Human Factors of Overtaking Lane Design: Simulator Data and Research Findings

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Executive Summary

This research is aimed at improving overtaking safety through a better understanding of the human factors of driver behaviour in a range of overtaking situations and road configurations. The research explored the relative merits of several types of overtaking lane and signage treatments in the safety and controlled environment of a driving simulator.

The Kaimai route between the Waikato and Tauranga (SH 29 between Rapurapu Road and Omanawa Road) was recreated in the driving simulator. The simulation was populated with a mixture of cars, light trucks, and heavy trucks to represent a traffic volume of 14,000 passenger car units per day. Three lane marking and sign treatments were applied to the road: the Current NZ design, the "New NZ" standard, and the Australian standard. Thirty-one participants, 17 women and 14 men, ranging in age from 19 to 71 years with driving experience ranging from 3 to 53 years were tested. In the within-subjects experimental design employed, each participant drove six simulations across three experimental sessions.

A multivariate analysis of variance revealed a significant difference in participants' lane positions and a significant interaction between participant gender and the phase of the overtaking lane (arising from the lower speeds and longer following distances maintained by female participants during the pre-merge and merge phases). Comparing the effects of the three treatment types across the various overtaking sites showed that at sites with long approaches and high forward visibility the driving behaviour was approximately equivalent under the three treatments.

At sites where visibility was somewhat restricted due to the topography or road geometry, there were pronounced differences in lane position, speed, and the number of vehicles overtaken. The diverge continuity line used in the New NZ and Australian treatments was successful in moving more drivers to the left. The Australian treatment achieved this effect sooner and at higher vehicle speeds than the New NZ treatment resulting in greater rates of overtaking early in the passing lane. Towards the end of the lane, the Australian treatment had the effect of slowing drivers and reducing overall overtaking rates compared to the Current and New NZ treatments. The hatched runout at the end of the New NZ treatment delayed drivers' move to the right lane in the merge section.

The New NZ treatment resulted in an increase in safe driving at a marginal cost in efficiency. The simulator methodology worked well in exploring these phenomena safely and cost-effectively. Merge area designs are still not optimal and will be addressed in future experimentation using the simulator methodology.

Abstract

The project was aimed at improving overtaking lane design through a better understanding of driver behaviour during overtaking. Overtaking lane designs and road geometries representative of those found on State Highways were re-created in the driving simulator used for this research. Results showed that when the diverge and merge areas are clearly visible, there is little difference between the three different road marking and signage treatments investigated. However, there were significant differences when these areas are not clearly visible. Both the 'new NZ' and the Australian treatments worked well in the diverge area, but not in the merge area. Further research is proposed to investigate the effect of factors such as merge length, merge placement, alternative marking schemes and sign placement.

1 Background

The aim of this research is to improve overtaking safety and efficiency through improvements in road signage, markings, geometry and speed control associated with the placement and layout of passing lanes.

The approach of the present research is to explore the effects of several types of overtaking lane and signage treatments in the safety and controlled environment of a state-of-the-art driving simulator. Use of the driving simulator as a research tool affords an opportunity to explore the relationships between overtaking lane design and driving behaviour in a way that is not practical or cost effective on-road. This research applies the knowledge and technologies gained through the on-going Foundation for Research Science and Technology (FRST) funded research on vehicle, road and driver interaction (FRST contract C08815, Vehicle-Road Interaction) to a problem of considerable road safety concern.

Part of the FRST funded research focuses on both the interactions between the driver, the vehicle, and the underlying road geometry. The FRST funded research includes the use of a purpose-built driving simulator, the collection of field trial data using instrumented vehicles and mathematical modelling. The project has highlighted the importance of driver attention and workload on driver performance and road safety. Workload and driver attention can be affected by interventions such as road signing and marking and road geometry.

The current research focuses on overtaking because road deaths involving overtaking have been rapidly increasing with 31, 42 and 45 deaths for the 12 months to January 1997, 1998 and 1999 respectively. This is a 45% increase over the 3 years and now accounts for 10% of all road deaths[1]. Passing manoeuvres require a series of complex information-processing and decision processes which, according to research undertaken by Khasnabis[2] (1986), makes these manoeuvres one of the most demanding and risky operations performed by a motorist. Drivers surveyed in the US identified problems associated with failure to follow signs and markings properly, and failure to use lanes (Mutabazi et. al.[3] 1998).

Well-designed passing lanes can have a significant effect in reducing the number of overtaking related crashes by providing drivers with the opportunity to pass safely. May (1991)[4] found from field trials that passing lane entrance designs can increase the number of vehicles that enter the basic lane and the number of passes per passing-lane length. May also found through simulation that passing lanes from 400 to 1200 metres long appeared to be the most effective depending on downstream roadway and traffic conditions.

