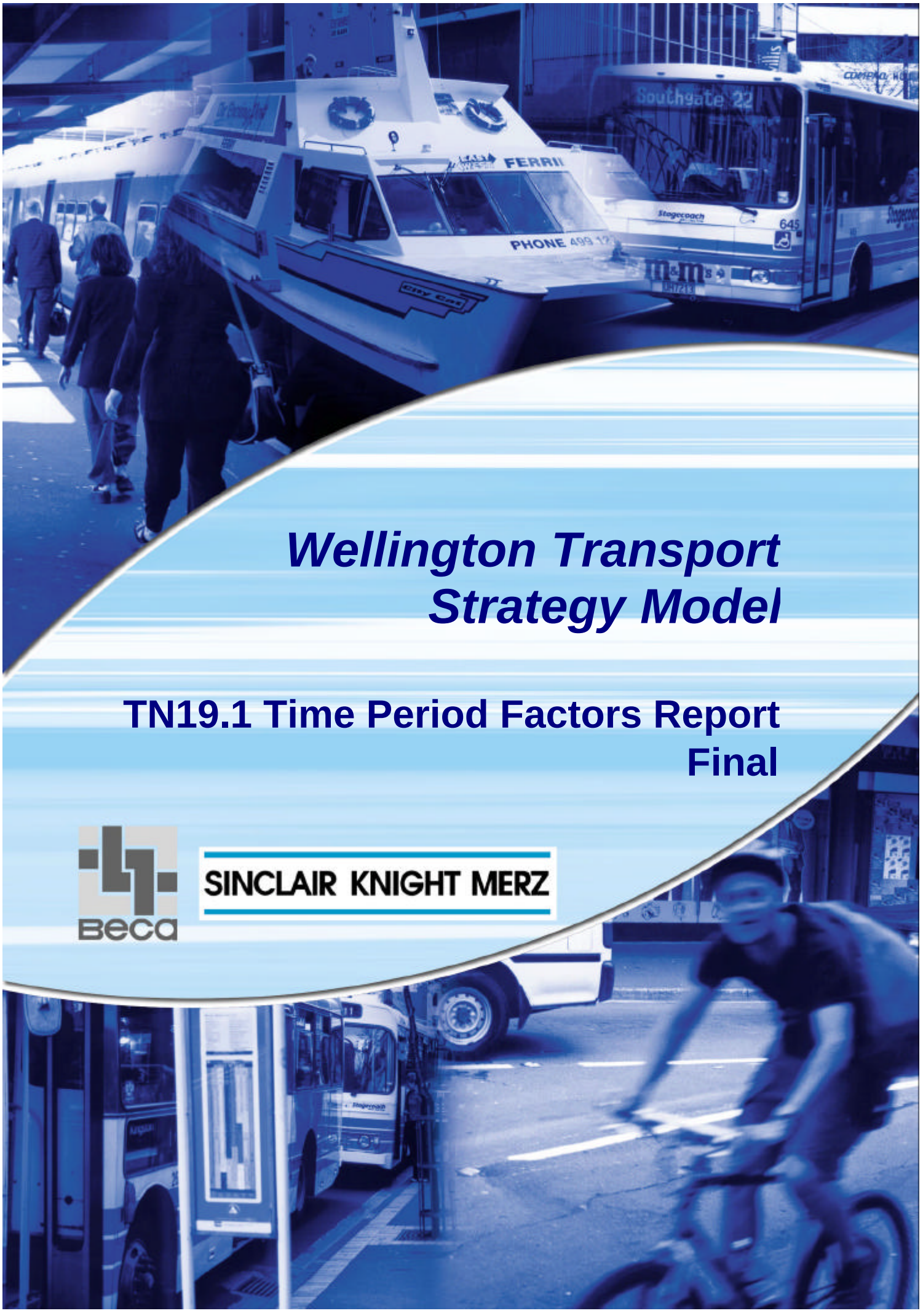

Wellington Transport Strategy Model

TN19.1 Time Period Factors Report
Final

Beca

SINCLAIR KNIGHT MERZ

Wellington Transport Strategy Model

Time Period Factors Report

Final

July 2003

prepared for

Greater Wellington – The Regional Council

By

Beca Carter Hollings & Ferner Ltd

And

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1. Introduction

The demand models (trip end, distribution and mode choice) produce 24 hour person trip matrices by purpose and mode in production/attraction form (trips are 'produced' at home and 'attracted' to workplaces, schools, shops etc). The function of the time period factors is to allocate the trips in these matrices to three time periods (am peak, interpeak and pm peak) and to convert them into origin/destination form (to reflect the actual direction of travel) prior to assignment to the networks. Additionally, for the road assignment procedure, we must convert person to vehicular trips.

In future, the proportion of travel in any one of the time periods may change through the process of peak-spreading. Such changes are estimated separately in the peak-spreading module.

Finally, we describe the factors used to convert the forecasts of person trips by light vehicle into vehicle trips.

2. Time Period Factors

2.1 Data Specification

2.1.1 General Principles

The process takes the 24 hour P/A matrices for each purpose and mode and apportions them between the three time periods, recognising the directionality of the travel in each time period. We might expect that in the am peak most people will start their trip from home, while in the pm peak, the majority may be returning home. The resulting matrices are in O/D form, as required for assignment (so that the traffic flows are correct in each direction).

The process is designed to do the following. Take for example the HBW matrix:

- this is in P/A form, which means that the matrix cell ij contains the total number of HBW trips made in the day which are produced in zone i, the home zone, and attracted to zone j where the workplace is located;
- in the am peak, about half of these trips will appear on the road network travelling from home to work, from i to j;
- in the pm peak the other half of the trips will occur in the opposite direction from j to i, as people return home from work;
- the time period factoring process takes the 24 hour matrix and converts it into an O/D matrix for each time period which reflects these characteristics of the different time periods.

