TN24 - WELLINGTON TRANSPORT ANALYTICAL TOOLS 2019-21 UPDATE – HOUSEHOLD TRAVEL SURVEY AND MOBILE PHONE DATA

PREPARED FOR **GREATER WELLINGTON REGIONAL COUNCIL**

October 2022

Stantec | **JACOBS**

QUALITY STATEMENT

PROJECT MANAGER	PROJECT TECHNICAL LEAD
Ali Siddiqui	Julie Ballantyne

PREPARED BY		
Geoffrey Cornelis	....	1/11/2022

CHECKED BY		
Scott Wilkinson	....	1/11/2022

REVIEWED BY		
Julie Ballantyne	....	1/11/2022

APPROVED FOR ISSUE BY		
Julie Ballantyne	....	1/11/2022

CHRISTCHURCH
Hazeldean Business Park, 2 Hazeldean Road, Addington, Christchurch 8024
PO Box 13-052, Armagh, Christchurch 8141
TEL +64 3 366 7449, FAX +64 3 366 7780

REVISION SCHEDULE

Rev No.	Date	Description	Signature or Typed Name (documentation on file)			
			Prepared by	Checked by	Reviewed by	Approved by
1	5/10/2022	Draft, building on previous memo	GC	SW	JEB	JEB
2	1/11/2022	Final	GC	SW	JEB	JEB

Stantec Jacobs │ TN24 - Wellington Transport Analytical Tools 2019-21 update – Household travel survey and Mobile phone data │ October 2022

Status: Final │ Project No.: 310203597 │ Our ref: TN24 - Wellington Analytical Tools 2019-21 Update - HTS & Mobile phone data.docx

Greater Wellington Regional Council

TN24 - Wellington Transport Analytical Tools 2019-21 update – Household travel survey and Mobile phone data

CONTENTS

LIST OF TABLES

Stantec Jacobs │ TN24 - Wellington Transport Analytical Tools 2019-21 update – Household travel survey and Mobile phone data │ October 2022

Status: Final │ Project No.: 310203597 │ Our ref: TN24 - Wellington Analytical Tools 2019-21 Update - HTS & Mobile phone data.docx

LIST OF FIGURES

Stantec Jacobs │ TN24 - Wellington Transport Analytical Tools 2019-21 update – Household travel survey and Mobile phone data │ October 2022

Status: Final │ Project No.: 310203597 │ Our ref: TN24 - Wellington Analytical Tools 2019-21 Update - HTS & Mobile phone data.docx

1.   Introduction

This technical note is part of a series documenting the 2019-2022 update of components of the Wellington Regional Transportation Planning Analytical Tools ("Analytical Tools", "Tools"). The higher-level Analytical Tools are maintained and operated by Greater Wellington Regional Council (GWRC), who are the client for this project. This project is being primarily delivered by Stantec and Jacobs, supported by GWRC transport planners.

This technical note details the processing and preliminary analysis of the two main sources of information on travel patterns in the Wellington region used for the rebuild of the Wellington Transport Strategy Model (WTSM) and the development of the new Wellington Traffic Assignment Model) WTAM:

- the Household Travel Survey (HTS)
- Person-level travel patterns from mobile phone location data

2.   Household Travel Survey

2.1   Background

Household Travel Survey data for the Greater Wellington Region was obtained from the annual rolling surveys carried out by the Ministry of Transport (MoT), for the years 2015 to 2019 for the whole country. In addition, a "boost" sample was to be collected in 2019-2020 in the Wellington region to increase the total sample available specifically for this project. This extra collection was interrupted half-way in March 2020 because of the impact of Covid-19 and following lockdown. While the resulting sample is smaller than would typically be required for the development of a strategic transport model, it will still represent one of the main sources of data to rebuild the WTSM.

The resulting dataset therefore ranges from 2015 to 2020 but is referred to as '2018 HTS' in the remainder of this document for simplicity, as it will be used to update WTSM to a 2018 base year.

The survey was already pre-processed and checked for consistency by the MoT, and comprises four main tables, consistent with typical household travel surveys:

- Household table
- Person table
- Trip table
- Address table

The data for these four tables can be linked by household, person and address IDs.

The number of days surveyed differ depending on the survey year and is as follows:

- 7 consecutive days (i.e. 5 weekdays) for the first three years (2015 to 2018)
- 2 consecutive days for the last 2 years (2018 to 2020)

2.2   Data cleaning and processing

In order to prepare the dataset for input into the model development, a data cleaning and processing exercise was carried out to discard non-relevant records, aggregate the data as required and recategorize variables such as modes and purposes into categories consistent with use for the Wellington models update.

The HTS dataset was processed as follows:

- As the HTS includes data for the whole country, only trips within the Wellington region or between the region and outside (having a least one end in the region) were retained, with all other trips discarded.
- Weekend trips were discarded as the model is to be representative of an average weekday.
- Only households with a response status of 'full' or partial' were kept. It was established that in all cases, households with a 'partial' responses status included at least one fully responding person and at least one non-responding.

October 2022 │ Status: Final │ Project No.: 310203597 │ Our ref: TN24 - Wellington Analytical Tools 2019-21 Update - HTS & Mobile phone data.docx

Page 1

- Only people with a response status of 'full' were kept.
- Modes were reclassified to align with transport model definitions:
  - Private vehicles: car driver, car passenger, motorcycle, taxi and ridesharing
  - Public transport: bus, rail, ferry
  - Active modes: pedestrian, cycle
- Truck trips were removed, as these are represented separately in a dedicated heavy vehicle model within WTSM.
- Purposes were reclassified to align with traditional transport model definitions.
  - Home-based work (HBW)
  - Home-based education (HBE)
  - Home-based shopping (HBS)
  - Home-based other (HBO)
  - Non-home based (NHB)
  - Business (BSN)
- Car driver trips with purpose equal to 'accompany', 'pick up' or 'drop off' were allocated the trip purpose of the accompanied passenger when feasible. These accounted for 6.8% of the full dataset. For the remaining cases when no passenger could be associated, the purpose was set to home-based other or non-home based depending on the home being at either end of the trip or not.
- Trip legs were grouped into trips, applying the following modal hierarchy to identify the main mode:
  - 1 - Rail / Ferry
  - 2 - Bus
  - 3 - Car driver
  - 4 - Car passenger
  - 5 - Cycle
  - 6 - Walk

For example a trip including a car driver leg and then a rail leg was allocated to rail, whereas a trip including car driver and walk was allocated to car.

The resulting trip was allocated the starting point and time of the first leg, and the end point and time of the last leg, while length and duration were aggregated. Trip purpose from the last leg was used, as all previous legs of a trip in the HTS have purpose set to 'Change Mode'.

It must be noted that the naming used is different in the New Zealand MoT HTS than used in the transport model, with standard definitions of 'trip' and 'trip leg' in the model (and in this note) being referred to as respectively 'journey' and 'trip' instead in the MoT HTS (the definition further differing in other HTS, where journey can be considered as the full two-way outbound from home and back, potentially multi-segment and multi-model)

- Time periods (AM peak, Inter peak, PM peak and Overnight) were added based on the midpoint time of the trip, based on the following times:
  - AM Peak: 06:00 – 09:00
  - Inter Peak: 09:00 – 15:00
  - PM Peak: 15:00 – 18:00
  - Overnight: 18:00 – 06:00
- All records for trips within the Wellington region but associated with households not resident in the region were discarded.
- In addition a number of issues were found and corrected, including:

October 2022 | Status: Final | Project No.: 310203597 | Our ref: TN24 - Wellington Analytical Tools 2019-21 Update - HTS & Mobile phone data.docx

Page 2

o Some trips with a single leg did not have the same leg and trip address for either origin or destination. In all cases, it was determined that the trips address was incorrect, and it was therefore replaced with the leg address. This issue affected 0.4% of the records.

o A few records had modes classified as 'Other', which were reclassified manually based on the value in the 'trmodeother' field. For example 'Electric bicycle' was classified as cycle, and 'Mitsubishi Outlander' was classified as 'car'.

o A limited number of records (0.3%) had modes which will not be included in the transport model such as 'rail non-local', 'bus non-local' and 'plane'. These records were still included but will not be used in the model estimation.

A number of additional logic and sense-checking tests were carried out, including:

- Looking for trips with unrealistic length, duration, or speed

- People without license or under driving age being classified as car drivers

- Trips with same origin and destination

- Sense-checking of origin and destination address types (home, workplace, other) being consistent with trip purposes

- Verifying that the start time of each trip is after the end time of the previous trip

These did not highlight any further issue with the dataset.

The resulting number of household, people and trip records at each stage of the cleaning process is shown in the table below.

Table 2-1: HTS records numbers

Step	Households	Persons	Trips
Start (trips in Wellington region only)	1,773	4,282	59,497
Only responding households (full or partial)	1,594	3,832	57,107
Removed trucks	1,594	3,829	56,926
Aggregated trip legs to trips	1,594	3,829	52,986
Weekday only	1,476	3,583	39,294
Fully responding people	1,460	2,974	36,792
Households with address in Wellington region only	1,372	2,864	36,043

This amounts to a circa 0.7% sample size in terms of households, which can be considered a small sample, with transport models generally requiring about 1.2-1.5% sample size. One mitigating factor however is the fact that multiple days were surveyed per household.

As a result, whereas the sample is significantly smaller than the survey carried out for the 2001 Wellington model which had a sample size of 1.7%, the number of trips collected is roughly the same (35,900 trip records in 2001).

The geographical distribution of the sampled households is shown in the following figures. The coordinates of all households have been applied a randomised +/- 500m adjustment for confidentiality purposes, and for clarity as they would otherwise largely overlap due to the MoT approach of selecting clusters of households within a random sample of statistical areas.

October 2022 | Status: Final | Project No.: 310203597 | Our ref: TN24 - Wellington Analytical Tools 2019-21 Update - HTS & Mobile phone data.docx
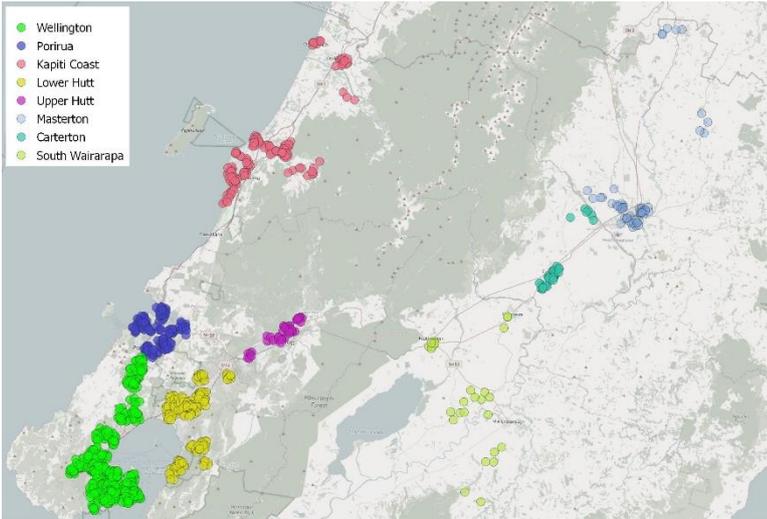
Page 3

Figure 2-1: Household sample – whole region
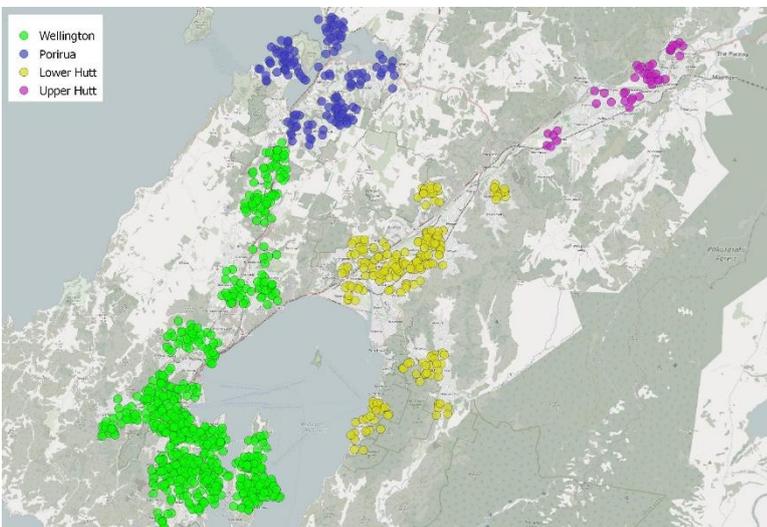