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1 Road Deaths, Land Transport Safety Authority official road fatality statistics.
2 Khasnabis S., Operational and Safety Problems of Trucks in no-passing zones on two-lane Rural Highways. TRB Record 1052, 1986.
3 Mutabazi M.I., Russell E.R. & Stokes R.W. Driver's Attitudes, Understanding, and Acceptance of Passing Lanes in Kansas, TRB record 1628, 1998.
4 May A.D. Traffic Performance and Design of Passing Lanes, TRB Record 1303, 1991.

The following extract from Austroads "Rural Road Design, Guide to the Geometric Design of Rural Roads" is pertinent:

> *"On an existing road, overtaking opportunities can be increased either by improved alignment or the provision of auxiliary lanes. Of the two options, auxiliary lanes will generally prove to be the most cost-effective in reducing the level of traffic bunching. This is because realignment to provide overtaking opportunities is likely to be a much more expensive option, and even then the opportunities are only available when opposing traffic permits. This has been demonstrated by ARRB simulation studies, which showed that the provision of auxiliary lanes at regular spacings often led to greater improvements in overall traffic operations than even major alignment improvements (Hoban 1983).*
>
> *A two lane road with auxiliary lanes at regular intervals provides an intermediate level of service between those of two lanes and four lanes. The auxiliary lanes thus offer an economical means for deferring the need for the provision of dual carriageways. Where a four lane road has already been provided, and traffic volumes are consistently high, the need for auxiliary lanes on grades may still arise when there is a high proportion of heavy vehicles".*

The crash statistics show that there is an urgent need to address the safety problems associated with overtaking, and the provision of well-designed auxiliary lanes for overtaking. At present there are two types of overtaking lanes; passing lanes and slow vehicle lanes. Concern about the use, design and control measures for these has been raised at National Traffic Management Workshops held by the IPENZ Transportation Group. At the 1998 Traffic Management Workshop held at Hamilton, a remit was presented on the ambiguity of signs, citing signage at passing lanes, and Transit New Zealand were called on to investigate and make changes to the signs manual if necessary. This action was endorsed by workshop participants.

In the present research, the medium-fidelity driving simulator at Waikato University (see Appendix A) was used to explore the effectiveness of several alternative designs for overtaking lane treatments across a range of road situations. Human factors measures collected in the laboratory include lane positioning, speed, maintenance of headway distances, rates of vehicle overtaking, and the occurrence of collisions.

A steering group of traffic engineering professionals and was established to help guide the research and to ensure the findings and recommendations are realistic and practical.

2 Technical Approach

The technical approach for this project was divided into a sequence of four tasks, these being:

- Task 1 – Selection of road sites and possible treatments
- Task 2 – Roadside recreation and testing
- Task 3A – Human factors analysis
- Task 3B – Relationship to engineering road design
- Task 4 – Conclusion and recommendations

The first task was the selection of existing road sites containing overtaking lanes representing a range of road geometries, clear-sight distances, and road signage. This task also included identification of alternative lane marking and signage treatments for each site.

The second task was the recreation of these overtaking lanes (including the alternative treatments) in the laboratory using the driving simulator at Waikato University and testing them with a minimum of thirty volunteer participants.

The third task involved the identification of the human factors variables affecting driver behaviour at the road sites. The various features for each design alternative at each road site were evaluated in terms of their effect on drivers' speeds, lane positions, and number of vehicles overtaken. The relationship between the analysis and engineering road design has been included in this task. The fourth and final task was the development of an Advisory Document providing recommendations for the safe design and management of overtaking lanes. The tasks align with the following sections.

3 Selection of Road Sites and Possible Treatments

During this task, existing road sites containing overtaking lanes were selected for the analysis. The selection of candidate sites was based on engineering and crash history data, and the selection of possible treatments based on existing methods used in New Zealand and overseas.

3.1 Site Selection

To identify suitable candidate sites for analysis, an investigation into crash data from the Land Transport Safety Authority (LTSA) crash database was undertaken, and crashes that could be attributed to overtaking were identified. It was decided to limit candidate sites to the North Island for practical reasons of accessibility. The Regional Managers and Highways Engineers (or their Consultants) for the ten Transit Regions in the North Island were contacted. After outlining the aim of the research project, they were asked to put forward overtaking sites that were considered to work well, sites that were considered to have safety problems, sites where satisfactory improvements had been made, and slow vehicle bay sites.