2.1.2 Variables

The following parameters are used in the derivation of the time period factors.

Time Periods
There are three time periods:
- am peak: 07.01-09.00
- interpeak: 09.01-16.00
- pm peak: 16.01-18.00

Purpose
There are 6 trip purposes:
- Home Based Work (HBW),
- Home Based Education (HBEd),
- Home Based Shopping (HBSh),
- Home Based Other (HBO),
- Non Home Based Other (NHBO), and
- Employers Business (EB).

Trip Direction
We identified whether the trip was to or from home.

Mode
Time period factors are developed separately for two modes, both car (driver and passenger) and public transport.

Geography
In principle the time period factors may vary by location but, in practice, the household survey sample size will only permit limited disaggregation in this respect. In any case, in previous studies we have not found these variations to be greatly significant. Therefore, for the purposes of this analysis, the region has been split up into two areas, the Wellington TLA, and the remaining TLA's. The time period factors have initially been calculated for each cell of a 2x2 matrix and aggregated where appropriate.

2.2 Data Processing

2.2.1 Data Source

The data set used in the time period factor calculations has been derived primarily from the household survey with the following exceptions:

- screenline survey trips at sites 1 and 3 (expanded) for all purposes replaced the household survey external trips
- HBW and HBEd (expanded) trips from the rail survey replaced the corresponding trips from the household survey, and
- all bus trips (expanded) from the school survey were combined with the household survey HBEd trips.

The final dataset contained 1,673,796 expanded trips; this dataset is the same as that used for the attraction model development.

2.2.2 Acceptance Checks

Time period factors are only required for car and public transport trips, hence all other modes were removed from the dataset. In total 321,375 trips (19%) were rejected out of a possible 1,673,796 trips.

2.2.3 Additional Trip Data

Additional variables were added to the dataset as specified in Section 1.2. These include:

- the time period - whether it was AM, PM, Inter Peak, or Other,
- the trip purpose - whether it was HBW, HBEd, HBSh, HBO, NHBO, or BU,
- the trip direction - whether the trip was to/from home where applicable,
- the mode – whether it was Car or Public Transport (as mentioned above, all other modes were disregarded)
- the location of the trip, recoded to Wellington TLA or Other.

2.2.4 Preparation of Processed Trip Matrices

Having adjusted the dataset as described above, 2x2 trip matrices where produced for each combination of the variables described in Section 1.2.

The following is an example of two of the HBW matrices (see Appendix A for all tables).

From Home

24 Hour	Wellington	Other	Total
Wellington	34800	5239	40039
Other	13739	50198	63938
Total	48539	55437	103976

To Home

24 Hour	Wellington	Other	Total
Wellington	27299	10437	37736
Other	4553	40712	45265
Total	31852	51149	83001

2.3 Analysis

The process (in words) is as follows, the mathematical structure of the analysis being described in Appendix B. The process is described for a single mode and trip purpose and all matrices are in the aforementioned 2x2 format:

- 24 hour to home and from matrices were created from the household and other surveys as described above. These are origin destination matrices;
- the 'from home' matrices for the 3 time periods are also obtained from the household and other surveys in a similar manner to the 24 hour matrix.. they are divided by the 24 hour 'from home' matrix to obtain the percentage of trips that occur in each time period (in 2x2 matrix format);
- where the percentages are not judged to vary significantly between the cells of the 2x2 matrix, they are aggregated to a single percentage;
- similarly the 'to home' matrix percentages are calculated;
- these percentages form the time period factors, the proportions of the 24 hour travel occurring in the 3 modelled time periods by direction of travel.

2.4 Analysis Results

Appendix A contains the trip matrices produced for this analysis and the corresponding matrices of percentages. These have been aggregated over geography where sample size dictates, and also over mode in some instances, to give the final factors in Table 2-1 to Table 2-6.

Table 2-1 Percentage of Trips for HBW for each Time Period

Direction	Time	Mode	W-W	O-O	W-O	O-W
From Home	7-9	Car	65%	56%	63%	
From Home	7-9	Public Transport	71%			
To Home	7-9	Car & PT	2%			
From Home	9-16	Car	20%			
From Home	9-16	Public Transport	10%			
To Home	9-16	Car	18%	27%	11%	
To Home	9-16	Public Transport	12%			
From Home	16-18	Car & PT	3%			
To Home	16-18	Car	46%		56%	
To Home	16-18	Public Transport	68%			

- For Columns W-W, O-O, W-O and O-W, W represents Wellington and O represents Other,
- I.e. W-O is trips from Wellington to Other

■ **Table 2-2 Percentage of Trips for HBEd for each Time Period**

Direction	Time	Mode	W-W	O-O	W-O	O-W
From Home	7-9	Car	71%			
From Home	7-9	Public Transport	78%			
To Home	7-9	Car	20%			
To Home	7-9	Public Transport	0%			
From Home	9-16	Car	24%			
From Home	9-16	Public Transport	18%			
To Home	9-16	Car	58%			
To Home	9-16	Public Transport	74%			
From Home	16-18	Car	2%			
From Home	16-18	Public Transport	0%			
To Home	16-18	Car	17%			
To Home	16-18	Public Transport	17%			

■ **Table 2-3 Percentage of Trips for HBSh for each Time Period**

Direction	Time	Mode	W-W	O-O	W-O	O-W
From Home	7-9	Car & PT	8%			
To Home	7-9	Car & PT	2%			
From Home	9-16	Car	63%			
From Home	9-16	Public Transport	72%			
To Home	9-16	Car	51%			
To Home	9-16	Public Transport	61%			
From Home	16-18	Car & PT	14%			
To Home	16-18	Car & PT	24%			

