APPENDIX A
SUPPORTING BACKGROUND RESEARCH

Performance Relative to Changes in AADT

1. Beca Infrastructure was commissioned to reassess the change in passing lane performance relative to different passing lane lengths and traffic volumes (Beca, December 2010). This analysis used US data (Harwood and St John, 1986) to develop tables of relative performance for savings on travel saving delays & vehicle operating costs, as well as frustration costs.

2. The performance of the US passing lanes was considered to be conservative compared to similar length NZ passing lanes but it was important to preserve the relativity of the factors compared to other passing lane lengths. So, the table of derived factors was retained as it was considered to be an improvement on the previous EEM Table A7.11.

3. NZ research also showed that the passing lanes' ability to reduce platooning started to diminish after a one-way flow threshold was achieved (Cenek & Lester, 2008). This threshold varied depending on the passing lane length and one-way traffic volume.

4. Within Cenek and Lester, sites 2e and 6e were identified where this reduction in performance occurred and the sites had similar gradient but different passing lane length. A mathematical relationship between change in upstream and downstream percentage following versus change in one-way hourly flow was developed and used to recalibrate the relativity table (based on US data) after the threshold volume was reached.

Effect of Gradient

4. AUSTROADS research has helped to estimate the effect of gradient on passing lane performance (AUSTROADS, 2010). Table A1 is taken from AUSTROADS 2010, which provides passing lane lengths relative to operating speed. Table A1 has been modified by adding in the estimated operating speeds and estimated median free speeds for the fast and slow lanes of a road section with a passing lane. These estimated speeds were checked against NZ surveyed median free speed results. The NZ results also show a general pattern of a higher median free speed within the fast lane and the slow lane having a similar speed compared to the upstream median free speed.

Table A1. Overtaking Lane Lengths (adapted from AUSTROADS, 2010 Table 9.2)

Operating Speed Without PL (km/hr)	Estimated Operating Speeds within PL (Fast, Slow Lane) km/hr	Estimated Median Free Speeds within PL (Fast, Slow Lane) km/hr	Overtaking Lane Lengths (excluding taper length) (m)	
			Minimum [3]	Desirable [3]
80	90, 80	79, 71	400	650
90 [1]	100, 90	88, 79	475	775
100	110, 100	97, 88	550	950
110 [2]	120, 110	105, 97	620	1070

Note: 1. The 90 km/hr operating speed is similar to Cenek & Lester site 6e with 7% gradient. 2. The 110 km/hr operating speed is similar to Cenek & Lester site 5f with 0% gradient. 3. The overtaking lane length values shown were derived from Table VI Hoban & Morrall, 1986 and are cited in Table 9.2 AUSTROADS, 2010.

5. These passing lane lengths do not relate to traffic flow, upstream demand and/or passing lane spacings. Therefore, they are not useful for determining layouts but the relativity between different speeds can be used to determine the relative change in length for different operating/median free speeds on different gradients.

6. The speeds in the fast lane are a reasonable indication of overtaking speed. However, the vehicles travelling in the slow lane are a mixture of slow vehicles being overtaken and faster free speed vehicles that have been directed into the slow lane due to the road markings. Therefore, the estimated slow lane speeds, which are based on surveyed median free speeds, are higher than the expected speed of slower overtaken vehicles. AUSTROADS 2010 indicates that the overtaken speed is about 17% less than the overtaking speed.

8. First, as a general rule, the Minimum values are slightly lower that the Passing and Overtaking Policy lengths of 600-800 m, with 800 m being a suggested minimum on a flat gradient at lower traffic volumes. The Desirable values are similar to the 1.0-1.2 km passing lane lengths (excluding tapers) on flat/rolling gradients for 4,000-7,000 vpd. Therefore, if comparing passing lanes on two-lane roads carrying up to 4,000 vpd, the average of the minimum and desirable length values would seem appropriate.

9. If you were to multiply the Desirable values by 1.5, the Road Train Desirable values, which are not shown in Modified Table 9.2, would be slightly higher than the 1.3-1.5 km passing lane lengths (excluding tapers), which are used in the Passing and Overtaking Policy for 7,000-12,000 vpd on flat/rolling gradients. Therefore, for higher traffic volumes of 4,000-12,000 vpd, the desirable length values would be better.

10. Second, processing of the Cenek and Lester speed results for sites 5f (0% flat gradient) and 6e (7% steep gradient) showed that based on the average from a number of survey points along the passing lane, site 5f had a median free speed of 106 km/hr in the fast lane with the slower lane recording 99 km/hr. These values compared closely with the estimated table values of 105 and 97 km/hr respectively.

11. For the median free speed values, AUSTROADS shows that the operating (85^{th} percentile) speed was about 1.14 times the median free speed for all speeds above 90 km/hr and reduced by 0.01 for every 10 km/hr reduction. (i.e. 1.13 times for 80 km/hr). Therefore, the estimated operating speed of the fast and the slower lane are 120 and 110 km/hr respectively.

12. Similarly, site 6e had a median free speed of 90 km/hr in the fast lane with the slower lane recording 81 km/hr. These values compare closely with the estimated table values of 88 and 79 km/hr respectively. The estimated operating speeds for the fast and slow lanes are 100 and 90 km/hr respectively.

13. Third, using the 90 and 110 km/hr speeds without passing lanes within the modified Table 9.2, road sections on steep gradients with typically a 90 km/hr operating speed can be converted to the equivalent length for a 110 km/hr operating speed. For example, site 2e was a 600 m passing lane on 7% gradient and is estimated to be the equivalent of about 800 m on flat gradient (i.e. 1070/775 = 1.38, so 600 x 1.38 = 828 say 800 m).
Site 6e is a 1,170 m passing lane on 7% gradient and is estimated to be about 1,600 m on a flat gradient (i.e. 1170 x 1.38 = 1615 m).

14. Fourth, after converting sites 2e and 6e to equivalent passing lane lengths on a flat gradient, the surveyed cut-off thresholds of respectively 250 vph one-way (6,000 vpd) and 700 vph one-way (14,000- 16,000 vpd) were used to estimate the cut-off thresholds for the rest of the passing lane lengths relative to AADT in Tables A7.11(a) & (b) within this memo.

15. An 800 m/1600 m scenario is difficult to produce in a regular stepwise pattern across the tables. Therefore, the average of the two scenarios of i) 600 m, 6,000 vpd/1600 m, 16,000 vpd and ii) 800 m, 6,000 vpd/1800 m, 14,000 vpd was used to calibrate the tables.

16. Fifth, the further processing of the Cenek and Lester speed data was done after Beca Infrastructure, Dec 2010 and helped to clarify the effect of passing lane lengths relative to speed. The Beca Infrastructure, Dec 2010 tables have been adjusted slightly as described above. Therefore, the table values in Beca Infrastructure, Dec 2010 are slightly different to the revised values shown in Tables A7.11(a) & (b) within the attached memo.

References

17. Beca Infrastructure, Dec 2010. Review of EEM Passing Lane Length Factors, Unpublished report prepared for New Zealand Transport Agency.

18. Cenek PD & Lester TJ, 2008. Operational Evaluation of Representative Passing Lanes Against Proposed Guidelines, Unpublished report prepared for New Zealand Transport Agency.

19. Harwood DW & St John AD, 1986. Operational Effectiveness of Passing Lanes on Two-Lane Highways, Phase II Report, Contract No. DTFH61-82-C-00070, Federal Highway Administration.

20. Hoban CJ & Morrall JF, 1986. Overtaking Practice in Canada and Australia, Research Report ARR 144 for Australian Road Research Board.