The Land Transport Safety Authority crash database was searched for the locations where four or more injury crashes had been attributed to overtaking manoeuvres, and the location of these crashes were passed on to each Transit region. The regional engineers then identified sixteen candidate sites, and details of these together with relevant Highway Information Sheets and aerial maps were sent to the research team. The candidate sites' characteristics varied from "no problem" sites with generous merge area and good visibility to sites with sharp horizontal curves or steep gradient/sharp curves combination or short passing lanes in mountainous areas with few passing lane opportunities.

Common comments from the regional engineers or their representatives regarding possible causes for problems at the overtaking sites put forward included: horizontal and vertical curve combination, sudden slowing of travel speed, multiple conflict areas, location of merge area on curve, and restricted visibility.

These sixteen candidate overtaking sites were presented to the Steering Committee for their consideration. In order to allow a structured analysis of overtaking lane configuration, the Steering Committee decided to focus on several key features of road geometry with particular attention to the physical characteristics at the merge areas, including: passing lanes on straights, left turns, right turns, and vertical turns. After discussing the geometry, crash history, and particulars of each of the sixteen candidate sites the committee noted that the Kaimai route between the Waikato and Tauranga (SH 29) contained examples of all of the above conditions. Rather than selecting multiple sites for each condition, the committee decided that a recreation of appropriate sections of SH 29 would contain all the necessary overtaking lane configurations.

Although we originally proposed to look at four overtaking sites for total of 12 passing lane configurations (four existing and eight alternative treatments), the final site selection recommendation from the Steering Committee contained six overtaking sites and three treatment conditions. All of the sites except for one representing a slow vehicle bay would be presented under all three treatments conditions for a total of 16 passing lane configurations. The six sites selected from SH29 were comprised of: one overtaking lane terminating on a straight, one overtaking lane on a right turn, one overtaking lane on a left turn, one overtaking lane with a vertical curve terminating post-crest, one overtaking lane on a blind corner, and a slow vehicle bay.

3.2 Treatments

To establish the type of treatments to be tested for each overtaking lane site, existing methods used overseas were investigated. Transport Canada, Federal Highway Administration, Highways Agency UK, VicRoads and Road and Transport Authority (RTA) Australia were contacted, and details of diverge and merge overtaking lane treatments were obtained. Since the commencement of this project, Transit New Zealand have reviewed the signage and marking for overtaking lanes, and at July 2000 produced a revision to the manual. This revised standard is referred to as the "New NZ" treatment in this report.

Looking at the treatments currently used in New Zealand and overseas, there were two types of diverge treatments: a widening to two lanes with a central lane line; and painting of a dashed continuity line directing traffic to the kerbside left lane. Three main types of merge treatments were currently used, and they included: ending of the lane line before the merge taper; continuing the lane line across the merge taper giving priority to the "overtaking" right lane; and continuing the lane line across the taper giving priority to the kerbside "slow" left lane. Variations to these main types included hatched areas at, or after, the merge taper.

The different types of overtaking lane treatments were put to the Steering Committee for consideration, and three treatments for the simulator recreations were selected as follows:

Treatment 1. Current NZ. Overtaking lane diverge and merge markings & signage existing along SH29 prior to July 2000 (white on black warning and entry signage and lane lines starting after the diverge taper and finishing at the start of the merge taper).

Treatment 2. New NZ. Overtaking lane diverge and merge markings and signage to be implemented along SH29 after July 2000 (corresponding to the new Transit Guidelines for Signs and Markings for Passing Lanes, dated March 2000, including new black on white warning and entry signage, continuity lines at start of overtaking lane directing traffic to left, and lane line stopping at the start of the merge taper with hatched run out painted on the road shoulder at the end of the merge area, tapering back to the standard shoulder width at 1 in 50).

Treatment 3. Australian. Australian overtaking lane markings and signage (including diverge continuity line moving traffic to left, merge continuity line giving priority to the right overtaking lane, and black on white signage and signage placement. Sign content to be modified to NZ symbolic standard).

It was decided not to trial the UK treatment which gave priority to the kerbside "slow" left lane at the merge taper, as it was considered that forcing the "overtaking" vehicle to give way was a potentially dangerous treatment that would not be acceptable in the current New Zealand driving climate.

The treatment configurations are shown schematically in Figure 1. As regards other aspects of the simulation conditions, the Steering Committee also recommended that the driving simulation scenarios should show each of the overtaking sites in both directions. Further, an option for examining the effect of different traffic volumes typical of 6,000, 10,000, and 14,000 passenger car units per day was discussed. Finally it was recommended that the vehicle dynamics of the simulated vehicle should represent a passenger car with a 2 to 2.5 litre engine and an automatic transmission.