■ **Table 2-4 Percentage of Trips for HBO for each Time Period**

Direction	Time	Mode	W-W	O-O	W-O	O-W
From Home	7-9	Car & PT	15%			
To Home	7-9	Car & PT	4%			
From Home	9-16	Car	35%			
From Home	9-16	Public Transport	53%			
To Home	9-16	Car & PT	27%			
From Home	16-18	Car & PT	17%			
To Home	16-18	Car	21%		14%	
To Home	16-18	Public Transport	32%			

■ **Table 2-5 Percentage of Trips for NHBO for each Time Period**

Direction	Time	Mode	W-W	O-O	W-O	O-W
	7-9	Car & PT	10%			
	9-16	Car & PT	59%		48%	
	16-18	Car & PT	17%		22%	

■ **Table 2-6 Percentage of Trips for BU for each Time Period**

Direction	Time	Mode	W-W	O-O	W-O	O-W
From Home	7-9	Car & PT	17%			
To Home	7-9	Car & PT	10%			
From Home	9-16	Car & PT	64%			
To Home	9-16	Car & PT	62%			
From Home	16-18	Car & PT	10%			
To Home	16-18	Car & PT	17%			

2.5 Further Adjustments

Subsequent to the model validation, the comparison of road and public transport modelled volumes against count data suggested a slight bias in the assumed time period factors. These factors have therefore been adjusted to account for this bias, with all AM time period factors being decreased by 2.5% (multiplied by 0.975) and all PM factors being increased by 2.5% (multiplied by 1.025).

3. Peak Spreading

3.1 Specification

In future years, we are concerned that the car time period factors for each purpose may change and, in particular, be affected by congestion pricing strategies. The approach which has been adopted to model such peak-spreading is an incremental model which estimates the change in the peak proportion as a function of the change in the peak/interpeak cost differential.

$$MF^1(d)^t_{pij} = \frac{MF^0(d)^t_{pIJ} * \exp\lambda_p.(GC^1(d)^t_{pij} - GC^0(d)^t_{pij})}{\Sigma_k[MF^0(d)^k_{pIJ} * \exp\lambda_p.(GC^1(d)^k_{pij} - GC^0(d)^k_{pij})]}$$

Where the superscripts 0 and 1 describe base and policy, λ_p is implicitly negative, the choices (k in the denominator) are the am peak and pm peak and rest of day (the other 20 hours, using costs for the interpeak to represent all off-peak travel).

In principle λ_p should be larger than the distribution model parameter for car trips for each trip purpose; this parameter will be set to give reasonable results and be consistent with the Sydney Harbour Tunnel experience and any other international evidence. The final value for this parameter will be set during the model validation phase – consequently this paper will be re-issued once this has been done.

The above formula is applied to the am and pm peaks and it seems appropriate to assume that the impact on the interpeak is (i) in the reverse direction and (ii) half of the sum of these 2 effects (in that some of the change will be to the pre-am peak and post-pm peak). In other words, traffic spilled out of the am peak (or vice versa) would have to be assumed to split equally between the pre- and post-peak times; thus the impact on the interpeak would be half of the 'spill'; ditto the pm peak.

A further refinement of this approach will be considered. These matrix peak factors (MF) are the proportions of trips in each of the 2 peak periods out of the whole day, and the model predicts how these proportions may change. But we may (obviously) feel that the time period choice of peak trip-makers is limited to other times of day adjacent to the present peak periods, and does not encompass the whole day. Thus, in modelling the choice of time period (ie peak-spreading), we may consider re-expressing the matrix factor as follows.

Using the formulae above but dropping sub- and superscripts, the basic calculation for the am peak factor is:

$$MF_p^{7\text{-}9} = \frac{T_p^{7\text{-}9}}{T_p^{24}}$$ (ie the proportion of trips in the peak period)[1]

We can re-express this as, say:

$$MF_p^{7\text{-}9} = \frac{T_p^{7\text{-}9}}{T_p^{6\text{-}10}} * \frac{T_p^{6\text{-}10}}{T_p^{24}}$$

[1] It is unclear whether this should vary by direction.

In this formulation we have the proportion of trips in an extended peak period times the proportion that this extended period is of the whole day. We may argue that the peak spreading formula should be applied to the first term in this expression, while the second is stable (ie unchanged) in future forecasting. The significance of this is that restriction of the competitive time period from 24 hours to 4 hours (in this example) reduces the sensitivity of the peak-spreading module or, conversely, requires a larger coefficient (λ) to achieve the same sensitivity. Such a transformation may therefore enable us to ensure that the coefficient value meets the hierarchy constraints.

3.2 Application

In the final version of WTSM the first form of the function has been implemented. The adopted value of the peak spreading parameter is –0.015. This value has been based on the international experience suggesting a elasticity of the peak period proportion to change in generalised cost of -0.2 to -0.5. This value fo the parameter yields an elasticity in the Wellington model of –0.32 in the am peak for those sectors of the matrix travelling in the peak direction.

The table below details the impacts of this parameter in 2011. The first series of rows provides data for the entire matrix, while the second series provides information on the peak direction of travel only. Not suprisingly the reduction of peak period trips is greatest in the peak direction

Table 3-1 WTSM Response to Peak Spreading – 2011 Car Trip Matrix

Car Trips		AM	Interpeak	PM	24 Hr
All Trips	2011 Base	199019	660643	281300	1533137
	2011 With Peak Spreading	197569	662893	280028	1534830
	Change	-0.7%	0.3%	-0.5%	0.1%
Peak Direction	Change	-3.1%	2.4%	-3.1%	

4. Conversion from Passenger to Vehicle Trips

The purpose of these factors is to convert car mode person trips to equivalent numbers of vehicles for the traffic assignment. The approach adopted is similar to that used in the time period factor calculations and the factors are the average number of person trips per vehicle trip which are the ratio of total car driver & passenger trips to car driver trips (for each trip purpose).

