TECHNICAL NOTE

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Subject Technical Note on the Analysis of State Highway Network Performance at Key Locations

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Purpose of Technical Note

- The purpose of this technical note is to present an analysis of recent State highway network performance
- This will inform the approach to the submission on the WIAL runway extension and subsequent discussion with WIAL on the appropriateness of the haulage windows for the construction of the proposed runway extension.

Overview of the Project

WIAL have lodged an application for consent to construct an extension their runway some 350m towards the south into Cook Strait. The primary purpose of this runway extension is to enable long haul flights from Asia and North America to land at Wellington.

It is proposed by WIAL that the construction of the runway extension will require the haulage of up to 30 HPMV vehicles per hour on SH1 between the hours of 9:30am to 2:30pm and 10:00pm to 6:00am weekday. It is proposed that when 30 vehicles an hour are run they will depart in 2 minute intervals. When lessor volumes of HMPV are run the spacing of trucks will broadly be proportionately larger. HPMV vehicles will run full on SH1 from Kiwi point and SH2 from Horokiwi[1] to SH1 to the airport. They will then undertake the same trip in the reverse direction running empty.

It should be noted that although WIAL suggest they would like to start construction sooner rather than later, their consent application is for 10 years. An early construction start may see construction commence in 1 to 2 years but construction may still be continuing in 5 years' time. In the worst case, in terms of the consent application, construction could start in 10 years and continue for a further 3 years.

Analysis

The Terrace tunnel southbound and the Mt Victoria tunnel westbound are two critical bottlenecks on the network. This does not mean that they are the only locations where congestion occurs during peak periods. However, these two bottlenecks act to control the flow of traffic that uses State highway 1 in the inner city. For this reason, they have a controlling impact on highway performance in the CBD and

[1] Because of structural weaknesses at the Petone Interchange it is expected that vehicles would travel north to Dowse Interchange and use the interchange to enable travel on SH2 in a southbound direction.

so it is important to understand the performance of these bottlenecks when determining potential haulage windows for the runway extension construction.

Impact on the Terrace Tunnel Southbound

Figure 1 below shows a summary of traffic volumes counted in 15 minute intervals at the Terrace Tunnel southbound for the month of February and the first two weeks of March 2016. Only weekday Tuesday, Wednesday and Thursday counts were used for the period 4:00am to 11:00am. These days were chosen as the days are more representative of weekday traffic whereas Mondays and Fridays are subject to more public holidays or persons seeking to take long weekends. The 4:00am to 8:00pm period encapsulates the morning peak period and provides suitable shoulders to allow us to understand the effects of peak period queuing extending beyond the peak period.

The mean traffic volume profile (blue or 50 percentile) is shown along with a 95 and 99 percentile synthesised profiles. In a non-leap year there are 245 working days. A 50 percentile curve is the mean curve and traffic volumes will be greater than this curve 122.5 working days a year. A 95 percentile curve will be exceeded 12.3 working days a year. A 99 percentile curve will be exceeded 2.5 working days a year.