The recommendations from the Steering Committee were then sent to the peer reviewers for comment. Peer reviewer comments were generally supportive with reviewers raising for discussion many interesting questions including: the traffic densities to be represented (matching volume levels to the four classes in the National Highway Strategy document); whether to include other special-case sites of interest (e.g., sites with right turn bays at the start of passing lanes), including sites with straighter lanes, tighter curves, and steeper hills; examining the effect of various lane widths (particularly as regards the ability to overtake trucks); the effect of different types of roadside environment; examination of alternative merge taper lengths; representation of "actual" top end of speed range, including degraded visibility conditions such as fog and night time driving; and the necessity of including a slow vehicle bay in the scenarios.

4 Road Site Recreation and Testing.

Based on the comments received from the Peer Reviewers, and subsequent discussion of the reviews by the Steering Committee members, a final selection of six overtaking sites along SH29 was made. The selected sites were then inspected, measured, photographed and the entire route videotaped from a moving vehicle. Road geometry data were obtained from the RGDAS database and traffic volume and speed data were obtained from both on-site observations and Transit New Zealand. The resulting information was used to create two simulations of SH29, one eastbound and one westbound, between Rapurapu Road and Omanawa Road (past the Power Station). Each simulation contained three overtaking sites in the direction of travel with the other three shown in the opposing lanes. The six overtaking lanes selected for the analysis were as follows:

Site East 1. Post-crest. A 4 kilometre overtaking lane with a 120 metre diverge taper, incorporating several turns, terminating on a gentle left turn just past the crest of a hill with an 88 metre merge taper.

Site East 2. Left. A 1 kilometre overtaking lane with a 60 metre diverge taper terminating on a left turn with a 60 metre merge taper.

Site West 3. Straight. A 3 kilometre overtaking lane with a 60 metre diverge taper, incorporating several turns, terminating on a straight with an 88 metre merge taper.

Site West 4. Right. A 1.5 kilometre overtaking lane with an 80 metre diverge taper terminating on a right turn with a 60 metre merge taper.

Site West 5. Blind. A 1.5 kilometre overtaking lane with an 80 metre diverge taper terminating on a blind left turn with a 120 metre merge taper.

Site SVB. Slow vehicle bay. A 200 metre slow vehicle bay with a 32 metre diverge taper and a 64 metre merge taper.

The road geometry depicted in the simulations was an accurate representation of SH29 with the exception that some overtaking lanes and stretches of road that were not of interest were removed to enable participants to drive the complete east/west circuit within an hour. The three lane marking and sign treatments described earlier were then applied to the road resulting in a total of six simulated tracks: eastbound and westbound current, eastbound and westbound new, and eastbound and westbound Australian.

Members of the Steering Committee and one of the peer reviewers then individually drove the simulated roads to ensure that the treatments were accurate and in accordance with good road engineering practice. Other traffic was then placed in the simulations to represent a traffic volume of 14,000 passenger car units per day. The traffic was a representative mixture of cars, light trucks, and heavy trucks. Figures 2 to 4 show "bird's eye views" of the diverge and merge portions of each of the three lane treatment types. Figure 5 shows the diverge and merge portions of the slow vehicle bay. Figures 6 through 9 show the signage used in each of the overtaking lane treatments.

At this point, the testing protocols were developed and an ethical approval application was lodged with the University of Waikato's Psychology Research and Ethics Review Committee. Approval to proceed was granted by the Committee and participant testing began on 26 September 2000 with four volunteer participants used to fine-tune the vehicle dynamics, data capture points, and experimental procedures. The simulations and data collection procedures were then finalised and the full experimental trials began on 6 October.

In the within-subjects experimental design employed, each participant drove six simulations across three experimental sessions. During the first session each participant was given a practice track to drive until they felt comfortable operating the simulator. Participants then drove the eastbound and westbound routes for one of the three treatments (Current, New, or Australian). The order of presentation of treatment condition and east/westbound legs was counterbalanced across all participants. During the second session, the participant drove the east/west pair for another treatment condition, and the final east/west pair during the third experimental session. Subsequent sessions for each participant were scheduled between one and three days apart. Each participant received $20 in gift in recognition of their participation in the experiment.

A total of 35 participants were tested (exclusive of the four used to pilot the experimental procedure); 19 women and 16 men ranging in age from 19 to 80 years. Four participants withdrew from the experiment either because of discomfort during the first experimental session (difficulties seeing the computer screen or motion sickness) or they declined to continue past the first session due to the time commitment required. The remaining 31 participants, 17 women and 14 men, ranged in age from 19 to 71 years (average age 38.19) and ranged in driving experience from 3 to 53 years (average 20.58 years). The distribution of participants' ages and years of driving experience are shown in the table below. Participants were instructed to "*drive normally, just as you would in your own car*" and informal notes recorded by the experimenters during the testing indicated that the participants did indeed treat the scenarios very seriously. A total of approximately 70 hours of driving data were collected in the simulator and retained for analysis. Details of the driving simulator are available in Appendix A.