The values are shown below in Tables 4-1 to 4-6. These factors will be applied in conjunction with the time period factors.

- **Table 4-1 Average Person Trips per Vehicle Trip for HBW Trips**

Direction	Time	W-W	O-O	W-O	O-W
From Home	7-9	1.27	1.12	1.18	
To Home	7-9	1.08			
From Home	9-16	1.14			
To Home	9-16	1.13	1.16	1.10	
From Home	16-18	1.18			
To Home	16-18	1.19		1.27	

- **Table 4-2 Average Person Trips per Vehicle Trip for HBEd Trips**

Direction	Time	W-W	O-O	W-O	O-W
From Home	7-9	2.63			
To Home	7-9	1.00			
From Home	9-16	1.42			
To Home	9-16	2.14			
From Home	16-18	1.35			
To Home	16-18	1.79			

- **Table 4-3 Average Person Trips per Vehicle Trip for HBSh Trips**

Direction	Time	W-W	O-O	W-O	O-W
From Home	7-9	1.26			
To Home	7-9	1.12			
From Home	9-16	1.32			
To Home	9-16	1.28			
From Home	16-18	1.50			
To Home	16-18	1.38			

■ **Table 4-4 Average Person Trips per Vehicle Trip for HBO Trips**

Direction	Time	W-W	O-O	W-O	O-W
From Home	7-9	1.37			
To Home	7-9	1.09			
From Home	9-16	1.32			
To Home	9-16	1.35			
From Home	16-18	1.59			
To Home	16-18	1.69		1.29	

■ **Table 4-5 Average Person Trips per Vehicle Trip for NHBO Trips**

Direction	Time	W-W	O-O	W-O	O-W
	7-9	1.39			
	9-16	1.34		1.24	
	16-18	1.47		1.34	

■ **Table 4-6 Average Person Trips per Vehicle Trip for BU Trips**

Direction	Time	W-W	O-O	W-O	O-W
From Home	7-9	1.06			
To Home	7-9	1.06			
From Home	9-16	1.11			
To Home	9-16	1.10			
From Home	16-18	1.11			
To Home	16-18	1.12			

Appendix A Time Period Tables

■ Table A-1 HBW Car Trips - Actual Number of Trips and Proportion of Total Trips For Each Period

From Home

24 Hour	Wellington	Other	Total
Wellington	34800	5239	40039
Other	13739	50198	63938
Total	48539	55437	103976

To Home

24 Hour	Wellington	Other	Total
Wellington	27299	10437	37736
Other	4553	40712	45265
Total	31852	51149	83001

From Home

7-9	Wellington	Other	Total
Wellington	22535	3519	26054
Other	8446	27977	36423
Total	30981	31496	62477

To Home

7-9	Wellington	Other	Total
Wellington	647	290	937
Other	132	899	1031
Total	778	1189	1968

From Home

7-9	Wellington	Other	Total
Wellington	65%	67%	65%
Other	61%	56%	57%
Total	64%	57%	60%

To Home

7-9	Wellington	Other	Total
Wellington	2%	3%	2%
Other	3%	2%	2%
Total	2%	2%	2%

From Home

9-16	Wellington	Other	Total
Wellington	6738	653	7391
Other	2055	11293	13348
Total	8792	11946	20739

To Home

9-16	Wellington	Other	Total
Wellington	4880	1207	6088
Other	509	10798	11308
Total	5390	12006	17395

From Home

9-16	Wellington	Other	Total
Wellington	19%	12%	18%
Other	15%	22%	21%
Total	18%	22%	20%

To Home

9-16	Wellington	Other	Total
Wellington	18%	12%	16%
Other	11%	27%	25%
Total	17%	23%	21%

From Home

16-18	Wellington	Other	Total
Wellington	1368	57	1425
Other	47	1956	2003
Total	1414	2013	3427

To Home

16-18	Wellington	Other	Total
Wellington	11913	5916	17829
Other	2412	19544	21956
Total	14325	25460	39785

From Home

16-18	Wellington	Other	Total
Wellington	4%	1%	4%
Other	0%	4%	3%
Total	3%	4%	3%

To Home

16-18	Wellington	Other	Total
Wellington	44%	57%	47%
Other	53%	48%	49%
Total	45%	50%	48%

■ Table A-2 HBW Public Transport Trips - Actual Number of Trips and Proportion of Total Trips For Each Period

From Home

24 Hour	Wellington	Other	Total
Wellington	10967	333	11300
Other	8927	2016	10943
Total	19894	2349	22243

To Home

24 Hour	Wellington	Other	Total
Wellington	8003	8941	16944
Other	290	1234	1525
Total	8293	10175	18468

From Home

7-9	Wellington	Other	Total
Wellington	8515	155	8670
Other	6175	1035	7209
Total	14690	1190	15879

To Home

7-9	Wellington	Other	Total
Wellington	5	52	56
Other	7	5	12
Total	12	57	69

From Home

7-9	Wellington	Other	Total
Wellington	78%	47%	77%
Other	69%	51%	66%
Total	74%	51%	71%

To Home

7-9	Wellington	Other	Total
Wellington	0%	1%	0%
Other	3%	0%	1%
Total	0%	1%	0%

From Home

9-16	Wellington	Other	Total
Wellington	1264	19	1283
Other	569	364	933
Total	1833	383	2216