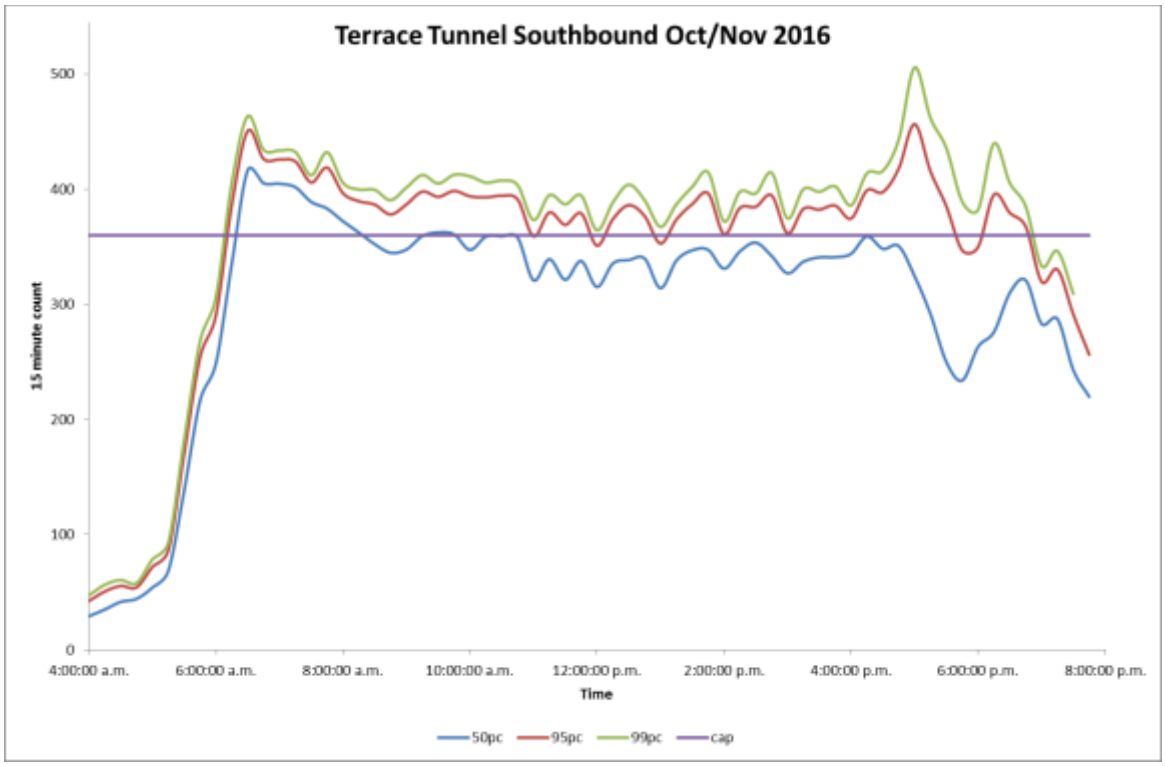

Figure 1 Terrace Tunnel Southbound Profiles February/March 2016

There are several key features to note.

1. The highest morning 15 minute volumes for each of the curves occur before the nominal "morning peak" of 7am to 9am. They occur in the 15 minutes from 6:30 to 6:45am for the remainder of the curves.

2. From about 5:15am to the point where the maximum 15 minute volumes occurs the curves are steep. This means small percentage changes in traffic volumes can lead to significant changes in the traffic volume-time profile.
3. It is clear that flow breakdown and the onset of queuing occurs at these maximum volumes. This suggests flow breakdown can occur at volumes higher than capacity but is short lived. Capacity is approximately 340 to 370 vehicles per 15 minutes.
4. Traffic volumes remain high throughout the morning, after the peak period, as lower demands permit queue discharge. However, increases in demand will see the queuing period extend into later in the day till the morning peak and evening peak eventually merge.
5. On an average working day 2016 volumes are on the cusp of capacity in the evening peak from about 4:00 to 4:45pm. However, there is significant variability in traffic flows as shown by the 95 and 99 percentile curves that capacity is frequently exceeded on many working days that will lead to flow breakdown and queueing.

Peak Spreading to periods later in the morning

As noted above the traffic volumes at the Terrace Tunnel southbound remain high in the post morning peak period and rise to reach capacity again during the evening peak. Figure 2 below shows the change in the mean traffic volume profile from 2013 to 2016 for the February to March period or the Terrace Tunnel southbound bottleneck.