Distribution of participant ages and driving experience (in years).								
Participant age			19-23	24-33	34-43	44-53	54-64	65+
	Men	#	4	2	4	0	3	1
		%	13%	7%	13%	0%	10%	3%
	Women	#	3	3	4	6	1	0
		%	10%	10%	13%	19%	3%	0%
Driving experience			3-5	6-15	16-25	26-35	36-45	45+
	Men	#	3	4	3	0	3	1
		%	10%	13%	10%	0%	10%	3%
	Women	#	1	5	3	6	1	0
		%	3%	16%	10%	19%	3%	0%

5 Human Factors Analysis

Averages for lane position, vehicle speed, steering wheel angle, and following distance were calculated for each treatment condition across the 31 participants. The averages were calculated at eight metre intervals through the diverge and merge sections of each overtaking lane and at 120 metre intervals for the 500 metres leading up to and following each diverge and merge section. A multivariate analysis of variance (MANOVA) calculated on these averages indicated highly significant differences between the six overtaking lanes across all four driving performance measures ($F_{(20, 580)} = 22.70$, $p < .001$), indicating that the six lanes selected by the Steering Committee represented six reliably different overtaking situations.

Analysis of the effects of the three lane treatment conditions revealed a significant difference for participants' lane positions ($F_{(2,58)} = 5.61$, $p < .01$). The analysis also indicated a significant interaction between participant gender and the phase of the overtaking lane (diverge, merge, etc.) ($F_{(20,580)} = 2.03$, $p < .01$) arising from the lower speeds ($F_{(5,145)} = 4.30$, $p < .001$) and longer following distances ($F_{(5,145)} = 2.41$, $p < .05$) maintained by female participants during the pre-merge and merge phases.

Figure 10 shows the average lane positions and speeds for the three treatment conditions at overtaking lane East 1, the long (4 km) overtaking lane terminating on a gentle left turn just past the crest of a hill. Lane position is measured from the centre line of the vehicle to the centre line of the road. A lane position of 0m is when the vehicle is straddling the centre line. It can be seen that the average lane position during the diverge is further left for the Australian lane treatment throughout the diverge taper. Post hoc statistical comparison of the average position across the entire diverge indicated a significant difference between the Current NZ and Australian treatments $t = 2.576$, $df = 30$, $p < .01$. Looking at the merge section of the lane, the Australian treatment was associated with significantly lower speeds at the end of the merge ($t = 2.340$, $df = 30$, $p < .05$) as compared to the New NZ treatment.

Figure 11 shows individual participants' paths through the diverge and merge sections of overtaking lane East 1. Here it can be seen that the diverge continuity lines used in the New NZ and Australian treatment do appear to move more of the participants to the left. This effect appears somewhat earlier for the Australian treatment, and was presumably due to the Australian approach signage as that was the only difference between this portion of the New NZ and Australian treatments.
Figure 12 shows the average positions and speeds for lane East 2, the relatively short overtaking lane terminating on a left turn with a 60 metre merge taper. Once again, the Australian treatment moved more participants to the left sooner ($t = 3.682$, $df = 30$, $p < .001$ comparing New NZ and Australian averages throughout the diverge). Looking at the pre-diverge speeds it can also be seen that for this situation the Australian signage had the effect of increasing participants' speeds in preparation for overtaking ($t = 2.201$, $df = 30$, $p < .05$ comparing New NZ and Australian speeds in the 500 metres prior to the diverge). Looking at the merge section, the Australian treatment appears to move merging vehicles to the right sooner than the New NZ treatment ($t = 2.411$, $df = 30$, $p < .05$).

Figure 13 shows the participants' vehicle paths and we can see these differences in lane position in greater detail; a greater proportion of vehicles moving left sooner in the New NZ and Australian treatments and somewhat later merge to the right in the New NZ treatment (which employed the hatched runout at the end of the merge section).

At this point one can reasonably ask how these differences in speed and lane position effect the participants' rate of overtaking, particularly for relatively short overtaking lanes such as the one represented in the East 2 scenario. In the East 2 scenario, five vehicles were located at various positions ahead of the participant's vehicle (the precise distance ahead depended on the participants' speeds prior to reaching the diverge). Interestingly, the Current NZ treatment produced the highest rates of overtaking, averaging 2.97 vehicles (mode and median also equal to 3). In comparison, participants overtook an average of only 2.68 vehicles while driving the New NZ treatment and 2.42 vehicles on the Australian treatment.