To Home

9-16	Wellington	Other	Total
Wellington	1062	732	1794
Other	45	410	456
Total	1107	1143	2250

From Home

9-16	Wellington	Other	Total
Wellington	12%	6%	11%
Other	6%	18%	9%
Total	9%	16%	10%

To Home

9-16	Wellington	Other	Total
Wellington	13%	8%	11%
Other	16%	33%	30%
Total	13%	11%	12%

From Home

16-18	Wellington	Other	Total
Wellington	88	42	130
Other	23	232	255
Total	111	274	385

To Home

16-18	Wellington	Other	Total
Wellington	5441	6374	11815
Other	179	648	827
Total	5620	7022	12642

From Home

16-18	Wellington	Other	Total
Wellington	1%	13%	1%
Other	0%	12%	2%
Total	1%	12%	2%

To Home

16-18	Wellington	Other	Total
Wellington	68%	71%	70%
Other	62%	53%	54%
Total	68%	69%	68%

■ Table A-3 HBEd Car Trips - Actual Number of Trips and Proportion of Total Trips For Each Period

From Home

24 Hour	Wellington	Other	Total
Wellington	7671	258	7929
Other	1108	12229	13336
Total	8779	12487	21266

To Home

24 Hour	Wellington	Other	Total
Wellington	3161	1079	4241
Other	216	7392	7608
Total	3377	8472	11849

From Home

7-9	Wellington	Other	Total
Wellington	4848	131	4980
Other	644	9526	10170
Total	5492	9657	15150

To Home

7-9	Wellington	Other	Total
Wellington	911	0	911
Other	35	1385	1421
Total	946	1385	2331

From Home

7-9	Wellington	Other	Total
Wellington	63%	51%	63%
Other	58%	78%	76%
Total	63%	77%	71%

To Home

7-9	Wellington	Other	Total
Wellington	29%	0%	21%
Other	16%	19%	19%
Total	28%	16%	20%

From Home

9-16	Wellington	Other	Total
Wellington	2523	127	2649
Other	149	2234	2383
Total	2672	2361	5032

To Home

9-16	Wellington	Other	Total
Wellington	1846	727	2573
Other	0	4309	4309
Total	1846	5036	6882

From Home

9-16	Wellington	Other	Total
Wellington	33%	49%	33%
Other	13%	18%	18%
Total	30%	19%	24%

To Home

9-16	Wellington	Other	Total
Wellington	58%	67%	61%
Other	0%	58%	57%
Total	55%	59%	58%

From Home

16-18	Wellington	Other	Total
Wellington	207	0	207
Other	0	168	168

To Home

16-18	Wellington	Other	Total
Wellington	312	160	472
Other	181	1316	1497

From Home

16-18	Wellington	Other	Total
Wellington	3%	0%	3%
Other	0%	1%	1%

To Home

16-18	Wellington	Other	Total
Wellington	10%	15%	11%
Other	84%	18%	20%

Total	207	168	376	Total	492	1477	1969	Total	2%	1%	2%	Total	15%	17%	17%	

■ Table A-4 HBEd Public Transport Trips - Actual Number of Trips and Proportion of Total Trips For Each Period

From Home 24 Hour	Wellington	Other	Total
Wellington	4960	126	5086
Other	1829	1464	3293
Total	6789	1591	8380

To Home 24 Hour	Wellington	Other	Total
Wellington	4417	1753	6171
Other	161	1364	1525
Total	4579	3117	7696

From Home 7-9	Wellington	Other	Total
Wellington	4044	64	4108
Other	1071	1349	2419
Total	5114	1413	6527

To Home 7-9	Wellington	Other	Total
Wellington	0	8	8
Other	21	0	21
Total	21	8	29

From Home 7-9	Wellington	Other	Total
Wellington	82%	51%	81%
Other	59%	92%	73%
Total	75%	89%	78%

To Home 7-9	Wellington	Other	Total
Wellington	0%	0%	0%
Other	13%	0%	1%
Total	0%	0%	0%

From Home 9-16	Wellington	Other	Total
Wellington	824	33	857
Other	524	93	617
Total	1347	127	1474

To Home 9-16	Wellington	Other	Total
Wellington	3759	627	4386
Other	59	1248	1307
Total	3818	1875	5693

From Home 9-16	Wellington	Other	Total
Wellington	17%	26%	17%
Other	29%	6%	19%
Total	20%	8%	18%

To Home 9-16	Wellington	Other	Total
Wellington	85%	36%	71%
Other	37%	91%	86%
Total	83%	60%	74%

From Home 16-18	Wellington	Other	Total

To Home 16-18	Wellington	Other	Total

From Home 16-18	Wellington	Other	Total

To Home 16-18	Wellington	Other	Total

Wellington	0	11	11
Other	18	0	18
Total	18	11	29

Wellington	474	681	1155
Other	63	96	159
Total	537	777	1314

Wellington	0%	9%	0%
Other	1%	0%	1%
Total	0%	1%	0%

Wellington	11%	39%	19%
Other	39%	7%	10%
Total	12%	25%	17%

■ Table A-5 HBSh Car Trips - Actual Number of Trips and Proportion of Total Trips For Each Period

From Home 24 Hour	Wellington	Other	Total
Wellington	34387	4252	38638
Other	3178	66292	69470
Total	37565	70544	108109

To Home 24 Hour	Wellington	Other	Total
Wellington	48315	2207	50522
Other	3461	80987	84448
Total	51776	83195	134970

From Home 7-9	Wellington	Other	Total
Wellington	2341	250	2591
Other	431	4862	5293
Total	2772	5112	7884

