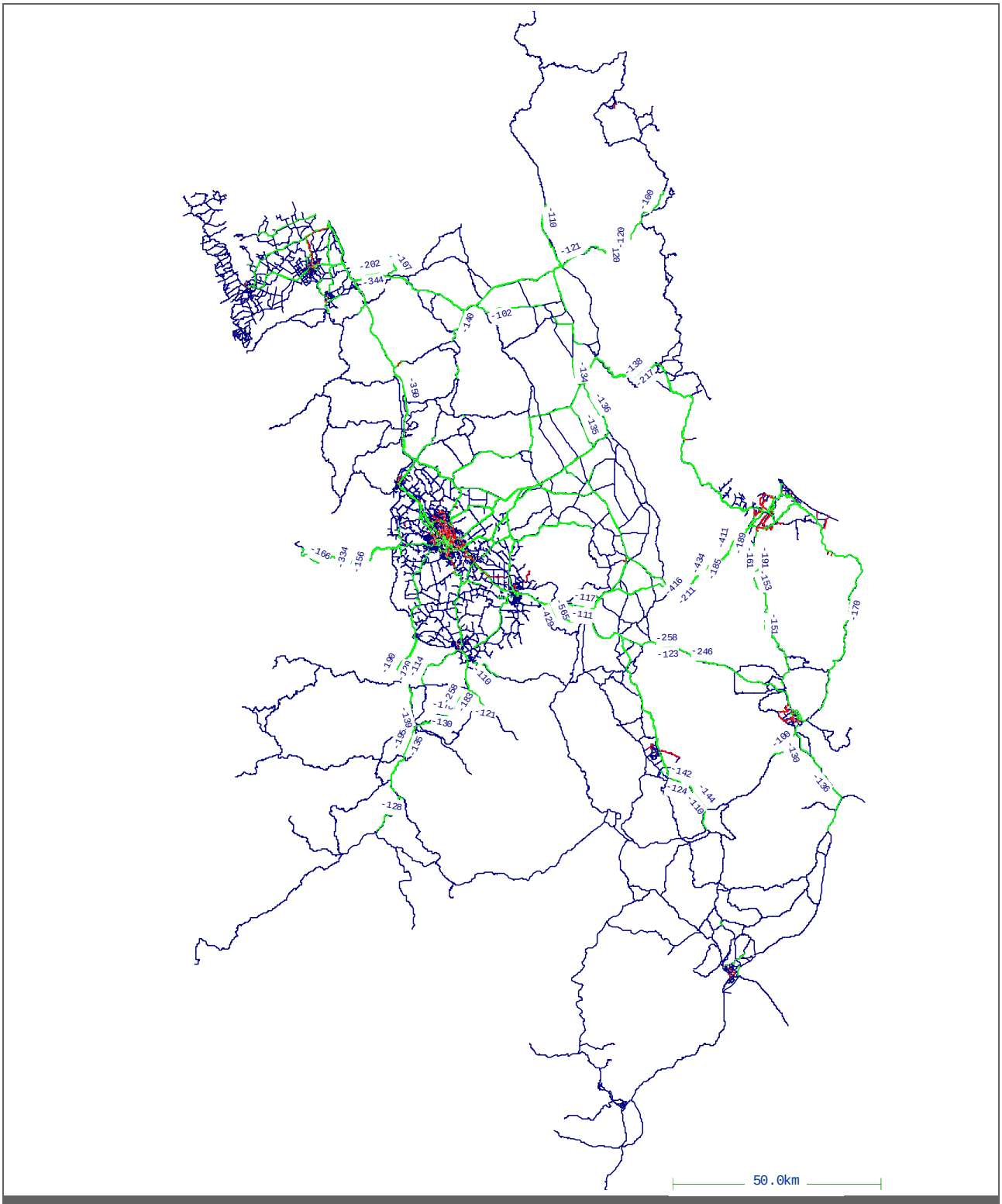
The morning peak and inter peak two-hourly volume changes between the three and the four step models are shown in **Figure 10** though **Figure 13**. A cut-off of 100 vehicles per hour, which is approximately 1000 vehicles per day has been applied.