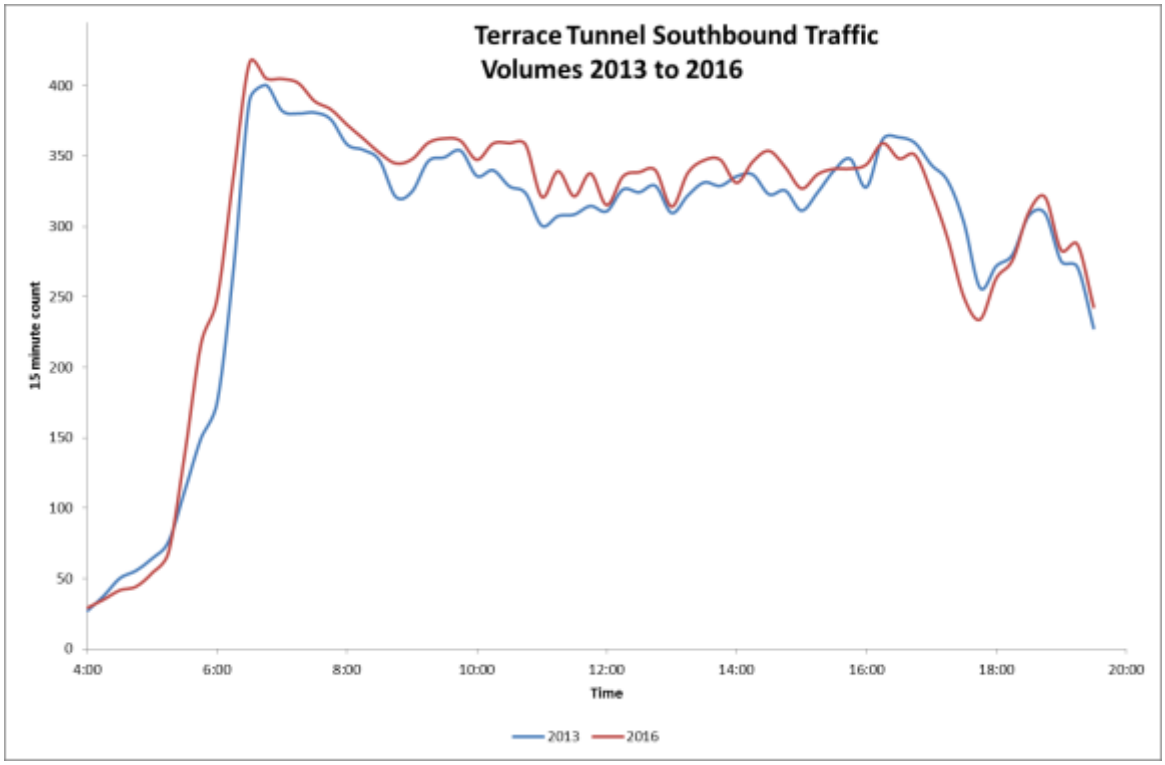

Figure 2 Terrace Tunnel Southbound Profiles February/March 2013 and 2016

It is clear from Figure 2 that mean traffic volumes in 2016 have generally increased over 2013 for the same time periods and same time of year. Average traffic growth rates per annum are presented in Table 1 below for different time periods during the day.

Time	5:15 to 6:30am	6:30 to 8:45am	8:45am to 11am	11am to 3pm	3 to 4pm
Growth Rate %pa	7.2	1.3	2.0	1.5	0.8

Table 1 Traffic Growth Rates per annum Terrace Southbound 2013 to 2016

Underlying growth of this order means that the morning peak and evening peak periods will eventually merge and there will come a time when continuous queuing at the Terrace Tunnel southbound till after the afternoon peak. Until this happens, the length of the inter peak period will continue to contract and the spare capacity will also reduce. This means the ability to absorb additional traffic will continue to shorten in time and the quantum of additional traffic at any given time will reduce.

Because of uncertainty around future traffic growth rates and day to day traffic variability as represented in Figure 1 it is not possible to be precise about what year the peaks may merge. As an indicative calculation using a range of growth rates of 0.8 to 1.2 per cent per annum this suggests the merging of the peaks is likely to occur in 12 to 19 years. However, before then there will be on-going shortening of the period between the peaks and reductions in spare capacity to provide for additional traffic.

The range of growth rates of 0.8 to 1.2 per cent per annum have been selected using Table 1. It is considered that this range is representative of the inter peak period recognising that Wellington has been in a strong growth mode since 2013 to 2016. Over a period of more than 5 years it has been assumed that the higher growth rates in Table 1 are unlikely to be maintained.

Practical breakdown of flow between the peaks has been estimated using a 15 minute merge capacity of 360 vehicles per lane. The local minimum volume for 2016 of 314 vehicles per lane over 15 minutes has been used to estimate the number of years required. Clearly different assumptions will yield different estimates of the time required.

Peak Spreading to periods earlier in the morning

Figures 1 and 2 above shows that the period immediately before the morning peak has relatively low traffic volumes. This gives capacity for additional traffic to be absorbed by lengthening the peak earlier in the morning.

Table 1 above shows that the morning peak pre-shoulder period (5:15 to 6.30am) has grown rapidly over the 2013 to 2016 period. The mean growth rate of 2016 over 2013 for the 5:15 to 6:30am period is 7.2 percent per annum. Another way of looking at this is that the pre-peak shoulder in 2016 achieves the same traffic volumes as 2013 9.4 minutes earlier. This means the morning peak pre-peak shoulder is advancing at a rate of 3.1 minute per annum.