To Home 7-9	Wellington	Other	Total
Wellington	1283	96	1379
Other	0	1693	1693
Total	1283	1789	3071

From Home 7-9	Wellington	Other	Total
Wellington	7%	6%	7%
Other	14%	7%	8%
Total	7%	7%	7%

To Home 7-9	Wellington	Other	Total
Wellington	3%	4%	3%
Other	0%	2%	2%
Total	2%	2%	2%

From Home 9-16	Wellington	Other	Total
Wellington	22431	2857	25288
Other	1952	40421	42372
Total	24383	43278	67661

To Home 9-16	Wellington	Other	Total
Wellington	24773	1093	25866
Other	1824	41380	43204
Total	26597	42473	69070

From Home 9-16	Wellington	Other	Total
Wellington	65%	67%	65%
Other	61%	61%	61%
Total	65%	61%	63%

To Home 9-16	Wellington	Other	Total
Wellington	51%	50%	51%
Other	53%	51%	51%
Total	51%	51%	51%

From Home 16-18	Wellington	Other	Total
Wellington	4446	193	4639
Other	536	9984	10519
Total	4982	10177	15159

To Home 16-18	Wellington	Other	Total
Wellington	10488	446	10934
Other	868	21142	22011
Total	11356	21589	32945

From Home 16-18	Wellington	Other	Total
Wellington	13%	5%	12%
Other	17%	15%	15%
Total	13%	14%	14%

To Home 16-18	Wellington	Other	Total
Wellington	22%	20%	22%
Other	25%	26%	26%
Total	22%	26%	24%

■ Table A-6 HBSh Public Transport Trips - Actual Number of Trips and Proportion of Total Trips For Each Period

From Home 24 Hour	Wellington	Other	Total
Wellington	3247	37	3284
Other	377	3168	3545
Total	3624	3205	6830

To Home 24 Hour	Wellington	Other	Total
Wellington	3906	414	4320
Other	34	2997	3031
Total	3940	3410	7351

From Home 7-9	Wellington	Other	Total
Wellington	715	0	715
Other	41	95	136
Total	756	95	850

To Home 7-9	Wellington	Other	Total
Wellington	0	3	3
Other	0	55	55
Total	0	58	58

From Home 7-9	Wellington	Other	Total
Wellington	22%	0%	22%
Other	11%	3%	4%
Total	21%	3%	12%

To Home 7-9	Wellington	Other	Total
Wellington	0%	1%	0%
Other	0%	2%	2%
Total	0%	2%	1%

From Home 9-16	Wellington	Other	Total
Wellington	1960	26	1985
Other	236	2695	2931

To Home 9-16	Wellington	Other	Total
Wellington	2298	227	2526
Other	26	1902	1929

From Home 9-16	Wellington	Other	Total
Wellington	60%	68%	60%
Other	63%	85%	83%

To Home 9-16	Wellington	Other	Total
Wellington	59%	55%	58%
Other	77%	63%	64%

Total	2196	2720	4916

Total	2325	2130	4454

Total	61%	85%	72%

Total	59%	62%	61%

From Home

16-18	Wellington	Other	Total
Wellington	194	10	204
Other	26	349	375
Total	219	359	578

To Home

16-18	Wellington	Other	Total
Wellington	959	54	1014
Other	1	869	870
Total	960	924	1884

From Home

16-18	Wellington	Other	Total
Wellington	6%	27%	6%
Other	7%	11%	11%
Total	6%	11%	8%

To Home

16-18	Wellington	Other	Total
Wellington	25%	13%	23%
Other	4%	29%	29%
Total	24%	27%	26%

■ Table A-7 HBO Car Trips - Actual Number of Trips and Proportion of Total Trips For Each Period

From Home

24 Hour	Wellington	Other	Total
Wellington	47925	4326	52251
Other	6343	78705	85048
Total	54268	83031	137299

To Home

24 Hour	Wellington	Other	Total
Wellington	54261	7247	61508
Other	4385	86451	90836
Total	58646	93698	152344

From Home

7-9	Wellington	Other	Total
Wellington	7263	713	7976
Other	923	11803	12726
Total	8185	12516	20701

To Home

7-9	Wellington	Other	Total
Wellington	2184	65	2249
Other	78	3601	3680
Total	2262	3666	5929

From Home

7-9	Wellington	Other	Total
Wellington	15%	16%	15%
Other	15%	15%	15%
Total	15%	15%	15%

To Home

7-9	Wellington	Other	Total
Wellington	4%	1%	4%
Other	2%	4%	4%
Total	4%	4%	4%

From Home

9-16	Wellington	Other	Total

To Home

9-16	Wellington	Other	Total

From Home

9-16	Wellington	Other	Total

To Home

9-16	Wellington	Other	Total

Wellington	15678	1082	16760
Other	1448	30267	31715
Total	17126	31349	48475

Wellington	12455	850	13305
Other	766	26796	27562
Total	13221	27646	40867

Wellington	33%	25%	32%
Other	23%	38%	37%
Total	32%	38%	35%

Wellington	23%	12%	22%
Other	17%	31%	30%
Total	23%	30%	27%

From Home

16-18	Wellington	Other	Total
Wellington	8742	629	9372
Other	902	13708	14609
Total	9644	14337	23981

To Home

16-18	Wellington	Other	Total
Wellington	11229	841	12070
Other	781	18208	18989
Total	12010	19049	31059

From Home

16-18	Wellington	Other	Total
Wellington	18%	15%	18%
Other	14%	17%	17%
Total	18%	17%	17%

To Home

16-18	Wellington	Other	Total
Wellington	21%	12%	20%
Other	18%	21%	21%
Total	20%	20%	20%