Morning Peak 2013
y = 1.0675x
R² = 0.8337
4 Step Total Volume
3 Step Total Volume
0
5000
10000
15000
20000
25000
30000
35000
40000
45000


Inter Peak 2013
y = 1.2096x
R² = 0.9339
4 Step Total Volume
3 Step Total Volume
0
5000
10000
15000
20000
25000
30000
35000
40000
45000

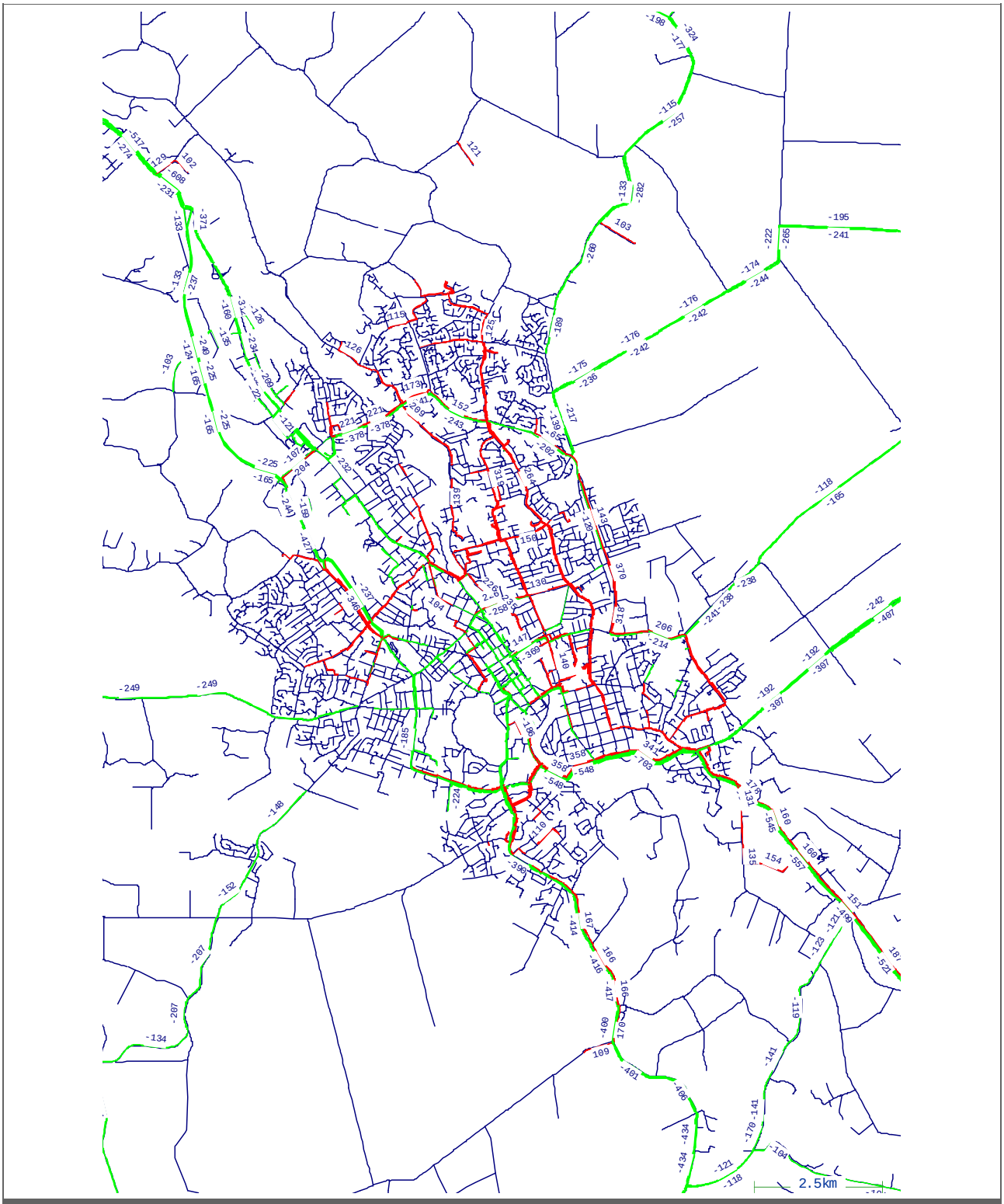

3 Step vs 4 Step Modelled Volume - AMP
y = 0.8654x
R² = 0.9088
4 STEP Modelled Volume
3 STEP Modelled Volume
0
1000
2000
3000
4000
5000


3 Step vs 4 Step Modelled Volume - INP
y = 0.7925x
R² = 0.8272
4 STEP Modelled Volume
3 STEP Modelled Volume
0
1000
2000
3000
4000
5000