Figure 2-2: Household sample – Wellington, Porirua and Hutt Valley

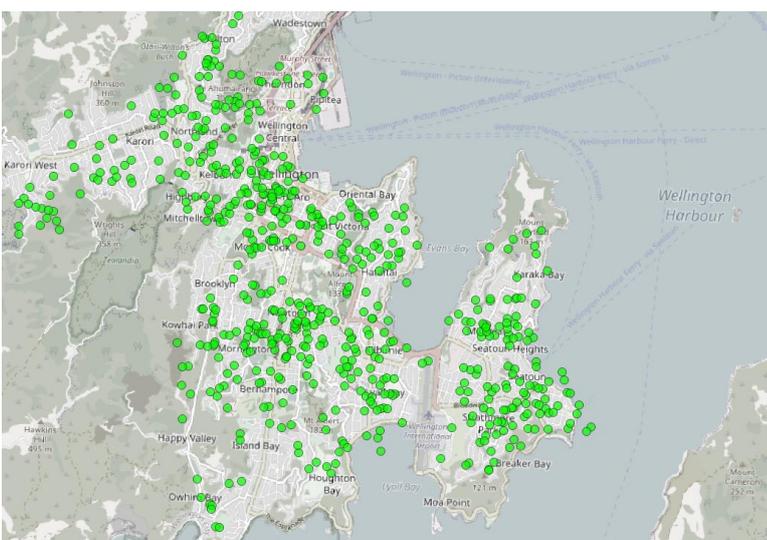Figure 2-3: Household sample – Wellington central

October 2022 │ Status: Final │ Project No.: 310203597 │ Our ref: TN24 - Wellington Analytical Tools 2019-21 Update - HTS & Mobile phone data.docx

Page 4

2.3 Expansion and weighting

The HTS expansion was carried out in three steps:

- Expansion factors were calculated per households to match regional totals.
- These factors were then applied to each person within the households, and weighting factors were then calculated and applied to match Census data for a number of population categories, to mitigate potential bias in terms of household size, car ownership, employment or age.
- The resulting factors were then applied to trips, and some further adjustments were applied.

This process is detailed in the remainder of this section.

2.3.1 Household expansion

First the number of households per Territorial Authority (TA) in the region was obtained from the Statistics New Zealand 2018 Census data. The actual number of households was then divided by the surveyed number of households in the sample to derive household expansion factors for each TA.

The number of households in both datasets and resulting expansion factors are shown in the following table.

Table 2-2: Household expansion

TA	Census	HTS	Factor
Wellington	77,974	738	106
Porirua	18,547	138	134
Kapiti	22,349	131	171
Lower Hutt	38,589	200	193
Upper Hutt	16,377	44	372
Masterton	10,262	56	183
South Wairarapa	4,477	28	160
Carterton	3,764	37	102
Total	192,339	1,372	

2.3.2 People weighting and expansion

The household expansion factors were applied to each person within the household, resulting in an expanded population. This had to then be weighted in order to match observed population across a number of metrics.

For this purpose, 2018 Census cross-tabulated data was obtained from Statistics New Zealand, with population broken down into a number of categories. The aim was to obtain the right balance between having sufficient level of detail to differentiate people with distinct travel behaviours, while ensuring the number of permutations would not lead to combinations with no or too little observed data in the HTS.

The data provided was for 'usually resident population in households', which is approximately 6% lower across the region than 'usually resident' population as it is a subset excluding non-private dwellings and households with incomplete information. In addition, the model will be based on 'estimated resident' population, which adds on average another 3% above the 'usually resident' statistic. Population numbers were therefore factored up to estimated resident population by sector.

The request to Statistics New Zealand was for population to be broken down into the following groups:

- Age bands:
  - 0-14 years old
  - 15-19 years old
  - 20-29 years old
  - 30-64 years old
  - 65+ years old

October 2022 | Status: Final | Project No.: 310203597 | Our ref: TN24 - Wellington Analytical Tools 2019-21 Update - HTS & Mobile phone data.docx

Page 5

- Employment:
    - Employed (full and part time)
    - Not employed (not in labour force and unemployed)
    - Work and labour force status unidentifiable
- Number of vehicles in households:
    - 0
    - 1
    - 2
    - 3+
- Household composition:
    - 1 adult
    - 2+ adults
    - Adult(s) with dependent child(ren)
- Sector: 11 sectors were defined, aiming for each sector to include at least 100 surveyed households in the HTS and as much as possible based on natural and administrative boundaries. These were: Wellington Central, Inner suburbs, West Wellington, South Wellington, Miramar, North Wellington, Hutt Valley North, Hutt Valley South, Wairarapa, Porirua and Kapiti Coast.
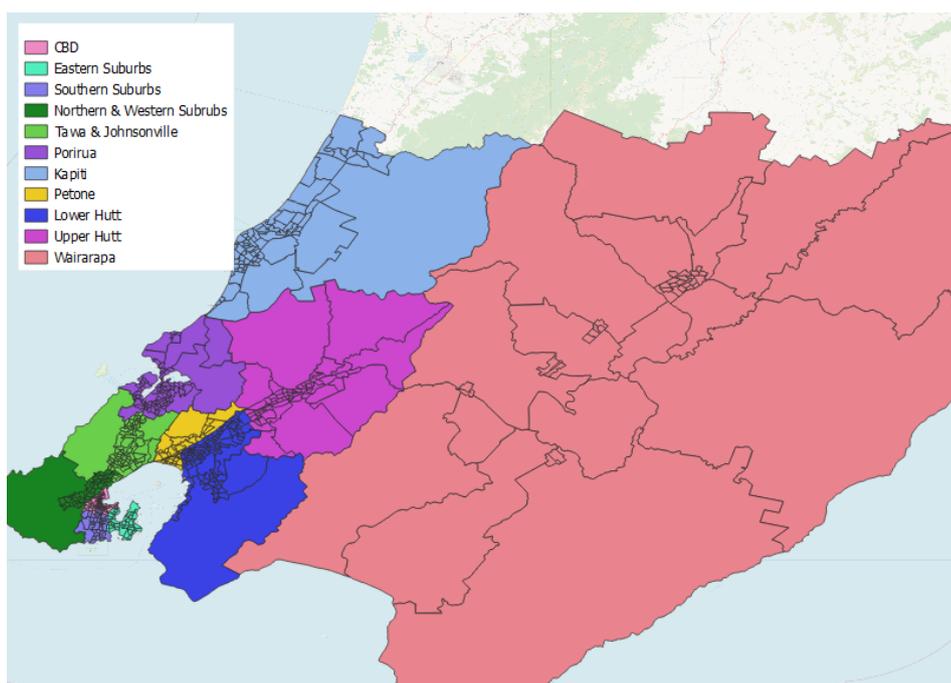
Figure 2-4: 11 Sector system

The number of categories and sectors still led to a significant number of combinations. As a result, the cross-table provided by Statistics New Zealand included many cells with the number of people falling under the minimum threshold of 6 applied for confidentiality and only included a '..C' value.

A process was developed to clean out this dataset. First, incompatible combinations were removed (e.g. employed 0-14 years old, or 0-14 years old in households with adults only), then each cell was factored iteratively to match the sub-totals per category, and ultimately the regional population total.

The calculation of people weighting factor was then carried out as follows:

- HTS records were allocated age band, household type, car ownership, employment and sector as per the Statistics NZ data definitions.
- Due to some sub-categories having a sizable population but no observed sample, the categories used were simplified, again trying to get the right balance between sufficiently detailed

October 2022 | Status: Final | Project No.: 310203597 | Our ref: TN24 - Wellington Analytical Tools 2019-21 Update - HTS & Mobile phone data.docx

Page 6

disaggregation and all sub-categories having a sufficient number of surveyed households. As a result, 'employment' was removed and not used further in the expansion process, and the following categories were merged:

- o '2' and '3+' cars grouped into '2+'

- o '20-29 years old' and '30-64 years old' grouped into '20-64 years old'

- o Hutt Valley North and Hutt Valley South grouped into Hutt Valley

- o South and Miramar grouped into South-East

- o Central and Inner grouped into Central

- As this still left a few combinations with too few observed households, some sub-categories were further grouped, for example households with only 1 adult and '1' or '2+' cars were grouped into '1 adult, 1+ car'.

- The expanded population calculated using the household expansion factors was compared against the Census data to derive weighting factor for each sub-category and sector.

Once the people weighting factors were calculated, expansion factors for people were derived as follows:

$$Exp_{Person} = Exp_{Household} * Weight_{Person}$$

2.3.3 Trip expansion factors

Finally, because households were surveyed over multiple weekdays, trip expansion factors for an average weekday were calculated as follows:

$$Exp_{Trip} = \frac{Exp_{Household} * Weight_{Person}}{No. \ weekdays \ surveyed}$$

An additional adjustment was calculated for the first three years of survey (2015 to 2018) which included 7 days surveyed per household. It was noted that for these, trip rates tended to drop at the end of the survey period, likely due to 'survey fatigue' and people becoming more likely to fail to report trips. This is illustrated in the following figure. It is noted that the days are survey days, and not specific days of the week. So the 6th and 7th survey days do not represent Saturday and Sunday across-the-board.
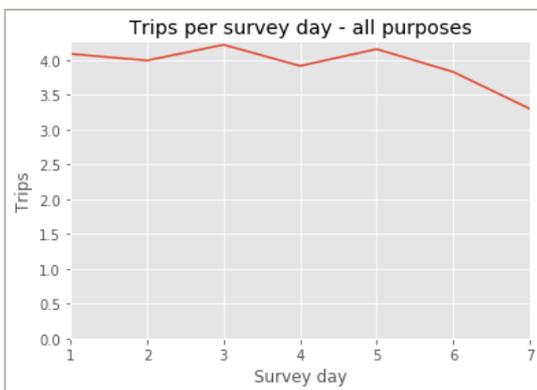
Figure 2-5: Trip rates per survey day (2015-2018 surveys)

Adjustments factors were calculated for all trips on day 6 and 7 of these surveys (all this analysis being carried out on weekdays only), to uplift trip rates to the average of the first 5 weekdays. This was done separately for each trip purpose. This adjustment also accounted for natural variation in trip rates during the week (e.g. Mondays have generally lower trip rates). All trip expansion factors were therefore converted to an average weekday before the uplift factors for days 6 and 7 were calculated.

The final trip expansion factors include these adjustments for trips carried out on survey days 6 and 7 of the first three survey years.

2.3.4 Resulting factors

The following plots show the resulting distribution of expansion factors for households, people and trips.

October 2022 | Status: Final | Project No.: 310203597 | Our ref: TN24 - Wellington Analytical Tools 2019-21 Update - HTS & Mobile phone data.docx

Page 7
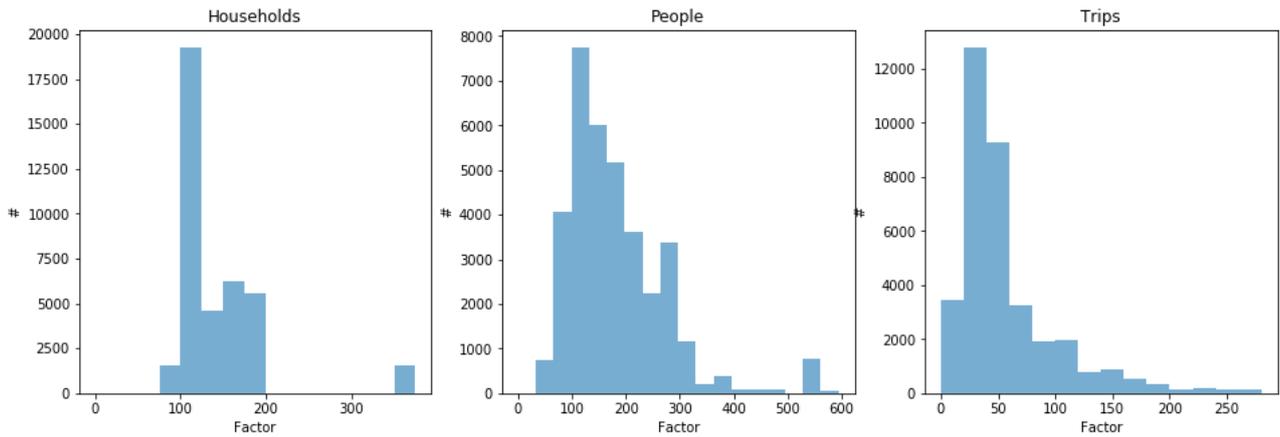
Figure 2-6: Expansion factors

The resulting factors are relatively high, which is an expected result of the small HTS sample. The distribution of households expansion factors shows that most factors are between 100 and 200, with a few households over 300. For people expansion factors, most factors are between 75 and 175, with a secondary spike between 225 and 275. Trip expansion factors follow a more standard right-tailed bell curve distribution.