■ Table A-8 HBO Public Transport Trips - Actual Number of Trips and Proportion of Total Trips For Each Period

From Home

24 Hour	Wellington	Other	Total
Wellington	2015	57	2072
Other	684	922	1606
Total	2699	979	3678

To Home

24 Hour	Wellington	Other	Total
Wellington	2402	399	2801
Other	46	1589	1634
Total	2448	1987	4435

From Home

7-9	Wellington	Other	Total
Wellington	137	0	137
Other	31	354	385
Total	168	354	522

To Home

7-9	Wellington	Other	Total
Wellington	0	0	0
Other	5	5	10
Total	5	5	10

From Home

7-9	Wellington	Other	Total
Wellington	7%	0%	7%
Other	5%	38%	24%
Total	6%	36%	14%

To Home

7-9	Wellington	Other	Total
Wellington	0%	0%	0%
Other	10%	0%	1%
Total	0%	0%	0%

From Home 9-16	Wellington	Other	Total
Wellington	1103	48	1151
Other	289	507	796
Total	1392	555	1947

To Home 9-16	Wellington	Other	Total
Wellington	534	120	655
Other	20	806	826
Total	555	926	1481

From Home 9-16	Wellington	Other	Total
Wellington	55%	84%	56%
Other	42%	55%	50%
Total	52%	57%	53%

To Home 9-16	Wellington	Other	Total
Wellington	22%	30%	23%
Other	44%	51%	51%
Total	23%	47%	33%

From Home 16-18	Wellington	Other	Total
Wellington	383	3	386
Other	67	9	76
Total	450	12	462

To Home 16-18	Wellington	Other	Total
Wellington	760	116	876
Other	9	546	556
Total	770	662	1432

From Home 16-18	Wellington	Other	Total
Wellington	19%	5%	19%
Other	10%	1%	5%
Total	17%	1%	13%

To Home 16-18	Wellington	Other	Total
Wellington	32%	29%	31%
Other	20%	34%	34%
Total	31%	33%	32%

■ Table A-9 NHBO Car Trips - Actual Number of Trips and Proportion of Total Trips For Each Period

24 Hour	Wellington	Other	Total
Wellington	117511	16157	133668
Other	13142	187857	200999
Total	130653	204013	334667

7-9	Wellington	Other	Total
Wellington	10756	1120	11875
Other	1431	20268	21699
Total	12187	21388	33575

7-9	Wellington	Other	Total
Wellington	9%	7%	9%
Other	11%	11%	11%
Total	9%	10%	10%

9-16	Wellington	Other	Total
Wellington	66678	7437	74115
Other	6741	114273	121014
Total	73419	121709	195128

16-18	Wellington	Other	Total
Wellington	21553	4182	25735
Other	2085	29129	31214
Total	23638	33311	56949

9-16	Wellington	Other	Total
Wellington	57%	46%	55%
Other	51%	61%	60%
Total	56%	60%	58%

16-18	Wellington	Other	Total
Wellington	18%	26%	19%
Other	16%	16%	16%
Total	18%	16%	17%

■ **Table A-10 NHBO Public Transport Trips - Actual Number of Trips and Proportion of Total Trips For Each Period**

24 Hour	Wellington	Other	Total
Wellington	5571	1054	6626
Other	1036	1929	2965
Total	6608	2983	9591

7-9	Wellington	Other	Total
Wellington	417	39	456

7-9	Wellington	Other	Total
Wellington	7%	4%	7%

Other	193	156	349
Total	611	195	805

9-16	Wellington	Other	Total
Wellington	2858	416	3274
Other	486	1415	1902
Total	3345	1831	5176

16-18	Wellington	Other	Total
Wellington	1573	341	1915
Other	228	203	431
Total	1802	544	2346

Other	19%	8%	12%
Total	9%	7%	8%

9-16	Wellington	Other	Total
Wellington	51%	39%	49%
Other	47%	73%	64%
Total	51%	61%	54%

16-18	Wellington	Other	Total
Wellington	28%	32%	29%
Other	22%	11%	15%
Total	27%	18%	24%

■ Table A-11 BU Car Trips - Actual Number of Trips and Proportion of Total Trips For Each Period

From Home

24	Wellington	Other	Total
Wellington	30744	4485	35229
Other	4767	27106	31873
Total	35511	31592	67102

To Home

24	Wellington	Other	Total
Wellington	30526	4853	35379
Other	4984	28370	33354
Total	35510	33223	68733

7-9	Wellington	Other	Total
Wellington	5641	418	6059
Other	1087	4440	5528
Total	6728	4858	11586

7-9	Wellington	Other	Total
Wellington	3325	279	3604
Other	203	2727	2931
Total	3528	3006	6534

7-9	Wellington	Other	Total
Wellington	18%	9%	17%
Other	23%	16%	17%
Total	19%	15%	17%

7-9	Wellington	Other	Total
Wellington	11%	6%	10%
Other	4%	10%	9%
Total	10%	9%	10%

9-16	Wellington	Other	Total
Wellington	19068	2861	21929
Other	2445	18267	20711
Total	21513	21127	42640

9-16	Wellington	Other	Total
Wellington	18521	2906	21427
Other	2866	18264	21131
Total	21387	21170	42558

9-16	Wellington	Other	Total
Wellington	62%	64%	62%
Other	51%	67%	65%
Total	61%	67%	64%

9-16	Wellington	Other	Total
Wellington	61%	60%	61%
Other	58%	64%	63%
Total	60%	64%	62%

16-18	Wellington	Other	Total
Wellington	3341	664	4005
Other	490	2399	2890
Total	3831	3064	6895