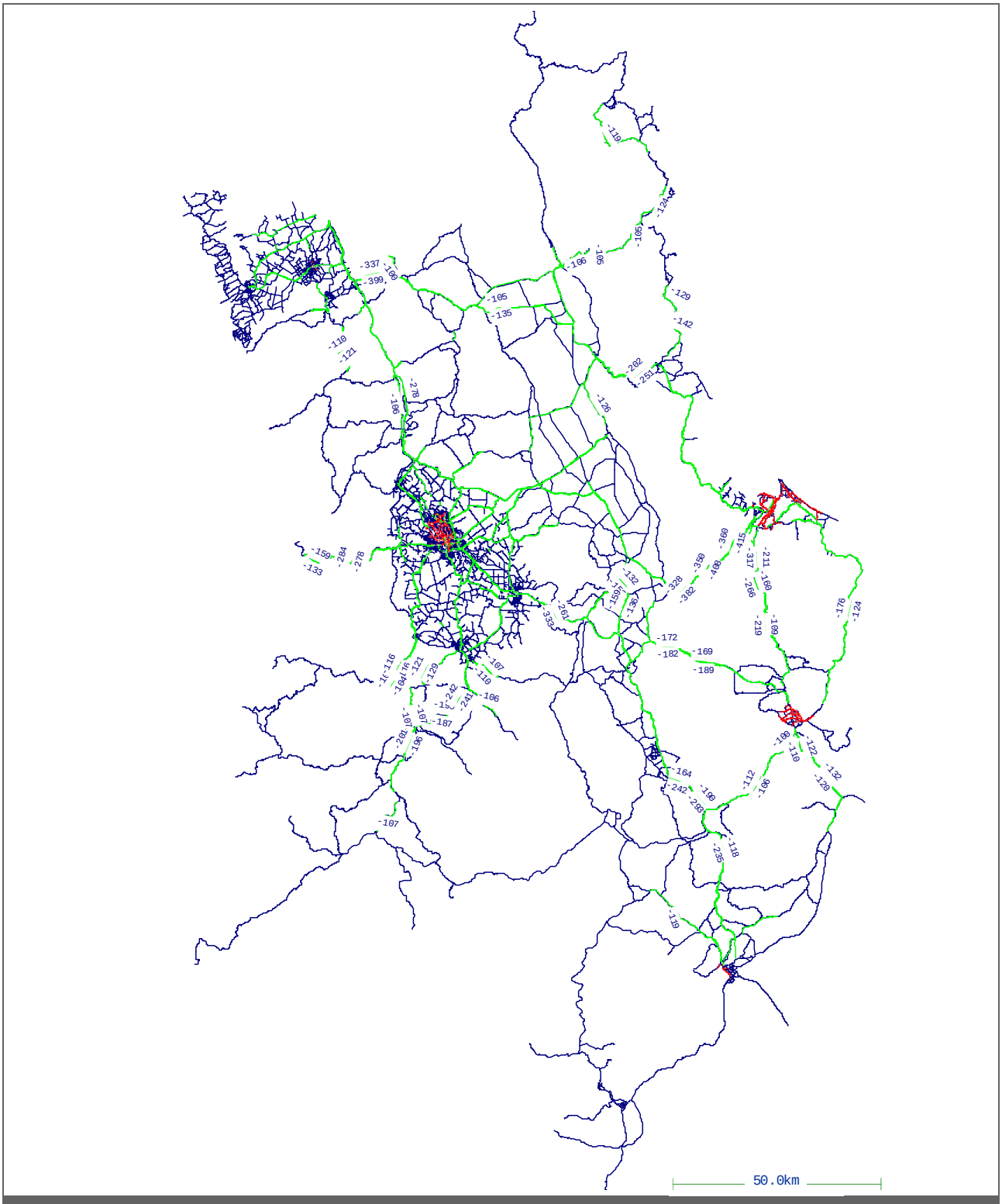
Three Step vs Four Step Volume Changes
Study Area Overview – Morning Peak