This secondary spike in household and people expansion factors is due to the lower sample rates and resulting higher factors in parts of the Hutt valley and Wairarapa sectors as shown in the following plots.
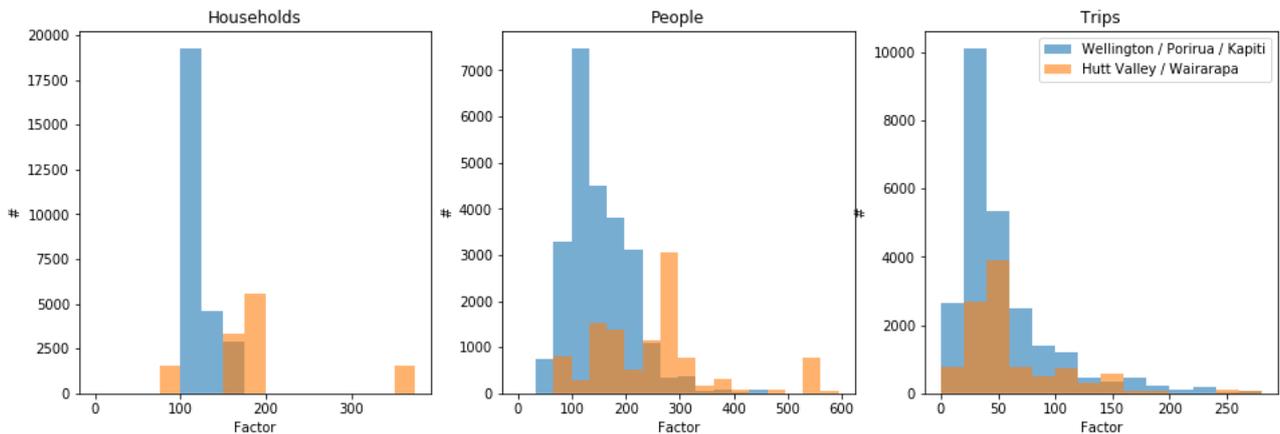
Figure 2-7: Expansion factors per area

A number of checks were carried out looking at the trip rates variations across the various categories (household types, car ownership, age and geographical sectors), separately per trip purpose. Results showed that the trips rates are either generally consistent or show variations that are explainable (e.g. more trips to education for households with children, or higher trip rates for households with more cars).

In addition, no outlier households or persons that would significantly skew the results were identified.

2.4   Comparison with observed

Trip matrices were output from the HTS based on the new WTSM zonal system and time periods. These were extracted separately for car and public transport, and assigned on the network using assignment procedures from the current version of WTSM. Assigned volumes were then compared against observed across a number of screenlines in the region, which are shown in the following figure (note: not all the screenlines available were used, with only the screenlines at the most strategic locations being included).

October 2022 │ Status: Final │ Project No.: 310203597 │ Our ref: TN24 - Wellington Analytical Tools 2019-21 Update - HTS & Mobile phone data.docx

Page 8
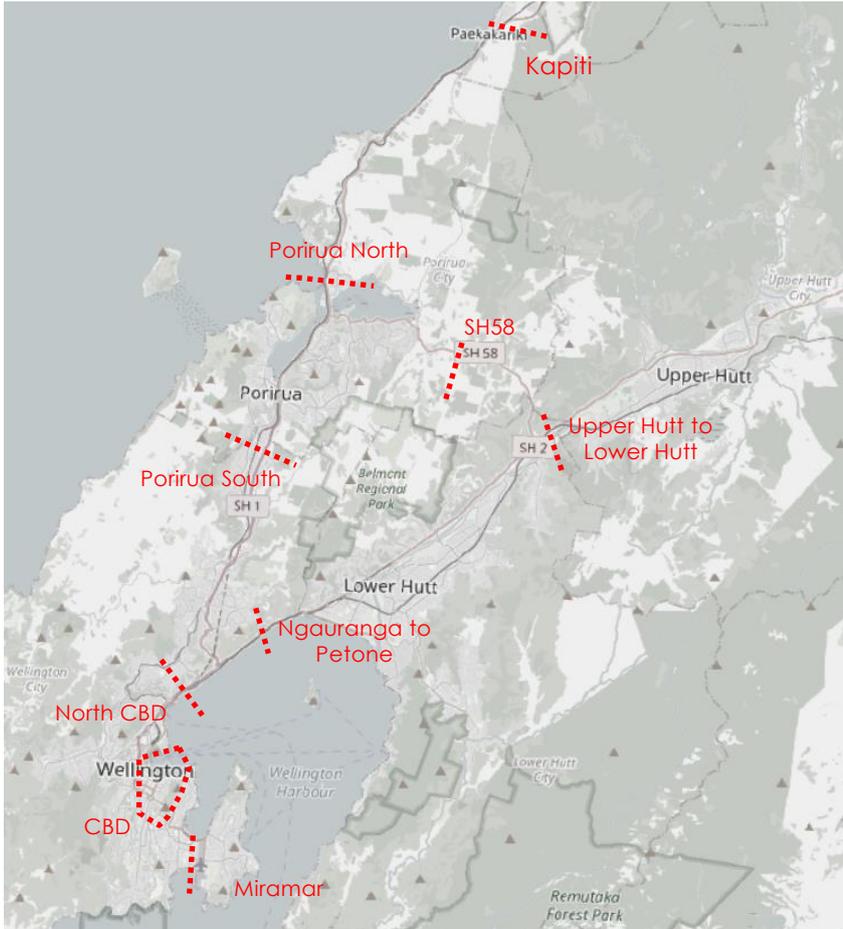
Figure 2-8: Screenlines for comparison

The observed data used was based on traffic counts for private vehicles and electronic ticketing data for bus demand. For rail no recent detailed data was available, with patronage from a 2011 survey factored up per line using automated door counts being used. This data however has some limitations as detailed in a separate note (Wellington Analytical Tools 2019-21 Update - Rail Patronage Growth Analysis for WPTM Update) and is less reliable especially for stations having experienced more significant growth since 2011.

A number of simplifications and assumptions were made to enable the comparison:

- Private vehicle matrices from the HTS include both car drivers and passengers. They were converted to vehicles using occupancies also obtained from the HTS for comparison with observed vehicles. (A separate test was carried out with only car drivers from the HTS used, and no occupancy applied. This resulted in lower and somewhat more inconsistent volumes, due to the smaller sample.)

- The current WTSM assignment procedures are set up for 2-hours period. The link and intersection capacities are calculated for 2 hours and the volumes must be consistent with this duration. The matrices from the HTS however cover the new, longer time periods. They were therefore simply factored down to 2 hours for assignment, and the resulting volumes were then factored back up to the whole period. Given that the comparison looks at volumes across screenline, this does not impact on overall volumes.

- The resulting matrices include all trips internal to the Wellington Region and made by people from Wellington region households. As a result, they do not include trips made by people not resident in the region including travel related to the airport and ferry terminals, or from/to the SH1 and SH2 externals. Regarding externals, this would be likely to have little impact for the SH2 external, but the SH1 external would likely have more of an impact on the Kapiti screenline and potentially Porirua North screenline. Traffic from/to the airport and ferry terminal can however be substantial, likely resulting in volumes from the HTS matrices underestimating volumes particularly on the CBD, North CBD and Miramar screenlines.

October 2022 | Status: Final | Project No.: 310203597 | Our ref: TN24 - Wellington Analytical Tools 2019-21 Update - HTS & Mobile phone data.docx

Page 9

The resulting comparison are shown in the following tables, respectively for private vehicles, public transport and total demand (expressed in person trips, with vehicles trips converted to person using the same occupancies are before).

Table 2-3: HTS vs screenlines – private vehicles

Screenline	Dir	AM Counts	AM HTS	AM Diff	IP Counts	IP HTS	IP Diff	PM Counts	PM HTS	PM Diff	Overnight Counts	Overnight HTS	Overnight Diff	24hr Counts	24hr HTS	24hr Diff
CBD	In	33,628	33,377	-1%	50,082	42,052	-16%	26,793	19,820	-26%	32,318	19,195	-41%	142,820	114,444	-20%
	Out	18,345	15,852	-14%	46,478	37,705	-19%	35,485	34,222	-4%	37,394	25,228	-33%	137,702	113,007	-18%
North CBD	In	20,068	21,138	5%	22,276	23,378	5%	11,988	10,344	-14%	12,232	9,167	-25%	66,564	64,027	-4%
	Out	8,302	6,322	-24%	21,760	20,381	-6%	20,688	20,527	-1%	17,690	14,628	-17%	68,440	61,858	-10%
Miramar	In	5,599	7,436	33%	8,872	9,338	5%	5,883	4,088	-31%	7,207	4,629	-36%	27,561	25,491	-8%
	Out	4,868	2,508	-48%	9,457	8,945	-5%	6,692	7,517	12%	7,225	5,961	-17%	28,242	24,930	-12%
Ngauranga to Petone	In	9,305	10,763	16%	13,551	12,295	-9%	7,938	7,244	-9%	7,305	6,004	-18%	38,099	36,306	-5%
	Out	6,107	5,355	-12%	12,961	12,710	-2%	9,495	10,743	13%	8,822	7,496	-15%	37,385	36,304	-3%
Upper Hutt to Lower Hutt	In	9,638	11,186	16%	9,646	8,876	-8%	5,851	3,899	-33%	5,212	4,129	-21%	30,347	28,090	-7%
	Out	4,028	2,670	-34%	9,019	8,199	-9%	10,080	12,588	25%	7,049	4,343	-38%	30,176	27,800	-8%
Porirua South	In	8,200	9,223	12%	11,679	10,662	-9%	6,954	7,793	12%	6,801	7,310	7%	33,634	34,988	4%
	Out	4,900	6,388	30%	11,751	10,653	-9%	9,642	10,488	9%	7,662	7,065	-8%	33,955	34,594	2%
Porirua North	In	5,105	5,458	7%	7,350	5,856	-20%	4,006	2,759	-31%	3,711	3,039	-18%	20,172	17,112	-15%
	Out	2,899	1,601	-45%	7,327	6,741	-8%	5,921	5,326	-10%	4,390	3,175	-28%	20,537	16,843	-18%
Kapiti	In	8,200	9,223	12%	11,679	10,662	-9%	6,954	7,793	12%	6,801	7,310	7%	33,634	34,988	4%
	Out	4,900	6,388	30%	11,751	10,653	-9%	9,642	10,488	9%	7,662	7,065	-8%	33,955	34,594	2%
SH58	In	2,441	1,991	-18%	2,528	2,078	-18%	2,431	2,075	-15%	1,464	1,127	-23%	8,864	7,272	-18%
	Out	2,224	1,564	-30%	2,568	2,238	-13%	2,516	2,495	-1%	1,477	526	-64%	8,785	6,822	-22%
Total		158,757	158,442	0%	270,734	243,421	-10%	188,959	180,210	-5%	182,422	137,399	-25%	800,872	719,472	-10%

For private vehicles, volumes from the HTS are overall close to observed during the peak periods, 10% lower in the Interpeak and 25% in the overnight periods, leading to a 10% underestimation over a weekday. This indicates some level of under-reporting, which typically does impact off peak periods more than the peaks. Some of this could also be caused by traffic related to non-wellington resident trips to/from the airport and ferry terminals.

There is some variability per screenline and direction, however peak direction volumes (inbound in the AM peak period and outbound in the PM peak) are generally within 10% on the most strategic screenlines such as CBD and north CBD.

The Miramar screenline shows peak direction volumes that are higher than observed and this is despite airport passenger-related trips from non-residents not being included, indicating a potential over-estimation from this sector. This is likely related to the South and East suburbs sectors having been merged for the estimation process.

The SH58 screenline appears to show an under-estimation of trips between the Hutt Valley and Porirua / North Wellington catchments in the HTS in all periods.

These differences are not unexpected when a very small sample (0.7% of households) is expanded to represent the region.