Figure 14 shows another effect of the merge treatments, the participants' positions relative to a vehicle merging ahead of them. The "target" vehicle depicted in the figure is the last of the five vehicles ahead of the participant and represents the moment at which it completes its merge from the left to the right lane. The figure illustrates the higher incidence of overtaking associated with the Current NZ and New NZ treatments (which were identical except for the hatched runout in the New NZ treatment) and some very short headway distances to the target vehicle by the end of the merge area particularly for the Australian treatment.

Figures 15 and 16 show the average positions and speeds for lanes West 3, a straight overtaking lane with an 88 metre merge taper, and West 4 which terminated on a gentle right turn with a 60 metre merge taper. Once again, the Australian treatment moved somewhat more participants to the left sooner and produced the highest speeds in the diverge section. The New NZ treatment also moved drivers to the left at the West 3 and West 4 sites, although there was no particular advantage over the Current NZ treatment at the West 4 site where many of the drivers moved left anyway[5]. Looking at the merge sections, all three treatments are approximately equivalent in moving drivers back to the right lane, although the Australian treatment was once again associated with the lowest merge speeds (particularly for the right turning West 4; $t = 3.633$, $df = 30$, $p < .001$ and $t = 5.711$, $df = 30$, $p < .001$ comparing Current NZ with Australian and New NZ with Australian respectively).

Figure 17 shows the average positions and speeds for lane West 5, the overtaking situation terminating on a blind left turn with a 120 metre merge taper. As with the other sites, the Australian treatment moved drivers left slightly earlier during the diverge. In the merge we see lane positions similar to those observed for the East 2 site, more drivers moving right sooner in the Australian treatment (the merge continuity line giving priority to the right lane) and a greater number of drivers staying left longer in the New NZ treatment (with the hatched runout for the left lane)($t = 4.363$, $df = 30$, $p < .001$ and $t = 3.845$, $df = 30$, $p < .001$ comparing New NZ with Australian and Current NZ with New NZ respectively).

[5] Due to a programming error the "keep left unless passing" sign at Site West 3 was positioned 12 metres after the start of the diverge taper for the New NZ treatment instead of 15 metres prior to the diverge taper. The results at this site, however, are consistent with the other sites in that the Australian treatment moved drivers to the left earlier than both the New NZ and the Current NZ treatments.

As before, drivers in the Australian treatment were driving at somewhat slower speeds in the pre-merge and merge sections. Figure 18 illustrates these lane position effects further with the individual vehicle paths for the diverge and merge sections of West 5. As with the East 2 scenario, there were five vehicles dispersed ahead of the participants as they approached the overtaking site. In this scenario, however, the vehicle immediately ahead of the participants' vehicle passed the next vehicle ahead before moving left and allowing the participants to pass (vehicle 1 passed vehicle 2 at 85 km/h approximately 100 metres after the diverge section then began moving left at 276 metres post diverge, completing the manoeuvre at 372 metres). As before the Current NZ treatment was associated with the highest rates of overtaking (3.61 vehicles), followed by the New NZ and Australian treatments (3.36 and 3.07 vehicles overtaken respectively).

Figure 19 shows, however, that these rates of overtaking were not uniform across the length of the overtaking lane. Plotted in the figure are the average and 75th percentile values for the number of vehicles passed in the first, second, and third portions of the overtaking lane. The faster speeds noted for the Australian treatment at the pre-diverge and diverge sections were accompanied by the highest rates of overtaking during the first 440 metres of the overtaking lane. The Australian treatment's slower speeds prior to and during the merge were associated with the lowest rates of overtaking. Many of the drivers overtook both the first and second cars in the first 440 metres of the overtaking lane whereas drivers in the Current NZ and New NZ treatment did not pass the second vehicle until somewhat later. Eighty-four percent of the participants in the Current NZ treatment were able to overtake four of the five leading vehicles by the end of the passing lane, with 2 drivers passing all five vehicles.

In the New NZ treatment 71% of the drivers passed four of the leading vehicles with four participants overtaking all five. Finally, in the Australian treatment 58% of the participants passed four vehicles with six drivers passing all five. The Australian treatment apparently provided an early advantage which a few of the drivers capitalised upon to overtake all of the vehicles. The majority of drivers, however, significantly reduced their speeds near the end of the overtaking lane, passed fewer vehicles in this section, and fewer vehicles overall.

Finally, Figure 20 shows the lane positions and speeds for the slow vehicle bay. Here there were no differential treatments at the site (the Current NZ, New NZ, and Australian labels merely reflect the treatments in effect at the other sites in that scenario), and indeed there are no appreciable (or statistically significant) differences in the averages plotted in the figure. It can be seen that most drivers stayed right and increased their speeds until the merge section when they again reduced their speeds and moved slightly to the left as if completing a passing manoeuvre, as the truck(s) merged right from the slow vehicle bay.