10



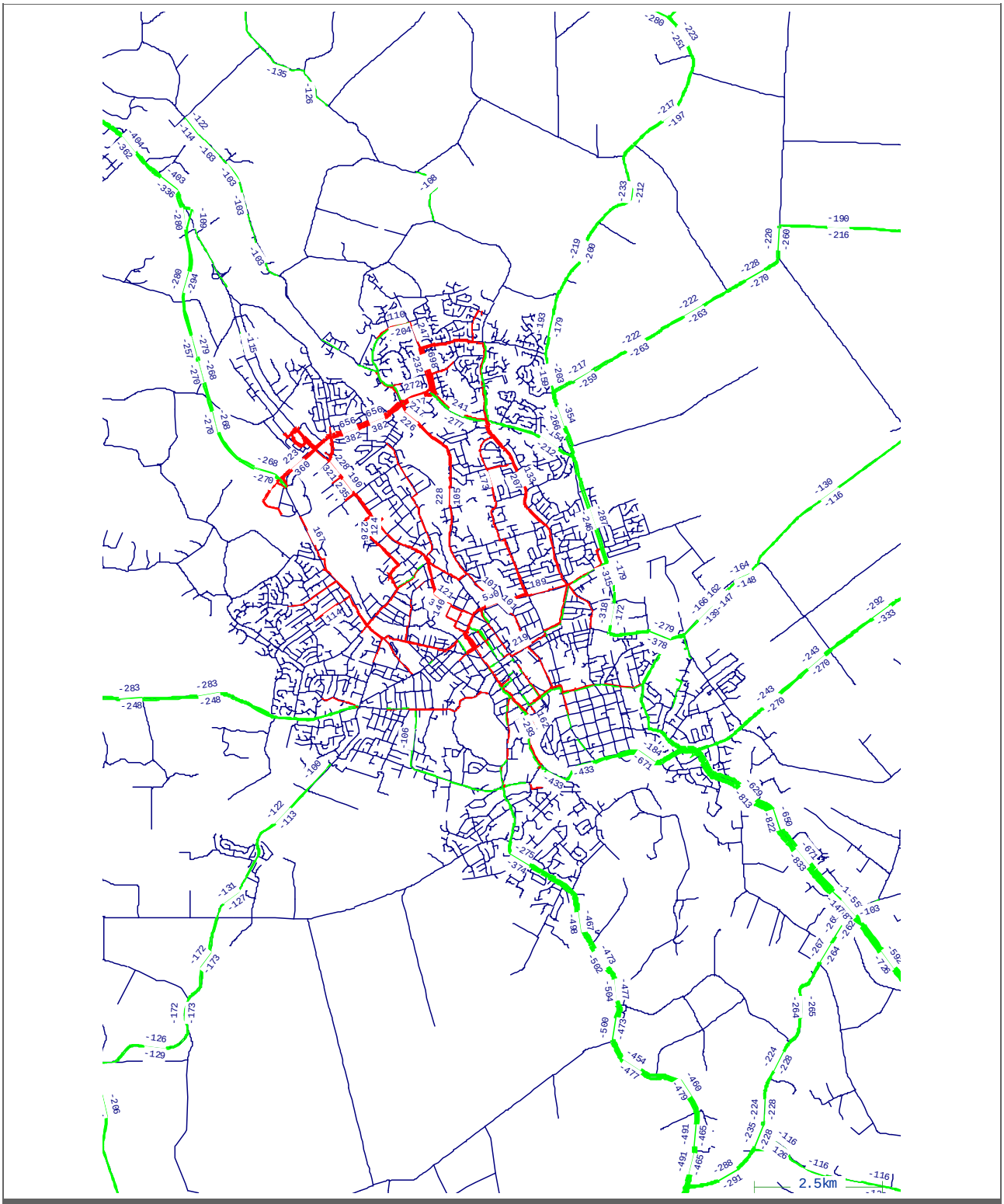
Three Step vs Four Step Volume Changes
Hamilton – Morning Peak

11



Three Step vs Four Step Volume Changes
Study Area Overview – Inter Peak

12



Three Step vs Four Step Volume Changes
Hamilton – Inter Peak

13

7. Conclusion

Overall, the four step model is considered sufficiently validated.

Compared with the three step model, the road vehicles do not replicate observed as well as the three step model. We would expect that roading projects be assessed using the three step model while the four step model would generally be used for public transport analysis.

Irrespective of this, any roading or public transport project assessments should be preceded by local area validation checks.