Over the 2016 to 2030 period the 50, 95 and 95 percentile morning peak period curves would advance 40 minutes at flow breakdown and queuing if this 2013 to 2016 period rate continued. However, again this growth rate is unusually high and is unlikely to be maintained every year for the next 13 years. Assuming a long term average growth rate over the period to 2030 40 to 60 percent of the levels of the 2013 to 2016 period this suggests the morning peak period may advance 16 to 24

minutes over the 2016 to 2030 period. However, higher growth rates will see higher levels of peak spreading.

Impact on Mt Victoria Tunnel Westbound

Figure 3 below shows a summary of traffic volumes counted in 15 minute intervals at the Mt Victoria Tunnel westbound for the last two weeks of October and the month of November 2016. Only weekday Tuesday, Wednesday and Thursday counts were used for the period 4:00am to 11:00am. These days were chosen as the days are more representative of weekday traffic whereas Mondays and Fridays are subject to more public holidays or persons seeking to take long weekends. The 4:00 to 11:00am period encapsulates the morning peak period and provides suitable shoulders to allow us to understand the effects of peak period queuing extending beyond the peak period.

The mean traffic volume profile (red or 50 percentile) is shown along with a 5, 95 and 99 percentile synthesised profiles.

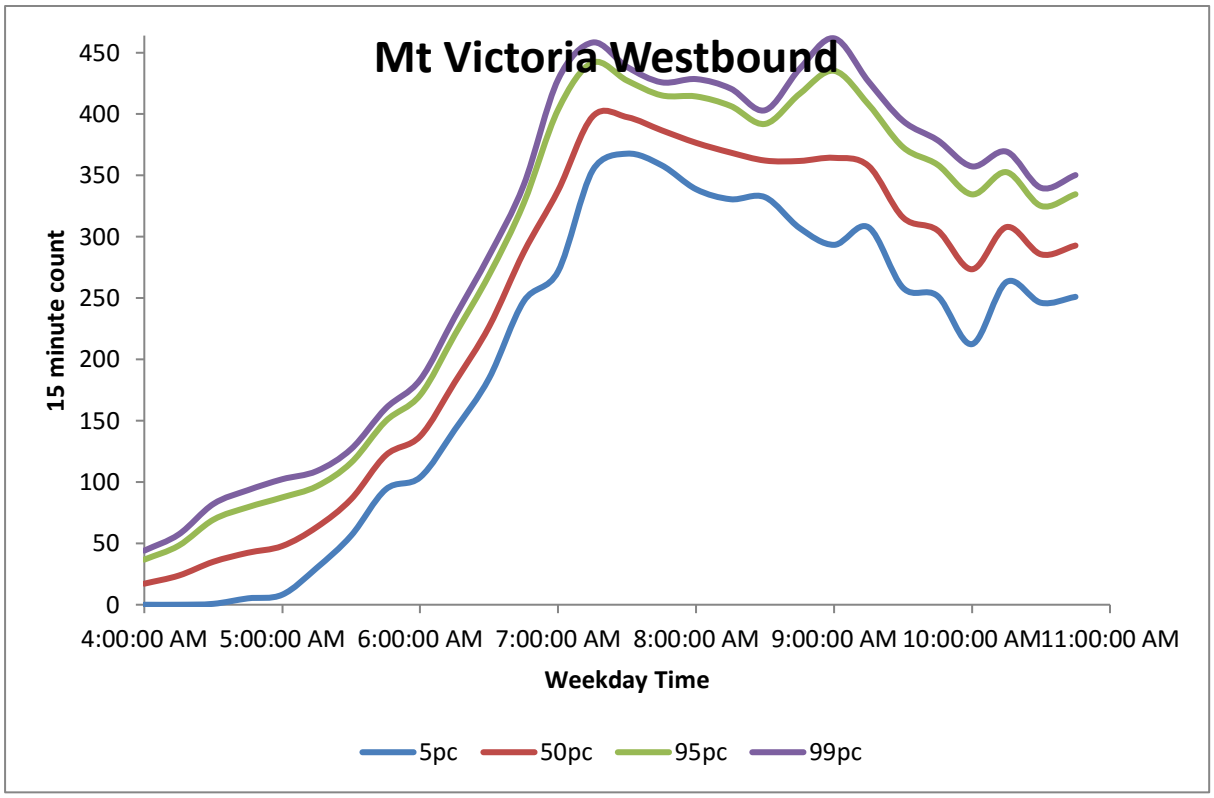

Figure 3 Mt Victoria Tunnel Westbound Morning Profiles October/November 2016

There are several key features to note.