October 2022 | Status: Final | Project No.: 310203597 | Our ref: TN24 - Wellington Analytical Tools 2019-21 Update - HTS & Mobile phone data.docx

Page 10

Table 2-4: HTS vs screenlines – public transport

Screenline	Dir	AM			IP			PM			Overnight			24hr		
		Counts	HTS	Diff	Counts	HTS	Diff	Counts	HTS	Diff	Counts	HTS	Diff	Counts	HTS	Diff
CBD	In	31,411	32,220	3%	10,728	9,443	-12%	3,623	5,407	49%	2,025	1,485	-27%	47,787	48,555	2%
	Out	2,176	2,324	7%	7,023	7,732	10%	27,799	29,248	5%	10,937	8,902	-19%	47,936	48,206	1%
North CBD	In	21,687	21,425	-1%	5,094	4,789	-6%	837	1,938	132%	962	561	-42%	28,580	28,713	0%
	Out	655	961	47%	3,037	3,361	11%	18,319	20,013	9%	6,934	4,670	-33%	28,945	29,006	0%
Miramar	In	1,514	1,973	30%	690	589	-15%	315	771	145%	187	194	4%	2,706	3,527	30%
	Out	206	466	126%	630	1,187	88%	1,142	1,713	50%	476	542	14%	2,455	3,907	59%
Ngauranga to Petone	In	8,613	7,322	-15%	1,815	2,487	37%	545	1,778	226%	423	281	-34%	11,396	11,868	4%
	Out	475	961	102%	1,149	1,469	28%	7,678	7,714	0%	2,660	2,202	-17%	11,961	12,345	3%
Upper Hutt to Lower	In	2,919	2,478	-15%	646	644	0%	413	1,819	340%	201	0	-100%	4,179	4,941	18%
	Out	526	1,246	137%	431	521	21%	2,814	2,692	-4%	933	516	-45%	4,704	4,974	6%
Porirua South	In	6,399	5,909	-8%	1,609	832	-48%	279	539	93%	432	121	-72%	8,719	7,402	-15%
	Out	274	366	34%	976	1,219	25%	5,164	5,147	0%	2,161	873	-60%	8,574	7,604	-11%
Porirua North	In	3,219	3,054	-5%	1,038	630	-39%	149	337	126%	232	0	-100%	4,638	4,021	-13%
	Out	51	24	-53%	491	413	-16%	2,525	2,502	-1%	1,076	658	-39%	4,144	3,597	-13%
Kapiti	In	801	2,157	169%	444	465	5%	105	214	104%	87	0	-100%	1,437	2,836	97%
	Out	49	24	-51%	317	936	195%	465	1,517	226%	200	318	59%	1,031	2,795	171%
SH58	In	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
	Out	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Total		80,973	82,910	2%	36,120	36,715	2%	72,173	83,348	15%	29,925	21,323	-29%	219,192	224,297	2%

Total public transport demand extracted from the HTS is generally close to observed overall. Importantly, peak period and direction volumes to the CBD in the AM peak and from the CBD in the PM peak are a good match with observed patronage. Counter peak direction volumes are higher than counts across most screenlines, and this is particularly the case for rail. It must be noted that these are based on a small number of observations in the HTS, and the observed rail data is somewhat less reliable.

The Kapiti screenline shows much higher volumes with the HTS demand than observed patronage, however as explained previously the rail data used for comparison is based on 2011 counts factored up using overall patronage per line. Patronage has increased significantly since at the Waikanae and Paraparaumu stations which may not be captured by the factored counts.

Table 2-5: HTS vs screenlines – private vehicle + public transport

Screenline	Dir	AM			IP			PM			Overnight			24hr		
		Counts	HTS	Diff	Counts	HTS	Diff	Counts	HTS	Diff	Counts	HTS	Diff	Counts	HTS	Diff
CBD	In	75,127	75,610	1%	72,829	61,588	-15%	40,061	32,362	-19%	46,300	27,782	-40%	234,318	197,342	-16%
	Out	26,025	22,932	-12%	64,656	54,486	-16%	76,059	75,789	0%	62,167	43,465	-30%	228,907	196,672	-14%
North CBD	In	47,775	48,904	2%	32,716	33,778	3%	17,141	16,006	-7%	17,720	13,120	-26%	115,352	111,809	-3%
	Out	11,447	9,180	-20%	30,019	28,634	-5%	46,455	47,930	3%	31,169	24,711	-21%	119,091	110,454	-7%
Miramar	In	8,793	11,640	32%	11,692	12,168	4%	8,316	6,331	-24%	10,061	6,537	-35%	38,861	36,675	-6%
	Out	6,534	3,726	-43%	12,357	12,278	-1%	10,243	11,936	17%	10,374	8,709	-16%	39,509	36,648	-7%
Ngauranga to Petone	In	20,709	21,314	3%	18,618	17,732	-5%	11,341	11,630	3%	10,431	8,506	-18%	61,099	59,183	-3%
	Out	8,414	7,923	-6%	17,220	17,229	0%	20,591	22,324	8%	14,746	12,472	-15%	60,971	59,948	-2%
Upper Hutt to Lower Hutt	In	15,449	17,020	10%	12,607	11,650	-8%	8,370	7,122	-15%	7,341	5,657	-23%	43,767	41,449	-5%
	Out	5,762	4,716	-18%	11,615	10,687	-8%	16,523	19,812	20%	10,590	6,466	-39%	44,490	41,682	-6%
Porirua South	In	17,059	17,899	5%	16,091	14,053	-13%	9,737	11,137	14%	9,749	10,136	4%	52,636	53,225	1%
	Out	6,644	8,669	30%	15,548	14,428	-7%	18,277	19,411	6%	12,658	10,553	-17%	53,126	53,061	0%
Porirua North	In	9,855	10,149	3%	10,152	7,892	-22%	5,597	4,089	-27%	5,316	4,163	-22%	30,921	26,294	-15%
	Out	3,820	2,105	-45%	9,577	8,772	-8%	10,578	9,746	-8%	7,091	5,008	-29%	31,065	25,631	-17%
Kapiti	In	11,461	14,147	23%	14,926	13,686	-8%	9,563	10,812	13%	9,404	10,015	6%	45,353	48,660	7%
	Out	6,419	8,328	30%	14,889	14,146	-5%	13,578	15,781	16%	10,697	9,998	-7%	45,583	48,252	6%
SH58	In	3,173	2,588	-18%	3,135	2,577	-18%	3,306	2,822	-15%	2,006	1,545	-23%	11,620	9,532	-18%
	Out	2,891	2,033	-30%	3,184	2,775	-13%	3,422	3,393	-1%	2,023	720	-64%	11,521	8,920	-23%
Total		287,357	288,885	1%	371,831	338,557	-9%	329,158	328,434	0%	279,843	209,560	-25%	1,268,189	1,165,436	-8%

As a result, overall demand (traffic + public transport) from the HTS is lower than observed volumes overall, indicating some under-reporting of trips, but this is mostly within off-peak time periods, with the AM and PM peaks being much closer. There are of course larger variations on a screenline by screenline level per time period and direction and these will need to be further investigated and potentially mitigated during the model development.

October 2022 | Status: Final | Project No.: 310203597 | Our ref: TN24 - Wellington Analytical Tools 2019-21 Update - HTS & Mobile phone data.docx

Page 11

No comparisons were made for active modes due to unavailability of observed data. The only source of data for 2018 is the CBD cordon but this only covers the AM peak direction for the 7-9am period. This could still be used to evaluate the general level of response in the HTS for this period for trips to the CBD, but not to validate the overall active mode demand.

Finally a simple check was made comparing the total number of trips (expanded, average weekday and not including externals and airport/ferry passengers) in the HTS against 24hr demand in the current WTSM, which is based on a 2013 land use although the model itself was calibrated against a 2001 HTS. Both include private vehicles, public transport and active modes. The HTS shows 2.1 million trips per day, whereas WTSM 2013 estimates 2.07 million trips. It could be expected that the new HTS would lead to a more pronounced increase from 2013 as it is based on an increased population compared with the current WTSM. In addition to potential under-reporting however, separate analysis indicates that trip rates have decreased since 2001. While this comparison is really only for sense checking, it is reassuring that both the HTS and the current version of the model return similar numbers of daily trips.

2.5 HTS preliminary analysis

This section presents a high level summary of analysis of the HTS, looking at trip rates, modal share, trip purposes, trip timing and trip length distribution. Results are presented for both the raw sample and the expanded dataset.

2.5.1 Trip rates

The trip rates resulting from the processed HTS are shown in the following table for all model purposes.

Table 2-6: HTS trip rates

Purpose	Sample	Expanded
Home-base work	0.54	0.57
Home-based education	0.27	0.39
Home-based shopping	0.53	0.53
Home-based other	0.93	0.92
Non-home based	1.47	1.35
Business	0.25	0.22
Total	**3.99**	**3.99**

While this is again mostly for sense checking as no alternative dataset exists to compare against for the Wellington region in 2018, trip rates are generally similar to results from the 2001 Wellington HTS and other HTS in New Zealand and elsewhere. The main difference with 2001 is that rates are generally lower, with the 2001 HTS leading to 4.6 trips per person on weekday in average. This could be due to the level of under-reporting but also matches trends observed in other cities in Western countries over recent years which have shown decreasing levels of travel.

2.5.2 Modal share

The following figures show the modal share for the raw and expanded datasets, for the whole region and for trips to the CBD only.

October 2022 │ Status: Final │ Project No.: 310203597 │ Our ref: TN24 - Wellington Analytical Tools 2019-21 Update - HTS & Mobile phone data.docx
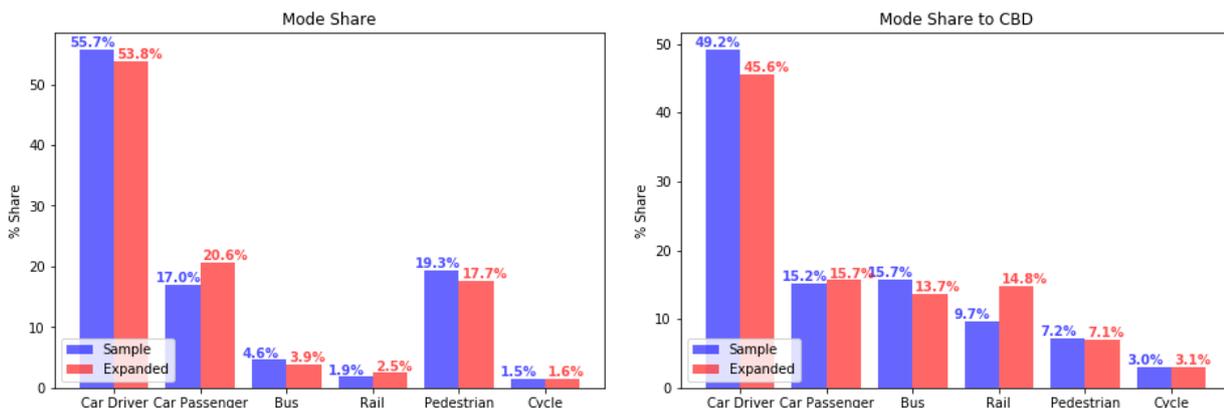
Page 12

Figure 2-9: Mode share

Results appear sensible and generally in line with known patterns in the Wellington region, with car being by far the main mode, followed by active modes (mostly walk) and public transport.

Looking more specifically at trips to the CBD (but not including trips within the CBD), the proportion of car trips decreases while public transport trips increase.

The expanded dataset shows a similar distribution as the raw sample, indicating that the expansion did not fundamentally alter the modal share. The main exception is for rail trips, especially to the CBD for which the expansion leads to an increase in share. This is likely due to the higher expansion factors applied to the Hutt Valley area which is one of the two main rail demand catchments in the region.