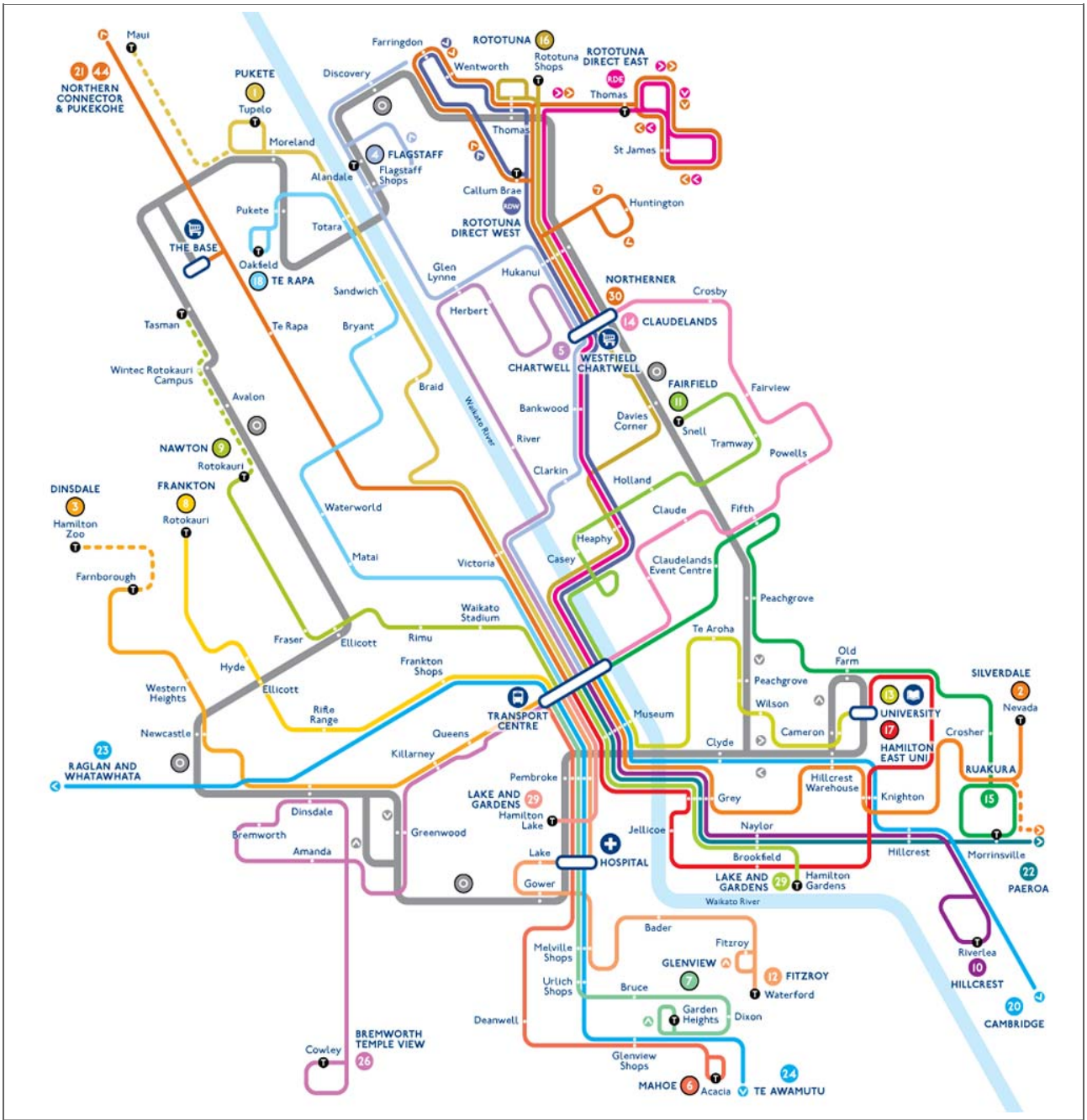
Appendix A

Hamilton Bus Routes

The bus route names are listed in Table A1 below and displayed in Figures A1, A2 and A3 following.