1. The highest 15 minute volumes for each of the curves occur during the nominal "morning peak" of 7am to 9am. They occur in the 15 minutes 7:15 to 7:30am.
2. From about 5:15am to the point where the maximum 15 minute volumes occurs the curves are steep but less steep than the corresponding Terrace Tunnel curves. This means small percentage changes in traffic volumes can lead to significant changes in the traffic volume-time profile.
3. It is clear that flow breakdown and the onset of queuing occurs at these maximum volumes. This suggests flow breakdown can occur at volumes higher than capacity but is short lived. Capacity is approximately 300 to 320 vehicles per 15 minutes.

4. Traffic volumes do not remain high throughout the morning as lower demands permit queue discharge. This means there is capacity later in the day for additional traffic to be absorbed. However, increases in demand will see the queuing period extend into later in the day although this will be less extensive the same process at the Terrace Tunnel southbound.

Applying the same kind of analysis as for the Terrace Tunnel we find:

Peak Spreading to periods later in the morning

As noted above the traffic volumes at the Mt Victoria Tunnel westbound fall off sharply in the post morning peak period. Underlying growth in the order of 0.6 to 1.1% per annum can be largely accommodated by spreading of the morning peak till later in the morning.

Because of uncertainty around future traffic growth rates and day to day traffic variability as represented in Figure 3 it is expected that the range of peak spreading later into the morning from 2016 to 2030 due to underlying general traffic growth will be in the range of 8 to 14 minutes depending on the traffic growth rate between 2016 and 2030.

The runway extension will further lengthen the morning peak till later in the morning but the degree to which this happens depends on the runway extension scenario selected. The "most likely" scenario may add up to 4 minutes of queuing whereas the "high" scenario could add 10 to 15 minutes. This also confirms the skewed risk profile that demand and network queuing produces.

Peak Spreading to periods earlier in the morning

Figure 3 above shows that the period immediately before the morning peak has relatively low traffic volumes. This gives capacity for additional traffic to be absorbed by lengthening the peak earlier in the morning. Over the 2016 to 2030 period the 50, 95 and 95 percentile curves advance between 10 and 15 minutes before the onset of flow breakdown and queuing depending on and because of the underlying growth.

CONCLUSION

- *At key bottlenecks such as the Terrace Tunnel southbound and Mt Victoria westbound further general underlying traffic growth acts to spread the peak. This causes two distinct effects. The peak will extend to last later and extend to start earlier. Additional traffic will extend the peak so that flow breakdown and queuing lasts longer.*
- *At these bottlenecks the traffic volume profile is steep before maximum flows and flow breakdown occurs. This provides the ability for additional traffic to flow but the consequence is flow breakdown and queuing occurs earlier. Underlying traffic growth is expected to cause flow breakdown to occur earlier by around 16 to 24 minutes at the Terrace Tunnel Southbound and 10 to 15 minutes at Mt Victoria Tunnel depending on the underlying traffic growth rate.*
- *At the Terrace Tunnel traffic volumes remain high following the morning peak and already queues can exist at this location near 10am in the morning. Underlying growth over the next few years will see the morning and evening peaks extend towards one another and eventually they will converge into a single peak. In this situation the impact of the runway extension becomes indiscernible.*
- *With the Mt Victoria Tunnel, current traffic volumes following the morning peak are significantly lower than the peak volumes providing more capacity for additional traffic to be absorbed.*
- *Because the width of the peak is dynamic and will grow as a consequence of general underlying traffic growth this makes it problematic for construction traffic to use the State highway network particularly at the Terrace Tunnel following the morning peak period and before the afternoon*

peak period. Over the next few years the window for construction traffic will shorten and the quantum of additional traffic generated by construction that will be able to be accepted will reduce.

- *Underlying general traffic will also mean that the morning peak will lengthen to incorporate earlier times, which in the case of the Terrace Tunnel will mean construction related traffic may have to cease haulage operations earlier than currently anticipated.*