2.5.3   Trip purposes

The following figure shows the distribution of trip per purpose for the raw and expanded datasets, for the whole region and for trips to the CBD only.
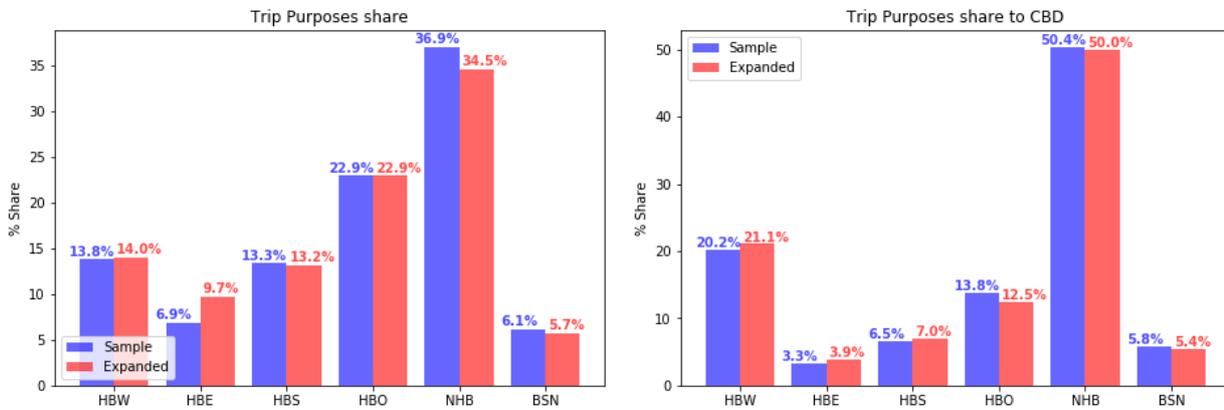

Figure 2-10: Trip purpose distribution

Again, results appear sensible and in line with typically observed patterns, with non-home based trips representing the largest share, followed by home-based other.

Results are similar for the raw dataset and expanded sample, with the largest relative difference being observed for home-based education trips.

2.5.4   Trip timing

The following figure shows the profile of trips timing (based on mid-point time of the trip) through the day for the raw and expanded datasets, for the whole region and for trips to the CBD only.

Figure 2-11: Trip timing profile

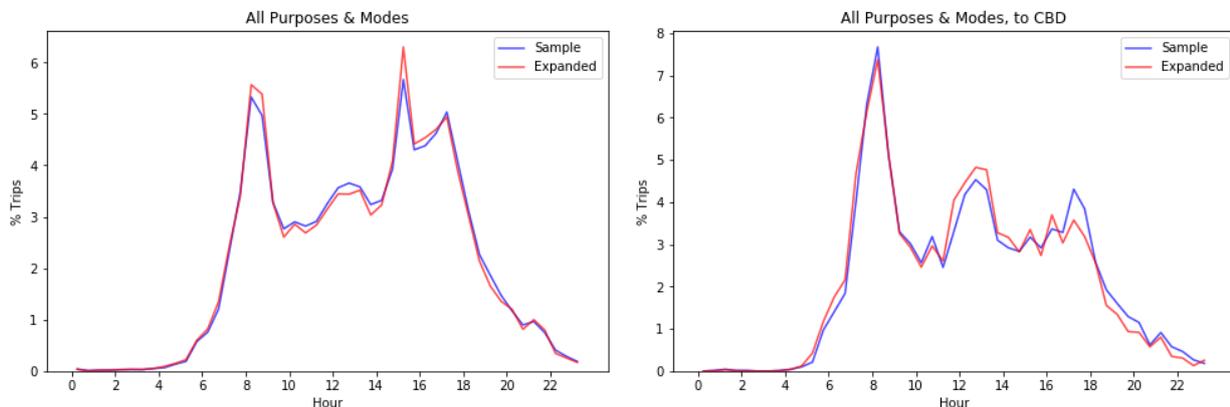Results for the whole region are representative of a typical daily demand profile, with clear peaks corresponding to the morning peak for commuting and school, and two distinct peaks in the afternoon matching the school and commuting return trips.

October 2022 │ Status: Final │ Project No.: 310203597 │ Our ref: TN24 - Wellington Analytical Tools 2019-21 Update - HTS & Mobile phone data.docx

Page 13

Looking at trips to the CBD only (and therefore not including trips from the CBD), the AM peak is more distinct showing that most trips in this direction occur in the 7 to 9am period as expected. Secondary peaks can be observed around lunchtime and in the PM peak period (5-7pm)

Results are similar for both the raw and expanded dataset, indicating that the expansion process did not significantly alter the trip timing profiles.

Mid-point trip timing profiles are shown separately per purpose in the following plot, for both the raw sample and expanded dataset.
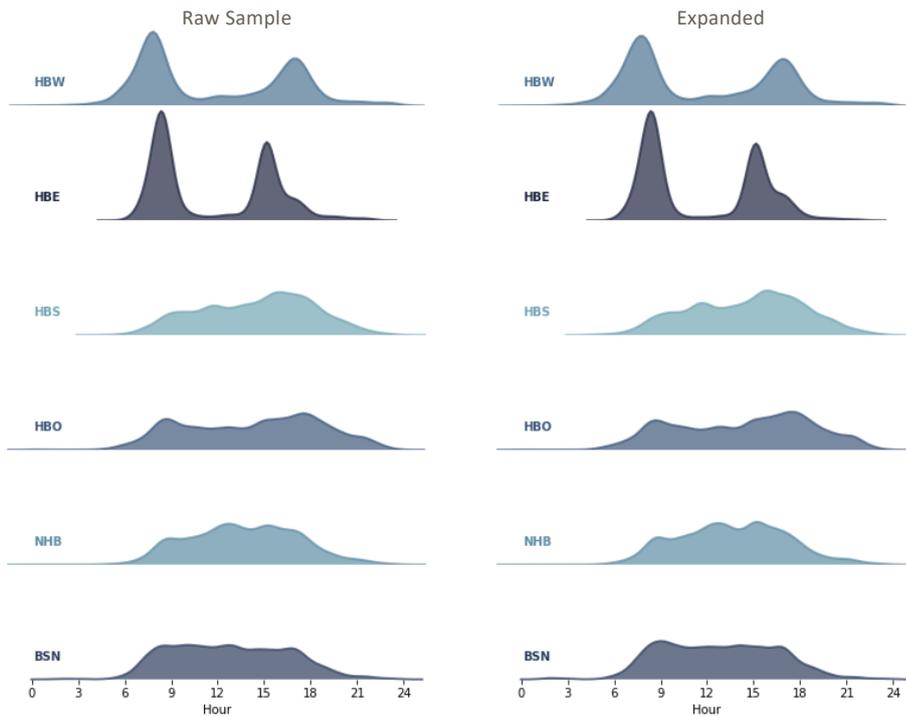
Figure 2-12: Trip timing profile per purpose (%)

2.5.5   Trip length distribution

The following figure shows the trip length distribution for the raw and expanded datasets, for the whole region. Results are first shown including all modes, then separately for car (including drivers and passengers), public transport and active modes.

October 2022 | Status: Final | Project No.: 310203597 | Our ref: TN24 - Wellington Analytical Tools 2019-21 Update - HTS & Mobile phone data.docx

Page 14

Figure 2-13: Trip length distribution per mode

Results are in line with typically observed patterns, with most trips being under 5km. Car trips are longer in average but still show most trips being less than 5km. While this may seem counter-intuitive and longer trips could be expected, it is consistent with findings from the 2001 Wellington HTS and surveys in other jurisdictions.
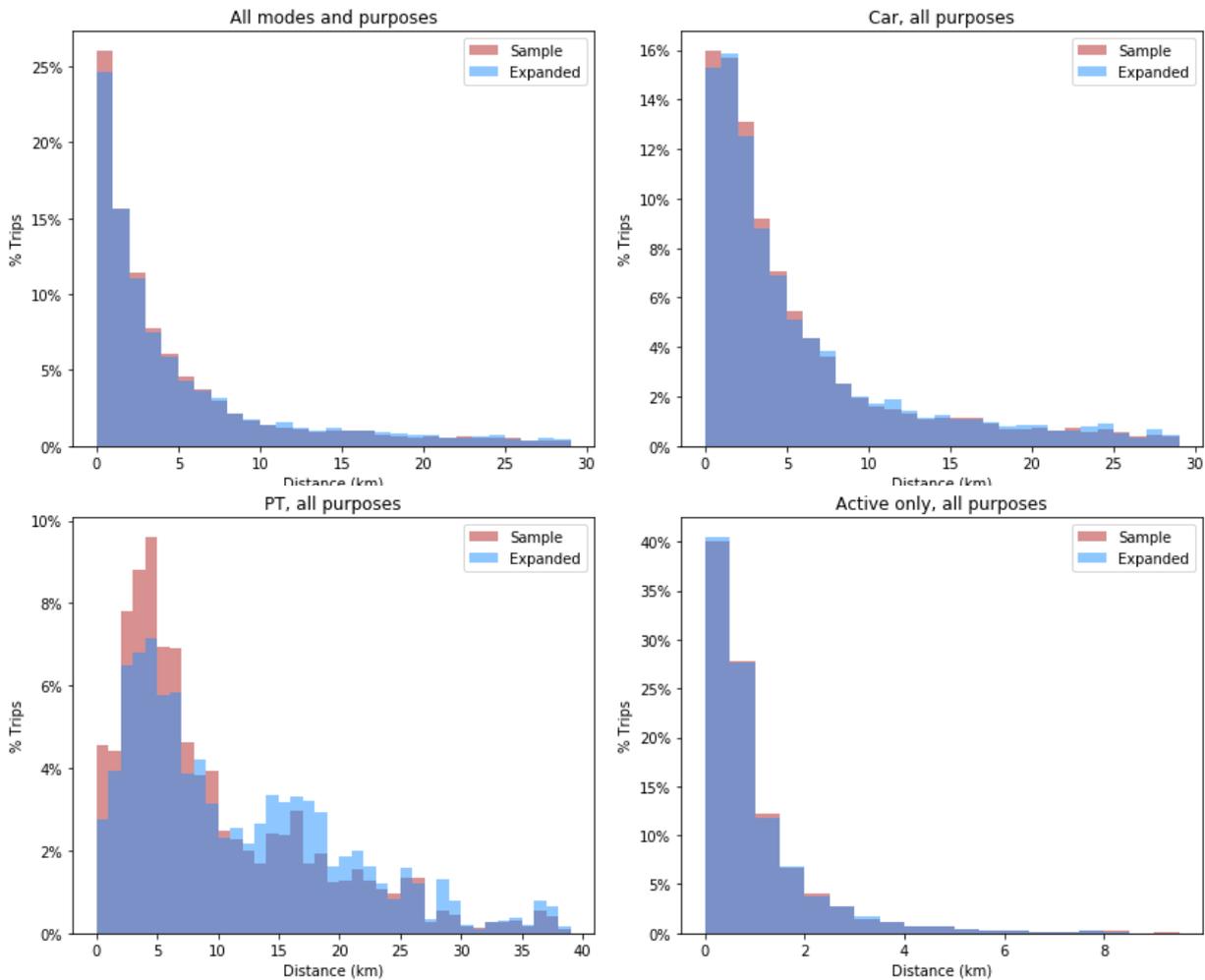
Active modes trips are shorter as expected, with most trips being under 2km. Public transport trips show two different peaks, one around 5km and another one around 15km, which correspond respectively to the peaks for bus and rail demand.

In terms of comparison between the raw and expanded datasets, results are very similar for all modes, with the exception of public transports for which they differ more noticeably.

Results for public transport were extracted separately for bus and rail to investigate these differences in more detail, as shown in the following figure.

October 2022 │ Status: Final │ Project No.: 310203597 │ Our ref: TN24 - Wellington Analytical Tools 2019-21 Update - HTS & Mobile phone data.docx
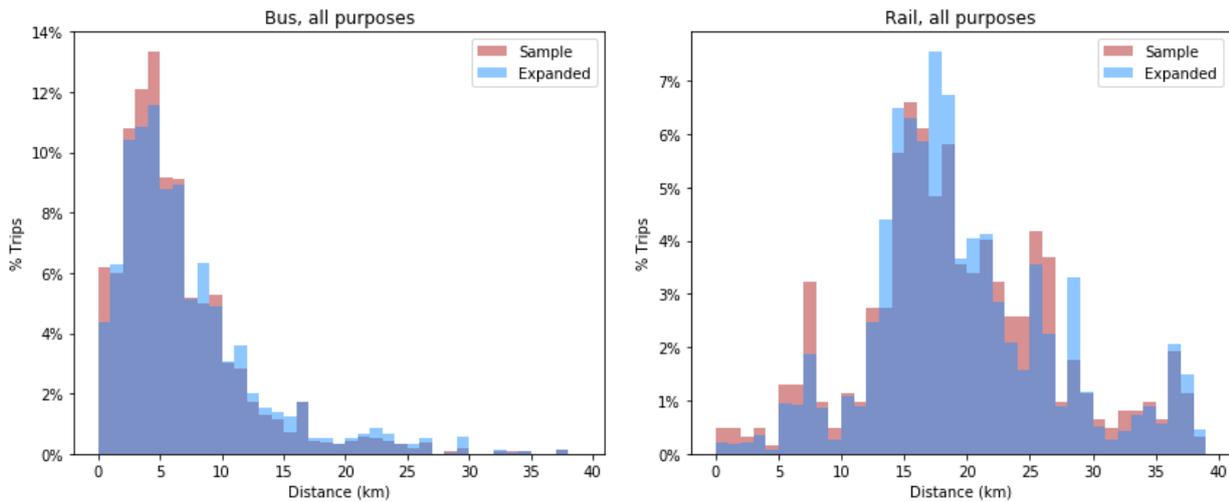
Page 15

Figure 2-14: Trip length distribution, bus and rail

The comparison between the two samples show that the expansion has led to slightly longer bus trips overall. For rail, the distribution for the expanded dataset shows an increase in distance overall but is also narrower, with less trips under 10km and over 20km. This is again likely due to the higher factors applied to households in the Hutt Valley. The distribution for rail also appears less smooth, a result of the lower sample of rail trips in the HTS.