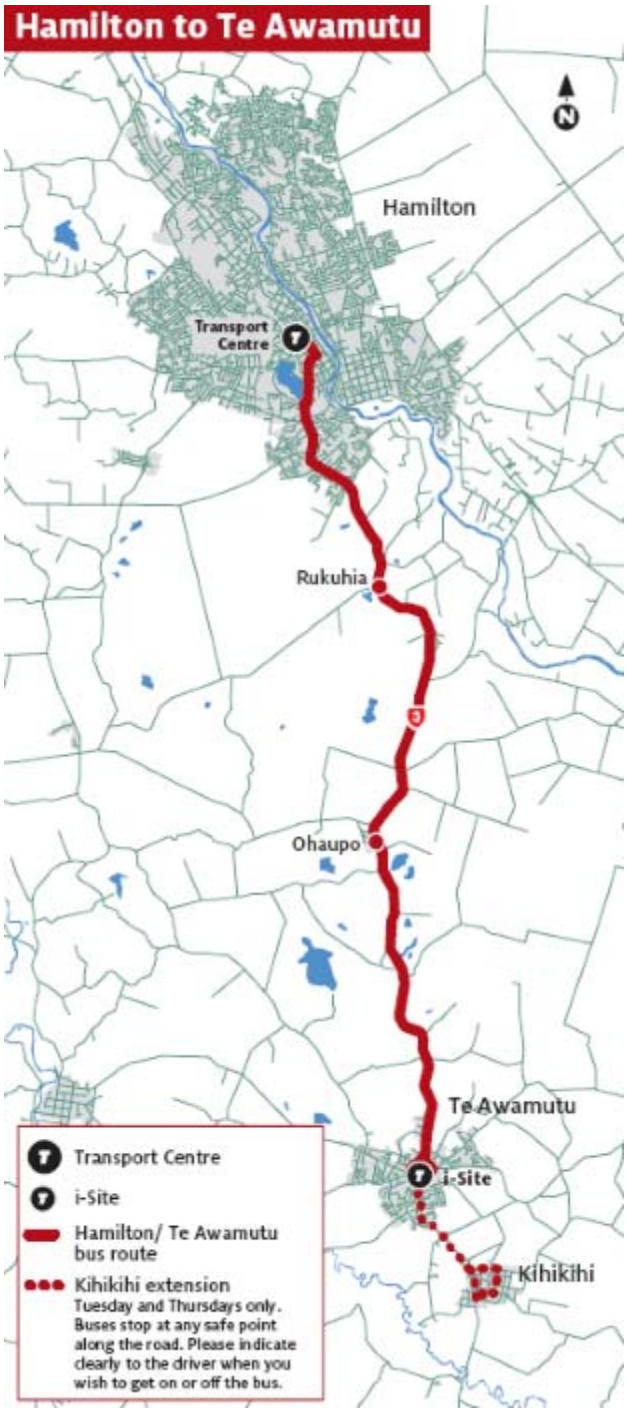
Existing Bus Routes	
O	Orbiter
1	Pukete
2	Silverdale
3	Dinsdale
4	Flagstaff
5	Chartwell
6	Mahoe
7	Glenview
8	Frankton
9	Nawton
10	Hillcrest
11	Fairfield
12	Fitzroy
13	University
14	Claudelands
15	Ruakura
16	Rototuna
17	Hamilton East Uni
18	Te Rapa
20	Cambridge
24	Te Awamutu
26	Bremworth Temple View
30	Northerner
RDE	Rototuna Direct East
RDE	Rototuna Direct West
51	CBD Shuttle
52a	OrbiterC: The Base - The Base
52	OrbiterA: The Base - The Base