6 Relationship with Engineering Road Design

To ascertain what recommendations could be developed for the Advisory Document, we examined the results in more detail to see what relationship there was to safety and efficiency of the overtaking lanes tested.

Site characteristics, taper lengths, speed differential, signage and sign position, and road markings at the merge and diverge areas were examined. Land Transport Safety Authority crash records have also been examined at the actual overtaking lane sites on State Highway 29 to see if existing safety problems exist at the merge/diverge areas of each site.

6.1 Site characteristics – lane position and speed

The following is a list of characteristics and details of results for each site. A route map showing the site locations on the recreated route, and plans and gradients at the recreated diverge and merge areas for each site are shown in Appendix C. Some elements of driver behaviour, as established with the human factors analysis, have been repeated in this section to provide a comprehensive picture of the site characteristics. The speeds shown are generally the range of average speeds across the different sections of the diverge / merge areas.

Site East 1 - Post-crest (4km)

General Description. At the diverge area, the road is straight with a slight uphill gradient, then curves to the right with the gradient steepening at the post merge area, that is, after the taper. The overtaking lane is long with a number of uphill horizontal curves. The road at the merge area curves gently to the left continuing on an uphill gradient, with the merge taper located just after a crest curve.

Diverge
Taper length 60m
Pre diverge speed – Current NZ 77-83, New NZ 80-83, Aust 81-83
Diverge speed – Current NZ 83-94, New NZ 83-90, Aust 83-90
Post diverge – Current NZ 94-105, New NZ 90-105, Aust 90-106
Pre diverge lane position – same for all treatments
Diverge lane position – Aust moved left soonest, then New NZ
Post merge position – Mid post merge same all treatments

Merge
Taper length 88m
Pre merge speed – Current NZ 70-81, New NZ 70-81, Aust 71-81
Merge speed – Current NZ 81-86, New NZ 81-83, Aust 81-80
Post merge speed – Current NZ 86-96, New NZ 83-94, Aust 80-94
Pre merge lane position – All treatments similar on average.
Merge lane position – Aust moved right sooner, New NZ later
Post merge position – All treatments similar on average.

Site East 2 – Left (1km)

General Description Site 2 is located on a winding section of road, and at the diverge area the gradient is fairly level, with an uphill gradient following the diverge taper. The merge area, including the merge taper, is located on a left hand curve at the top of the hill.

Diverge

Taper length 60m

Pre diverge speed –	Current NZ 79-78, New NZ 79-80, Aust 85-84
Diverge speed –	Current NZ 78-81, New NZ 80-83, Aust 84-84
Pre diverge lane position –	Aust moved left sooner, New & Current NZ Same.
Diverge lane position –	Aust moved left sooner, then New NZ, Current NZ later

Merge

Taper length 60m

Average Pre merge speed –	Current NZ 89, New NZ 89, Aust 87
Merge speed –	Current NZ 77-73, New NZ 76-74, Aust 70-70
Post merge speed –	Current NZ 73-89, New NZ 74-88, Aust 70-87
Pre merge lane position –	Aust moved right sooner
Merge lane position –	Aust moved right sooner, New & Current NZ similar, although New NZ moved right marginally later (hatched area)
Post merge lane position –	Similar all treatments

Following distances

Very short headway distances occurred by the end of the merge area, particularly for the Australian treatment. The highest incidence of overtaking was associated with the Current NZ and New NZ treatments.

Site West 3 - Straight (3km)

General Description Site 3 is a fairly long overtaking lane, with the diverge area located on a flat, left hand curve, with an uphill gradient after the diverge taper. The overtaking lane terminates on a straight, fairly level section of road.

Diverge

Diverge taper length 60m

Pre diverge speed –	Current NZ 84-83, New NZ 86-82, Aust 80-85
Diverge speed –	Current NZ 85-92, New NZ 84-88, Aust 87-92
Post diverge speed –	Current NZ 92-104, New NZ 88-101, Aust 92-98
Pre diverge lane position –	All treatments similar
Diverge lane position –	Aust moved left sooner, New NZ later
Post diverge lane position –	Current NZ further right, Aust & New NZ to the left

continued

Site West 3 - Straight (3km) ***continued***

Merge

Merge taper length 88m	
Pre merge speed –	Current NZ 106-97, New NZ 106-96, Aust 104-95
Merge speed –	Current NZ 97-98, New NZ 96-96, Aust 95-95
Post merge speed –	Current NZ 98-100, New NZ 96-102, Aust 95-100
Pre merge lane position –	Aust moved right sooner, then New NZ, Current NZ later
Merge lane position –	Similar all treatments
Post merge lane position –	Similar all treatments

Site West 4 - Right (1.5km)

General Description Site 4 is a shorter overtaking lane on an uphill, winding section of road. The diverge taper is located on a left hand curve which changes to an uphill gradient at the diverge area. The merge area is on a winding, uphill section of road, with the merge taper located on a right hand curve.