2.6 Summary and recommendations

The analysis of the MoT household travel survey and comparison against other observed patterns has led to the following findings:

- The sample size of the HTS amounts to a circa 0.7% in terms of households surveyed. This is low compared with the 1.2-1.5% sample size generally considered best practice for the development of strategic models. This is however partly mitigated by more days being surveyed per household, leading to a number of trip records comparable with the 2001 HTS.

- The raw dataset was expanded by applying expansion factors on households, and weighting factors to the resulting population to reduce potential biases. Due to the low sample size, some of the resulting factors are quite high, particularly for households in the Hutt Valley area.

- The expanded dataset was converted into demand matrices for private vehicles and public transport, and for all four modelled time periods. These matrices were assigned on the regional network and compared against observed patterns.

- For private vehicles, results show a potential 10% under-reporting overall, however the HTS was a better match for the more critical peak periods and directions, with most of the under-reporting occurring during off peak periods or for the counter-peak direction.

- For public transport, under-reporting mostly occurs in the overnight period which shows low level of public transport overall. At a daily level, demand therefore appears close to observed.

- Some specific issues were noted such as the Miramar screenline showing the HTS being too high for traffic, and the Kapiti screenline for public transport. Conversely, the SH58 screenline indicates that trips in the HTS may be under-estimated for this particular movement.

- A high level analysis of trip rates, mode share, trip purpose share, trip timing and trip length distribution was carried out, looking both at the raw sample and expanded dataset. All results were found to be a good match with known patterns in the Wellington region and generally in line with surveys for similar jurisdictions. Results from the expanded HTS were also similar to the raw sample, indicating that the expansion process did not significantly impact results at an aggregated level. The main exception to this are related to rail demand and likely caused by the higher expansion factors applied to the Hutt Valley catchment.

Based on these findings, the resulting expanded household travel survey dataset provides a robust basis for the development of the new Wellington Transport Strategy Model.

Results at an aggregate level are acceptable, however issues are likely to arise when using patterns at a more disaggregate level due to the small sample. This will have to be carefully considered during the

October 2022 │ Status: Final │ Project No.: 310203597 │ Our ref: TN24 - Wellington Analytical Tools 2019-21 Update - HTS & Mobile phone data.docx

Page 16

model development, and may result in compromises having to be made to balance the desired level of detail against having sufficient data to ensure proper estimation of the model parameters for each subset of demand.

It is also recommended that the potential for using additional sources of information such as mobile phone data (described in the following section), or public transport ticketing data is investigated to complement the HTS whenever required.

3.   Mobile Phone Mobility Data

3.1   Background

Mobility phone location data was delivered by Sparks venture data analysis company Qrious, in the form of synthetic person demand matrices. This section summarises the processing of these datasets, and presents an analysis of the resulting demand and high-level comparison with the Household Travel Survey detailed in the previous section as well as other sources of observed data. This mobility data is intended to be the main source of information for the development of detailed matrices for the new traffic assignment model (WTAM).

The matrices provided include trips within, from and to the Wellington region separately by:

- Time period:
    o   AM Peak: 06:00 – 09:00
    o   Inter Peak: 09:00 – 15:00
    o   PM Peak: 15:00 – 18:00
    o   Overnight: 18:00 – 06:00
- Mode:
    o   Walk
    o   Non-walk (all other modes, including private vehicles, public transport and cycling)
- Purpose:
    o   Home-based
    o   Non-home based

Both weekday and weekend matrices were provided but only the weekday matrices were analysed. Weekend matrices will not be used as part of the Wellington Transport Models Update project as the models represent average weekday conditions.

More detail on the process used by Qrious to produce the demand matrices from mobile phone data can be found in the technical note 'Matrix Delivery 3, for Qrious Synthetic Matrix 2020-07-29'.

An initial set of matrices was provided by Qrious for which an initial analysis was carried out as reported in the memorandum 'Analysis of Qrious matrices (version 1) and comparison with WTSM and observed data', dated 9th June 2021. Due to the 2018 HTS not being available at the time, the demand matrices were compared against patterns from the interim 2018 version of WTSM but this included some limitations due to the different zone system and time periods.

Following this analysis, the sample filtering and expansion processes were adjusted by Qrious and another iteration of matrices was produced. The same analysis was carried out to inform further refinement of the processing, before the final set of matrices was delivered.

The analysis reported in this memo is based on the final matrices, and uses data from the 2018 HTS for comparison. As noted previously it must however be considered that this HTS dataset once processed and cleaned represents a circa 0.7% sample of the regional population, which is considered low. As a result the HTS, while representing a valuable source of data for comparison, is itself likely to include some amount of sampling error and potential biases.

3.2   Matrix processing

The matrices were provided by Qrious as comma-separated values (CSV) text files and were processed as follows:

October 2022 | Status: Final | Project No.: 310203597 | Our ref: TN24 - Wellington Analytical Tools 2019-21 Update - HTS & Mobile phone data.docx

Page 17

- The CSV files were formatted to enable them to be read by the EMME software, and then imported in an EMME database with the new WTSM 820-zone system and networks.

- The public transport matrices from the Wellington Public Transport Model (WPTM) 2018 version were also imported into the same database. The various matrices for bus and rail and by purpose were summed up to produce total public transport matrices per time period.

- The 'non-walk' 'Home-based' and 'Non home-based' Qrious matrices were aggregated to produce total demand excluding walk.

- Public transport demand from WPTM was then subtracted to leave only private vehicle and cycle demand. This created an issue where some matrix cells had more public transport demand in the WPTM matrices than total demand in the Qrious ones, leading to negative values. To solve this issue, the negative values were first aggregated using the older WTSM 225-zone system, reallocated using the ratio of new to old zone and subtracted again from the Qrious matrices. The same process was then carried out again to remove the few remaining negative trips but using larger sectors. More detail on this adjustment and its impact is provided below.

- Due to the absence of detailed information on cycle demand, no adjustments were made to remove trips using this mode from the resulting matrix. According to the HTS, cycling represents circa 1.2% of regional travel demand, and up to 2% for trips to the Wellington CBD.

- Qrious matrices include both car drivers and passengers. Occupancies obtained from the HTS were applied to convert them to vehicles for comparison with observed traffic counts.

3.2.1 Negative values adjustments

As noted above, removing public transport trips from the total Qrious demand matrices resulted in a number of matrix cells with negative values. This could be caused by the Qrious matrices having too little demand, but could also be a result of some error in the WPTM PT matrices. While these are largely based on observed demand (bus electronic ticketing data and rail surveys), the allocation of demand from stops to zones is based on a gravity model which may introduce some error.

Another approach to the one described above was tried, using PT matrices from WPTM and total demand matrices from the current 2018 interim version of WTSM, all aggregated to the 225-zone system to derive the car mode share per OD, which would then be applied to the Qrious total non-walk demand matrices. A similar issue however occurred where the value of PT trips in WPTM was higher than the total demand in WTSM for a number of ODs. In addition, using mode share aggregated at 225-zone would lose some of the detail in the finer grained Qrious matrices.

For this reason, the approach adopted of using the detailed WPTM matrices, but the coarser 225-zone system only to smooth out negative values (and then larger sectors with the region divided into 42 sectors) was deemed appropriate.

However the number of Origin-Destination cells ending up with a negative value before the adjustments is significant. The following table shows the number of negative trips after subtracting PT demand and after each round of adjustments (first using 225 zones and then 42 sectors), and the number and percentage of cells with negative values.

Table 3-1: PT trips removal and negative values

Period	Demand before PT trips removal	Demand after PT trips removal	Negative trips	% negative ODs	Negative trips after 1st adjustment	Negative trips after 2nd adjustment
AM	305,097	261,840	-21,307	8%	-8,615	0
IP	486,982	452,901	-13,665	6%	-5,918	0
PM	349,833	307,626	-14,615	8%	-5,639	0
ON	359,218	342,860	-6,042	8%	-1,861	0

To better understand the magnitude of this issue and impact of adjustments, the following table and figure present the resulting distribution of OD cells per number of trips in the AM peak private vehicle matrix (results are similar for other time periods).

October 2022 | Status: Final | Project No.: 310203597 | Our ref: TN24 - Wellington Analytical Tools 2019-21 Update - HTS & Mobile phone data.docx

Page 18

Table 3-2: Number of trips per OD – AM Peak

Trips	Before PT trips removal				After PT trips removal			
	Number of ODs	%	Number of trips	%	Number of ODs	%	Number of trips	%
0	450,534	60%	0	0%	473,521	63%	0	0%
0 - 0.5	206,739	27%	29,264	10%	198,828	26%	27,367	11%
0.5 - 1.0	38,719	5%	27,531	9%	34,304	5%	24,316	9%
1.0 - 1.5	17,803	2%	21,800	7%	14,916	2%	18,244	7%
1.5 - 2.0	10,351	1%	17,917	6%	8,735	1%	15,100	6%
2+	32,754	4%	208,584	68%	26,596	4%	176,813	68%
Total	756,900		305,097		756,900		261,840	

As can be observed, before the PT trips removal about 60% of cells have no trips, with only 4% having more than 2 trips. These 4% of cells however include more than two thirds of the demand, so most trips occur for a limited number of ODs.

Following the PT trips removal and negative values adjustments, the share of cells with zero trips increases slightly, but the distribution of trips is only slightly altered. This indicates that these negative trips adjustments have not significantly impacted on the overall shape of the matrix.

3.3 Trip rates

Daily trip rates per person and household were calculated, based on the number of trips in the Qrious matrices and an Estimated Resident Population for the Wellington region of 526,000 people and 192,339 households. The resulting implied trip rates are shown in the following table, and compared with the same results from the HTS (all HTS metrics shown in this section are based on the expanded HTS).

Table 3-3: Trip rates

Trip rates	Mobile phone	HTS
per person	3.3	4.1
per household	9.0	11.0

The trip rates resulting from the mobile phone data matrices are about 20% lower than in the HTS. Trip rates from the HTS are themselves in line with expected trip rates historically observed in New Zealand, although somewhat lower reflecting a slight potential undercounting but also overall trends of decreasing trip rates globally.

The trip rates have increased compared with the initial version of the demand matrices that had rates of 2.6 trips per person but remain lower than observed.

While this difference in trip rates could be caused by a number of reasons, two potential explanations were suggested:

- Differences in sampling in the HTS and mobile phone data, with some population cohorts not as well represented in one dataset. As an examples, children and adolescents are included in the HTS but some would not have a mobile phone device. The absence of information on the sample used to derive mobile phone data means this cannot be investigated in more detail. It is a limitation understood in procuring this alternate data source.

- Acknowledged issue with Qrious being able to accurately identify short trips. To investigate this issue, trip rates were also calculated for both datasets but only including trips over 3km. In this case, trip rates are closer with Qrious at 2.2 trips per person compared with 2 in the HTS (respectively 5.9 and 5.3 per household). This issue is discussed further in section 3.9 on trip length distribution.

October 2022 | Status: Final | Project No.: 310203597 | Our ref: TN24 - Wellington Analytical Tools 2019-21 Update - HTS & Mobile phone data.docx

Page 19

3.4   Peak proportions

The following table shows the proportion of trips per time period for the Qrious matrices compared with the HTS. Results are shown for both all modes and for car trips only.