Table A1: Existing Bus Routes



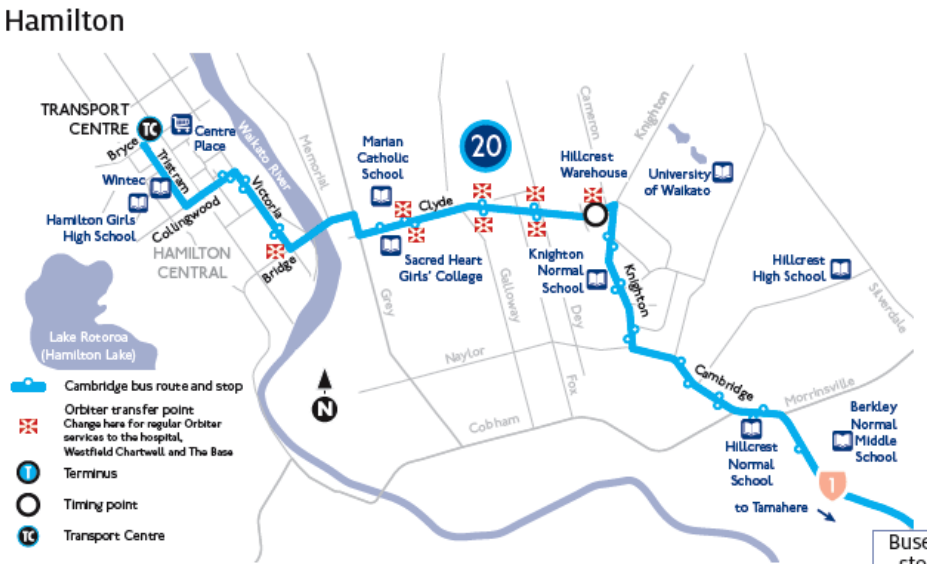
All Bus Routes

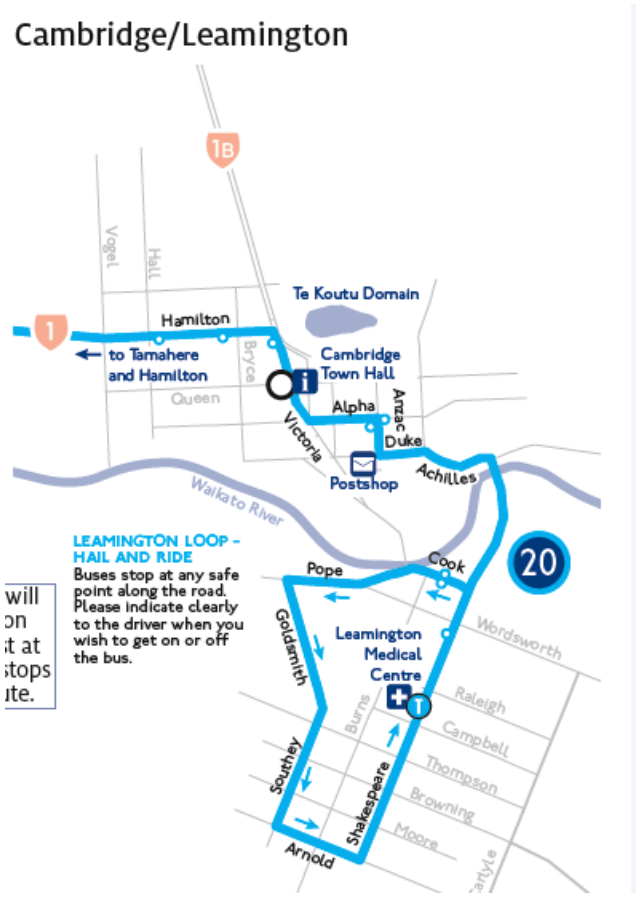
A1



Regional Bus Routes –
Hamilton to Te Awamutu

A2





Regional Bus Routes –
Hamilton to Leamington

A3

Appendix B

Hamilton Bus Route Frequencies

A list of the times at which each service runs is in the table below. The format of the bus frequencies file is:

- **1 30 0720 (Fixed headway)**; means Route 1 (Pukete In) service runs every 30 minutes in morning peak, starts at 07:20
- **5 0 @ 0715 0745 0815 0850 (Variable headway);** means Route 5 (Dinsdale In) service runs at specified time in morning peak, starts at 07:15, then 07:45, 08:15, 08:50

Route	Service Time	Service Name
1	@ 0650 0710 0720 0740 0745 0815 0850	Pukete In
2	@ 0650 0715 0745 0820 0850	Pukete Out
3	@ 0650 0720 0745 0755 0820 0850	Silverdale In
4	@ 0720 0750 0800 0820 0830 0850	Silverdale Out
5	@ 0645 0715 0740 0750 0815 0850	Dinsdale In
6	@ 0650 0715 0750 0820 0850	Dinsdale Out
7	30 0710	Flagstaff In
8	30 0720	Flagstaff Out
9	30 0720	Chartwell In
10	30 0720	Chartwell Out
11	30 0720	Mahoe In
12	30 0723	Mahoe Out
13	30 0720	Glenview In
14	@ 0653 0730 0808 0838 0905	Glenview Out
15	@ 0650 0720 0740 0750 0820 0850	Frankton In
16	@ 0650 0720 0750 0820 0840 0900	Frankton Out
17	30 0715	Nawton-TC IN
18	30 0715	Nawton-TC OUT
19	30 0650	Hillcrest-TC IN
20	30 0730	Hillcrest-TC OUT
21	30 0650	Fairfield-TC IN
22	30 0722	Fairfield-TC OUT
23	30 0650	Fitzroy-TC IN
24	30 0723	Fitzroy-TC OUT
25	30 0710	University-TC IN
26	30 0710	University-TC OUT
27	@ 0715 0740 0810 0840	Claudelands-TC IN
28	30 0720	Claudelands-TC OUT
29	@ 0715 0745 0820	Ruakura-TC IN

Route	Service Time	Service Name
30	@ 0715 0745 0825	Ruakura-TC OUT
31	@ 0700 0725 0755 0830	Rotoruna-TC IN
32	@ 0700 0730 0805 0835	Rotoruna-TC OUT
33	@ 0655 0720 0750 0825 0855	Hamilton East Uni-TC IN
34	@ 0655 0720 0755 0825 0855	Hamilton East Uni-TC OUT
35	@ 0650 0720 0735 0820 0850	Te Rapa-TC IN
36	@ 0650 0720 0755 0825 0855	Te Rapa-TC OUT
37	30 0715	Bremworth/Temple View-TC IN
38	30 0722	Bremworth/Temple View-TC OUT
39	@ 0715 0735 0825	Northerner-TC IN
40	@ 0655 0725 0755 0820 0845	Northerner-TC OUT
41	@ 0710 0740 0840	Rototuna Direct East
42	@ 0650 0725 0805	Rototuna Direct West
43	10 0700	CBD Shuttle
44	@ 0800	Hamilton to Leamington
45	@ 0700 0720 0900	Leamington to Hamilton
46	@ 0800	Hamilton to Te Awamutu
47	@ 0700 0730 0900	Te Awamutu to Hamilton
48	105 0615	OrbiterC: The Base to The Base
49	105 0622	OrbiterC: Flagstaff to Flagstaff
50	105 0626	OrbiterC: Rototuna to Rototuna
51	105 0620	OrbiterC: Chartwell to Chartwell
52	105 0620	OrbiterC: University to University
53	105 0615	OrbiterC: Hospital to Hospital
54	105 0615	OrbiterC: Dinsdale to Dinsdale
55	105 0624	OrbiterC: W Rotokauri to W Rotokauri
56	105 0615	OrbiterA: The Base to The Base
57	105 0620	OrbiterA: W Rotokauri to W Rotokauri
58	105 0615	OrbiterA: Dinsdale to Dinsdale
59	105 0625	OrbiterA: Hospital to Hospital
60	105 0610	OrbiterA: University to University
61	105 0610	OrbiterA: Chartwell to Chartwell
62	105 0614	OrbiterA: Rototuna to Rototuna
63	105 0618	OrbiterA: Flagstaff to Flagstaff