16-18	Wellington	Other	Total
Wellington	5523	946	6469
Other	854	4350	5204
Total	6377	5296	11673

16-18	Wellington	Other	Total
Wellington	11%	15%	11%
Other	10%	9%	9%
Total	11%	10%	10%

16-18	Wellington	Other	Total
Wellington	18%	19%	18%
Other	17%	15%	16%
Total	18%	16%	17%

■ Table A-12 BU Public Transport Trips - Actual Number of Trips and Proportion of Total Trips For Each Period

From Home

24	Wellington	Other	Total
Wellington	0	0	0

To Home

24	Wellington	Other	Total
Wellington	0	0	0

Other	0	0	0
Total	0	0	0

Other	0	0	0
Total	0	0	0

From Home

7-9	Wellington	Other	Total
Wellington	0	0	0
Other	0	0	0
Total	0	0	0

To Home

7-9	Wellington	Other	Total
Wellington	0	0	0
Other	0	0	0
Total	0	0	0

From Home

7-9	Wellington	Other	Total
Wellington	#DIV/0!	####	####
Other	#DIV/0!	####	####
Total	#DIV/0!	####	####

To Home

7-9	Wellington	Other	Total
Wellington	#DIV/0!	####	####
Other	#DIV/0!	####	####
Total	#DIV/0!	####	####

From Home

9-16	Wellington	Other	Total
Wellington	0	0	0
Other	0	0	0
Total	0	0	0

To Home

9-16	Wellington	Other	Total
Wellington	0	0	0
Other	0	0	0
Total	0	0	0

From Home

9-16	Wellington	Other	Total
Wellington	#DIV/0!	####	####
Other	#DIV/0!	####	####
Total	#DIV/0!	####	####

To Home

9-16	Wellington	Other	Total
Wellington	#DIV/0!	####	####
Other	#DIV/0!	####	####
Total	#DIV/0!	####	####

From Home

16-18	Wellington	Other	Total
Wellington	0	0	0
Other	0	0	0
Total	0	0	0

To Home

16-18	Wellington	Other	Total
Wellington	0	0	0
Other	0	0	0
Total	0	0	0

From Home

16-18	Wellington	Other	Total
Wellington	#DIV/0!	####	####
Other	#DIV/0!	####	####
Total	#DIV/0!	####	####

To Home

16-18	Wellington	Other	Total
Wellington	#DIV/0!	####	####
Other	#DIV/0!	####	####
Total	#DIV/0!	####	####

Appendix B Mathematical Specification of Time Period Factor Calculations

We have split the study area into 2 parts, Wellington TLA and the rest. We have then analysed the 2*2 matrix of trips to and from these areas, including the row and column totals and the overall total (a-j below).

	Wellington	Other	Total
Wellington	a	b	e
Other	c	d	f
Total	g	h	j

This matrix has been produced for each home-based trip purpose, and for car and public transport separately, using IJ to denote the TLA classification:

From home (fh) trips:	To home (th) trips
$T_{mp}(fh)^{24}{}_{IJ}$	$T_{mp}(th)^{24}{}_{IJ}$
$T_{mp}(fh)^{7\text{-}9}{}_{IJ}$	$T_{mp}(th)^{7\text{-}9}{}_{IJ}$
$T_{mp}(fh)^{9\text{-}16}{}_{IJ}$	$T_{mp}(th)^{9\text{-}16}{}_{IJ}$
$T_{mp}(fh)^{16\text{-}18}{}_{IJ}$	$T_{mp}(th)^{16\text{-}18}{}_{IJ}$

Note that:

- $T_{mp}(fh)^{24}{}_{IJ}$ & $T_{mp}(th)^{24}{}_{IJ}$ have been built up from the household trip data (see Section 2.3), and they are OD matrices;
- the other matrices (NHBO and EB) are built from the household data and are also OD matrices.

The time period factors are then simply the ratios of these matrices. Eg for the am peak, we will have:

$$T_{mp}(fh)^{7\text{-}9}{}_{IJ}/T_{mp}(fh)^{24}{}_{IJ} \;\&\; T_{mp}(th)^{7\text{-}9}{}_{IJ}/T_{mp}(th)^{24}{}_{IJ}$$

We will have 9 values for each (the a-j above). Allowing for sampling error we must decide whether any of the 4 cell (a-d) or 4 row/column total (e-h) values are significantly different from the average (j) to justify a geographic segmentation.

For NHB trips, there is no th/fh distinction, and they are on an O-D basis.

In all there are 2 modes* 4 time periods * (5 home based purposes * 2 directions + 1 NHB matrix) = 88 matrices (2*2). These have be converted into ratio matrices of which there are (2 modes * 3 time periods *(5 home based purposes * 2 directions + 1 NHB matrix) = 66 matrices of ratios.

This process will lead to a set of matrix factors which can be applied to the 24 hour directional matrices to develop time period matrices – which we may describe as $MF_{mp}(d)^{t}{}_{IJ}$ where d is direction and t time period.

These matrix factors are applied to the 24 hr demand matrices. The from home 24 hr matrices are calculated as 0.5* the 24hr PA matrix, and the to home matrices are 0.5* the transpose of the 24hr PA matrix.

Then the 3 time period OD matrices are computed as :

am: $T_{mp}(fh)^{7\text{-}9}_{IJ} + T_{mp}(th)^{7\text{-}9}_{IJ}$

inter: $T_{mp}(fh)^{9\text{-}16}_{IJ} + T_{mp}(th)^{9\text{-}16}_{IJ}$

pm: $T_{mp}(fh)^{16\text{-}18}_{IJ} + T_{mp}(th)^{16\text{-}18}_{IJ}$