Table 3-4: Time periods proportions

Time period	Total		Car	
	Qrious	HTS	Qrious	HTS
AM	20%	19%	19%	18%
IP	32%	38%	33%	38%
PM	23%	29%	23%	29%
ON	25%	14%	25%	16%

The proportion of trips in the AM peak is similar in both sets of matrices, however the Inter Peak and PM peak are about 6% lower (in absolute terms) in the Qrious matrices whereas the Overnight period is about 10% higher.

It must be noted that trips in the HTS have been allocated to a time period based on their mid-point time. Mobile phone data matrices are however based on the trip starting point. The analysis in the table above and in the following sections was also carried out with HTS trips allocated based on starting-point and the difference in results based on start or mid-point was negligible in all cases. Results presented in this memo are therefore based on mid-point for consistency with other HTS output.

3.5   Home-Based vs non-home-based

Mobile phone matrices were split into home-based and non-home based demand by Qrious, depending if either end of the trip was to/from the 'home' location.

The table below presents the proportion of home-based vs non-home based trips in the Qrious demand matrices and in the HTS, for each time period and for 24 hours.

Table 3-5: Home-based vs non home-based proportions

Time period	Qrious		HTS	
	HB	NHB	HB	NHB
AM	65%	35%	82%	18%
IP	49%	51%	54%	46%
PM	61%	39%	75%	25%
ON	72%	28%	66%	34%
24Hr	61%	39%	65%	35%

At a 24 hour level, there is a reasonably close match with the HTS, and a clear improvement compared with earlier versions of the matrices that showed a split of 37% Home-based and 63% Non-home-based.

Non-home based trips are however significantly higher in the Qrious matrices than in the HTS during the peak periods, especially the AM peak where they are circa twice higher. The share of non-home based trips is a better match in the Inter peak and lower in the Overnight period.

The same analysis was carried out with the datasets including only trips over 3km and the results are similar, with both showing a lower share of non-home based trips but the difference between the two increasing. This indicates that this issue is not related to the lack of short trips in the Qrious matrices.

3.6   Walk / non-walk mode share

This section considers the share of walk vs non-walk trips, first looking at overall patterns for the whole region, then at trips exclusively to the CBD (including within the CBD). Results are shown in the following tables, per time period and for the whole 24 hours.

October 2022 | Status: Final | Project No.: 310203597 | Our ref: TN24 - Wellington Analytical Tools 2019-21 Update - HTS & Mobile phone data.docx

Page 20

Table 3-6: Walk vs non-walk proportions – whole region

Time Period	Qrious		HTS	
	Walk	Non walk	Walk	Non walk
AM	11%	89%	15%	85%
IP	13%	87%	21%	79%
PM	12%	88%	11%	89%
ON	17%	83%	16%	84%
24hr	13%	87%	18%	82%

Table 3-7: Walk vs non-walk proportions – to CBD

Time Period	Qrious		HTS	
	Walk	Non walk	Walk	Non walk
AM	9%	91%	24%	76%
IP	14%	86%	57%	43%
PM	18%	82%	47%	53%
ON	15%	85%	49%	51%
24hr	13%	87%	45%	55%

Looking at overall results for the whole region the share of walk trips is generally lower in the Qrious matrices, and this is particularly noticeable in the Inter Peak, with other periods showing a better match. This is likely associated with less accuracy in short trips in the Qrious dataset.

For trips to and within the CBD, the HTS shows a much higher share of walk trips, especially during the Inter peak. This is in line with other surveys (including Journey to work data) and appears sensible, as the compact nature of the Wellington CBD leads to walking being a more attractive mode there compared with the rest of the region, especially for non-home based trips during the inter peak.

For trips to and within the CBD in the mobile phone demand however, the matrices are similar to overall regional patterns, with an even lower share of walk trips in the case of the AM peak.

Again the same analysis was carried out with the datasets including only trips over 3km. Predictably, the share of walk trips decreases in both set of matrices, but the drop is more marked in the HTS resulting in only 1% of walk trips regionally, compared with 10% in the Qrious matrices. For trips to the CBD the share of walk trips decreases to 3% in the HTS, and 6% in the Qrious matrices, lower than regionwide.

This discrepancy means that the matrices are less representative of observed mode share for trips to and from the CBD, however this mostly applies to shorter trips under 3km.

3.7   Traffic volumes across screenlines

The private vehicle trip matrices resulting from the processing described previously were assigned to the network using assignment procedures from the current WTSM. Assigned volumes were then compared against observed across the screenlines shown in Figure 2-8, similarly as per the HTS.

The observed data used was based on traffic counts for private vehicles.

A number of simplifications and assumptions were made to enable the comparison:

- Private vehicle matrices from mobile phone data include both car drivers and passengers. They were converted to vehicles using occupancies obtained from the HTS for comparison with observed vehicles.
- As for the HTS comparison, the current WTSM assignment procedures are set up for 2-hours period and the same adjustments were made in order to assign matrices for longer time periods.

The resulting comparison is shown in the following table.

October 2022 │ Status: Final │ Project No.: 310203597 │ Our ref: TN24 - Wellington Analytical Tools 2019-21 Update - HTS & Mobile phone data.docx

Page 21

Table 3-8: Mobile phone vs counts at screenlines – private vehicles

Screenline	Dir	AM			IP			PM			Overnight			24hr		
		Counts	Qrious	Diff	Counts	Qrious	Diff	Counts	Qrious	Diff	Counts	Qrious	Diff	Counts	Qrious	Diff
CBD	In	33,628	37,826	12%	50,082	34,065	-32%	26,793	19,742	-26%	32,318	21,077	-35%	142,820	112,710	-21%
	Out	18,345	16,157	-12%	46,478	37,322	-20%	35,485	35,350	0%	37,394	26,168	-30%	137,702	114,997	-16%
North CBD	In	20,068	24,330	21%	22,276	17,117	-23%	11,988	9,299	-22%	12,232	10,824	-12%	66,564	61,571	-8%
	Out	8,302	7,686	-7%	21,760	21,558	-1%	20,688	24,056	16%	17,690	12,206	-31%	68,440	65,506	-4%
Miramar	In	5,599	4,178	-25%	8,872	5,160	-42%	5,883	3,310	-44%	7,207	3,226	-55%	27,561	15,873	-42%
	Out	4,868	3,104	-36%	9,457	5,385	-43%	6,692	3,966	-41%	7,225	3,550	-51%	28,242	16,006	-43%
Ngauranga to Petone	In	9,305	12,388	33%	13,551	11,664	-14%	7,938	6,929	-13%	7,305	7,487	2%	38,099	38,467	1%
	Out	6,107	6,629	9%	12,961	13,554	5%	9,495	12,581	33%	8,822	6,994	-21%	37,385	39,759	6%
Upper Hutt to Lower Hutt	In	9,638	11,543	20%	9,646	8,951	-7%	5,851	5,478	-6%	5,212	5,773	11%	30,347	31,745	5%
	Out	4,028	4,830	20%	9,019	10,465	16%	10,080	11,658	16%	7,049	5,965	-15%	30,176	32,919	9%
Porirua South	In	8,200	9,405	15%	11,679	11,704	0%	6,954	6,024	-13%	6,801	7,656	13%	33,634	34,789	3%
	Out	4,900	5,242	7%	11,751	13,131	12%	9,642	11,061	15%	7,662	6,893	-10%	33,955	36,327	7%
Porirua North	In	5,105	4,669	-9%	7,350	4,152	-44%	4,006	2,487	-38%	3,711	3,031	-18%	20,172	14,340	-29%
	Out	2,899	2,709	-7%	7,327	5,376	-27%	5,921	5,268	-11%	4,390	2,574	-41%	20,537	15,927	-22%
Kapiti	In	8,200	9,405	15%	11,679	11,704	0%	6,954	6,024	-13%	6,801	7,656	13%	33,634	34,789	3%
	Out	4,900	5,242	7%	11,751	13,131	12%	9,642	11,061	15%	7,662	6,893	-10%	33,955	36,327	7%
SH58	In	2,441	2,586	6%	2,528	2,333	-8%	2,431	2,433	0%	1,464	1,250	-15%	8,864	8,603	-3%
	Out	2,224	2,283	3%	2,568	2,236	-13%	2,516	2,341	-7%	1,477	1,093	-26%	8,785	7,953	-9%
Total		158,757	170,213	7%	270,734	229,009	-15%	188,959	179,072	-5%	182,422	140,316	-23%	800,872	718,610	-10%

Overall and at a 24 hour level, assigned volumes from the mobile phone demand matrices are about 10% lower than observed counts. This is despite a circa 20% underestimation in trip rates per person, although these rates included all modes. The coefficient of determination (r^2) is within a 0.97-0.99 range for all periods, denoting a very high correlation at a screenline level.

Results per screenline however vary by time period, with the peak periods being generally closer to observed (+7% overall difference in the AM peak, -5% in the PM peak), whereas the off-peak periods are lower.

Interestingly, the Overnight period is the lowest at -23% of observed, despite being over-estimated compared with the HTS in terms of proportion of trips per time period as shown in Table 3-4. Conversely, the AM peak period is 7% high overall despite being a very close match to the HTS in terms of proportion per time period. A likely explanation between these inconsistencies is linked to the trip lengths being over or underestimated for some periods (see 'Trip length distribution' section).

Looking at results per screenline, the main pattern that can be observed is a tendency for peak period and peak directional volumes (inbound in the AM peak, outbound in the PM peak) to be over-estimated by about 10-20% (up to 30% for Ngauranga to Petone compared with counts).

3.8   Sectored distribution analysis

This section presents the analysis of trip distribution for the demand matrices aggregated to 10 sectors, and comparison with demand from the HTS.

The following figures shows the percentage distribution of trips per sector in the Qrious and HTS matrices, both by origin and destinations, for each time periods
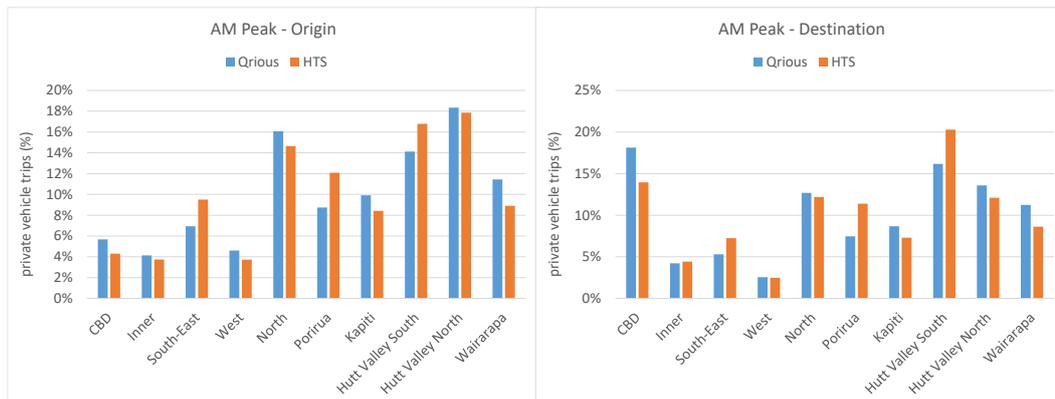

Figure 3-1: Private vehicle trip distribution – AM Peak

October 2022 | Status: Final | Project No.: 310203597 | Our ref: TN24 - Wellington Analytical Tools 2019-21 Update - HTS & Mobile phone data.docx
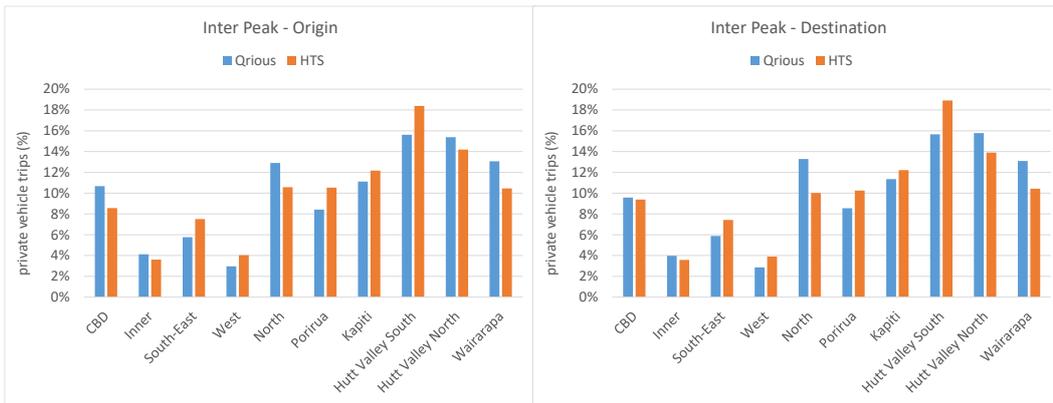
Page 22