Table B1: Waikato Morning Peak Model 7-9am - 2013 Bus Frequencies

Route	Service Time	Service Name
1	30 1120	Pukete In
2	30 1120	Pukete Out
3	@ 1120 1150 1250	Silverdale In
4	@ 1120 1220 1250	Silverdale Out
5	30 1120	Dinsdale In
6	30 1120	Dinsdale Out
7	@ 1110 1140 1240	Flagstaff In
8	@ 1120 1220 1250	Flagstaff Out
9	@ 1115 1145 1245	Chartwell In
10	@ 1115 1215 1245	Chartwell Out
11	30 1120	Mahoe In
12	30 1120	Mahoe Out
13	30 1105	Glenview In
14	30 1105	Glenview Out
15	20 1110	Frankton In
16	20 1100	Frankton Out
17	@ 1115 1145 1220 1245	Nawton-TC IN
18	30 1115	Nawton-TC OUT
19	@ 1055 1125 1155 1255	Hillcrest-TC IN
20	@ 1105 1135 1235	Hillcrest-TC OUT
21	30 1050	Fairfield-TC IN
22	30 1052	Fairfield-TC OUT
23	30 1050	Fitzroy-TC IN
24	30 1053	Fitzroy-TC OUT
25	30 1110	University-TC IN
26	30 1110	University-TC OUT
27	@ 1110 1140 1240	Claudelands-TC IN
28	@ 1115 1215 1245	Claudelands-TC OUT
29	@ 1120 1220	Ruakura-TC IN
30	@ 1050 1150 1250	Ruakura-TC OUT
31	30 1100	Rotoruna-TC IN
32	30 1105	Rotoruna-TC OUT
33	30 1055	Hamilton East Uni-TC IN
34	30 1055	Hamilton East Uni-TC OUT
35	30 1050	Te Rapa-TC IN
36	30 1050	Te Rapa-TC OUT

Route	Service Time	Service Name
37	@ 1115 1215	Bremworth/Temple View-TC IN
38	@ 1052 1152 1252	Bremworth/Temple View-TC OUT
39	@ 1115 1215	Northerner-TC IN
40	30 1110	Northerner-TC OUT
43	10 1100	CBD Shuttle
45	60 1100	Leamington to Hamilton
46	@ 1100	Hamilton to Te Awamutu
47	@ 1100	Te Awamutu to Hamilton
48	95 1100	OrbiterC: The Base to The Base
49	95 1100	OrbiterC: Flagstaff to Flagstaff
50	95 1100	OrbiterC: Rototuna to Rototuna
51	95 1100	OrbiterC: Chartwell to Chartwell
52	95 1100	OrbiterC: University to University
53	95 1100	OrbiterC: Hospital to Hospital
54	95 1100	OrbiterC: Dinsdale to Dinsdale
55	95 1100	OrbiterC: W Rotokauri to W Rotokauri
56	95 1100	OrbiterA: The Base to The Base
57	95 1100	OrbiterA: W Rotokauri to W Rotokauri
58	95 1100	OrbiterA: Dinsdale to Dinsdale
59	95 1100	OrbiterA: Hospital to Hospital
60	95 1100	OrbiterA: University to University
61	95 1100	OrbiterA: Chartwell to Chartwell
62	95 1100	OrbiterA: Rototuna to Rototuna
63	95 1100	OrbiterA: Flagstaff to Flagstaff

Table B2: Waikato Inter Peak Model 11am-1pm - 2013 Bus Frequencies