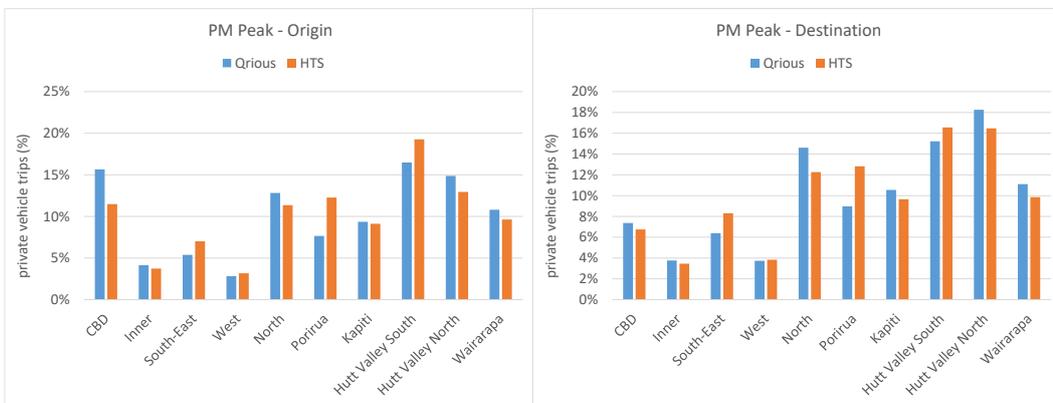Figure 3-2: Private vehicle trip distribution – Inter Peak

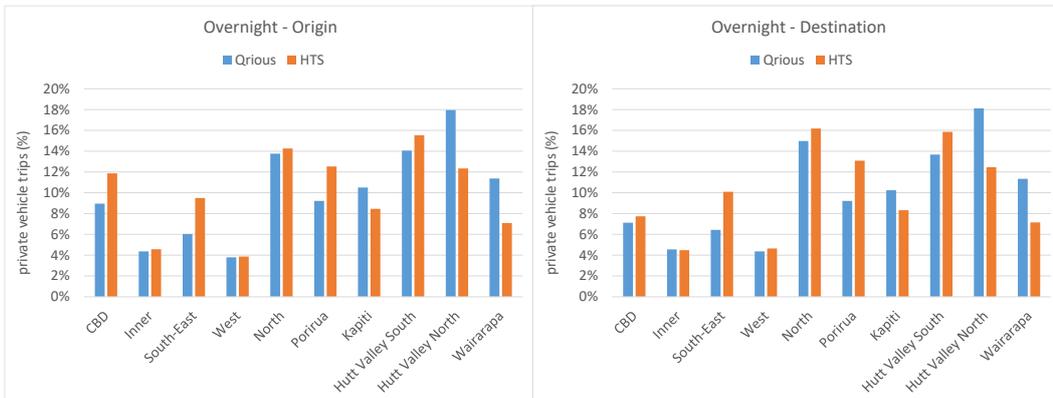Figure 3-3: Private vehicle trip distribution – PM Peak

Figure 3-4: Private vehicle trip distribution – Overnight

Generally demand to and from the CBD is higher in the Qrious matrices, but this is more pronounced in the peak direction (destination in the AM peak, origin in the PM peak) which matches findings from the analysis of peak traffic volumes across screenlines. Contrary to this, demand is consistently lower for some sectors such as Hutt Valley South and Porirua.

The following table shows the proportion of intra-sector trips in both demand sets, i.e. trips that have the same sector as origin and destination.

October 2022 │ Status: Final │ Project No.: 310203597 │ Our ref: TN24 - Wellington Analytical Tools 2019-21 Update - HTS & Mobile phone data.docx

Page 23

Table 3-9: Proportion of intra-sector trips – private vehicles

Sector	AM Peak		Inter Peak		PM Peak		Overnight	
	Qrious	HTS	Qrious	HTS	Qrious	HTS	Qrious	HTS
CBD	53%	45%	40%	43%	22%	29%	29%	29%
Inner	28%	21%	34%	29%	27%	25%	39%	27%
South-East	32%	35%	44%	42%	40%	50%	49%	37%
West	29%	38%	45%	60%	48%	65%	57%	42%
North	46%	55%	59%	61%	55%	64%	67%	64%
Porirua	51%	68%	63%	75%	60%	75%	69%	72%
Kapiti	81%	85%	94%	93%	93%	97%	91%	87%
Hutt Valley South	61%	74%	67%	76%	59%	66%	69%	60%
Hutt Valley North	56%	53%	76%	73%	75%	80%	80%	55%
Wairarapa	96%	95%	97%	98%	98%	99%	97%	97%
Total	57%	61%	68%	71%	60%	68%	70%	58%

With the exception of the Overnight period, the proportion of intra-sector trips is generally lower in the mobile phone demand matrices than in the HTS. This is consistent with the issue of under-representation of short trips discussed in the following section. The Porirua and Hutt Valley South sectors stand out again as showing the largest difference between the two datasets.

3.9   Trip length distribution

This section presents a comparison of trip length distribution from the mobile phone demand matrices and the HTS, for each time period, for private vehicle demand. This shows the proportion of trips within distance bands, with a 1km increment being used.

Results for each time period are shown in the following figures, with average trip length shown in
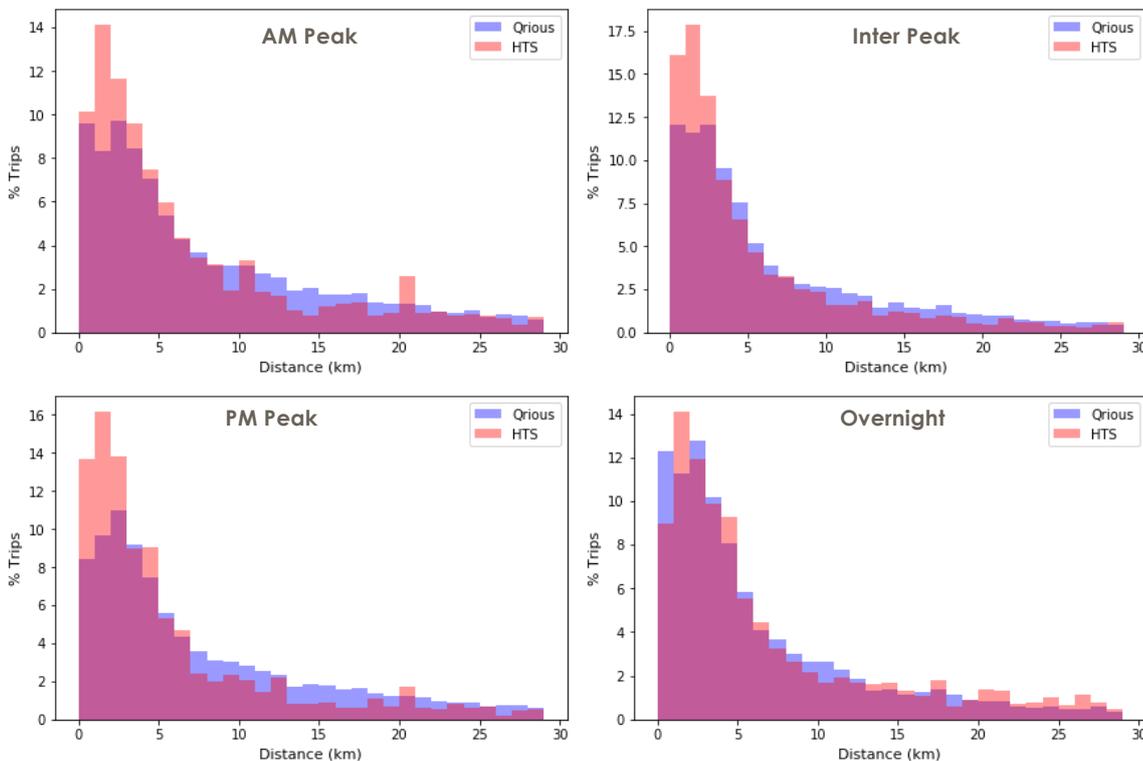
Table 3-10.

Figure 3-5: Private vehicle trip length distribution

October 2022 │ Status: Final │ Project No.: 310203597 │ Our ref: TN24 - Wellington Analytical Tools 2019-21 Update - HTS & Mobile phone data.docx

Page 24

Table 3-10: Average trip length (in km) – private vehicles

Period	Qrious	HTS
AM	11.6	9.0
IP	9.6	7.3
PM	10.9	7.5
ON	8.8	8.9

The plots show that the mobile phone demand matrices have generally a smaller proportion of short trips under 3km than observed in the HTS, resulting in longer average trip lengths. This occurs for all time periods, although to a different extent: the Overnight period is the closest match while at the other extreme, the PM peak average distance is close to 30% higher in the Qrious matrices than in the HTS.

The average distances were recalculated for the datasets with only trips over 3km for comparison, as shown in the following table.

Table 3-11: Average length trips over 3km (in km) – private vehicles

Period	Qrious	HTS
AM	15.4	13.1
IP	14.2	12.6
PM	14.2	12.1
ON	13.0	12.9

Overall trip length increase as expected but the difference between both datasets is less marked, with average length being about 10-15% longer (except Overnight) compared with 20-30% for all trips.

3.10 Summary and recommendations

The analysis of the final set of delivered Qrious matrices and comparison against HTS and traffic counts data has led to the following findings:

- Trip rates (for all modes) are about 20% lower in the Qrious matrices than both the HTS and values historically observed in New Zealand. However these lower rates appear to be mostly occurring for short trips, with rates for trips over 3km being much closer. The lower than typical trip rates was expected when the Qrious matrices were delivered.

- The proportions of trips per time period is close in the AM peak but less so in other periods. Overnight is particularly higher in the Qrious matrices.

- The split of home-based / non home-based trips is close overall, but the share of non-home based is higher during peak periods in the Qrious matrices.

- The split of walk / non-walk is a good match with the HTS overall, with a slightly lower share of walking in the Qrious matrices. Looking at more detailed results for trips to and within the CBD however, the share of short (<3km) walking trips appear very low, especially during the peak periods.

- Comparison of assigned Qrious matrices to observed traffic counts shows a good correlation overall but results differ by time period. Overall volumes are slightly too low but not as much as could be expected based on the lower trip rates (likely due to most of the missing trips being short distance). Peak direction volumes to and from the CBD are however consistently higher than counts by 10-20%. Off peak periods are generally lower, especially the Overnight period.

- Looking at sectored distribution, there is a good correlation with the HTS. Again peak demand from and to the CBD is higher than in the HTS, in line with the comparison against traffic counts. Other sectors such as Hutt Valley South and Porirua are lower.

- Trip length distribution analysis shows that average trip length for the Qrious matrices is in average 20-30% higher than in the HTS, with the exception of the Overnight period. There is also a lower proportion of intra-sector trips. This is to some extent caused by the lack of short trips in the Qrious matrices however, with average length for trips over 3km being a better match, about 10-20% longer.

October 2022 | Status: Final | Project No.: 310203597 | Our ref: TN24 - Wellington Analytical Tools 2019-21 Update - HTS & Mobile phone data.docx

Page 25

Based on these findings, while the inconsistencies of varying significance with share of trips by purpose, time periods, or walk/non-walk modes will likely need adjustment, the Qrious mobile phone demand matrices provide a sufficiently robust base to be used for this project. This includes the main intended use of these matrices for the development of a new traffic assignment model.

In particular, comparison with sectored trip distribution from the HTS and traffic count screenlines indicate that the overall 'shape' of the resulting private vehicle demand matrix is a good match with observed traffic patterns in the region.

The main issue identified however, and likely not well captured by the screenline comparison which focuses on longer distance trips, is the under-representation of short trips in the Qrious matrices. This will need to be addressed in order for the matrices to provide a better representation of regional traffic patterns. Special care will be needed for adjustments in the CBD, where this lack of short trips overall is counterbalanced by a lower share of walk trips than observed in the HTS. The ultimate amount of private vehicles trips in the CBD will need to be thoroughly checked again observed patterns, using the traffic counts and screenlines that were recently added to the validation dataset in addition to the CBD cordon.

October 2022 | Status: Final | Project No.: 310203597 | Our ref: TN24 - Wellington Analytical Tools 2019-21 Update - HTS & Mobile phone data.docx

Page 26

Appendices