Diverge

Diverge taper length 80m	
Pre diverge speed –	Current NZ 83-85, New NZ 83-82, Aust 85-87
Diverge speed —	Current NZ 85-90, New NZ 82-88, Aust 87-91
Post diverge speed –	Current NZ 90-105, New NZ 88-105, Aust 91-106
Pre diverge lane position –	All treatments similar
Diverge lane position –	All treatments similar, although Aust 0.4m further left
Post diverge lane position –	All treatments similar

Merge

Merge taper length 60m	
Pre merge speed –	Current NZ 108-100, New NZ 110-102, Aust 100-93
Merge speed –	Current NZ 100-100, New NZ 102-101 Aust 93-94
Post merge speed –	Current NZ 100-102, New NZ 101-102, Aust 94-98
Pre merge lane position –	Aust moved right much sooner, New &Current NZ same
Merge lane position –	All treatments similar
Post merge lane position –	All treatments similar, Current NZ moved left marginally sooner

Site West 5 - Blind (1.5km)

General Description Site 5 is a shorter overtaking lane, with the diverge area located on an uphill gradient on a left hand curve. The overtaking lane terminates on a "blind" sharp left hand curve, on a fairly level section of road.

Diverge

Diverge taper length 80m

Pre diverge speed –	Current NZ 80-85, New NZ 77-86, Aust 80-85
Diverge speed –	Current NZ 85-87, New NZ 86-89, Aust 85-88
Post diverge speed –	Current NZ 87-94, New NZ 89-92, Aust 88-94
Pre diverge lane position –	Similar all treatments, Aust moved left marginally sooner
Diverge lane position –	Similar all treatments
Post diverge lane position –	All treatments similar

Merge

Merge taper length 120m

Pre merge speed –	Current NZ 103-95, New NZ 103-94, Aust 98-93
Merge speed –	Current NZ 95-89, New NZ 94-90, Aust 91-89
Post merge speed –	Current NZ 89-87, New NZ 90-86, Aust 89-90
Pre merge lane position –	Aust moved right sooner, then NZ, Current NZ later
Merge lane position –	Aust moved right sooner, New NZ later
Post merge lane position –	All treatments similar

Number of vehicles overtaken

More vehicles overtaken at beginning of merge in Current & New NZ treatments compared with Australian treatment, although more drivers overtook in Australian treatment at the diverge area.

Slow Vehicle Bay (200m)

General Description The slow vehicle bay is located on a down hill gradient on a short section of straight road with horizontal curves before and after the bay.

Diverge

Diverge taper length 32m

Pre diverge speed –	Current NZ 63-66, New NZ 61-66, Aust 63-68
Diverge speed –	Current NZ 67-72, New NZ 70-75, Aust 71-75
Post diverge speed –	Current NZ 72-75, New NZ 75-80, Aust 75-79
	Lane positions similar through all stages for all treatments

Merge

Merge taper length 64m

Merge speed –	Current NZ 74-63, New NZ 66-64, Aust 70-65
Post merge speed –	Current NZ 63-83, New NZ 64-83, Aust 65-81
	Lane positions similar through all stages for all treatments

6.2 Taper lengths

In considering factors that may have affected the lane position and following distances for each treatment at the merge areas, it was decided to check the taper lengths to see if they complied with design guidelines. In most cases the merge tapers were significantly shorter than the guidelines. Actual tapers being between 40%-50% of recommended minimum lengths at some sites. In checking the diverge taper lengths, it was found that they generally were close to the guideline range, being typically around 86% of the recommended length. The tables shown in Appendix D list simulated and actual diverge and merge taper lengths for all sites, together with Transit NZ recommended lengths (March 2000 policy) and Australian standards and guidelines.

6.3 Speed differential

To see what effect the short taper lengths had on the merge manoeuvres, and mindful of the close following distances and lane position at the merge area at the more "challenging" sites, a consistency check of speeds over the merge area was undertaken. This consistency check of average speed and average 85%tile speed throughout the merge manoeuvre (including pre-merge, merge, and post-merge) showed that there were significant speed variations for the sites with restricted visibility and "challenging" topography at the merge areas.

The following excerpts from AustRoads[6] "Rural Road Design, Guide to the Geometric Design of Rural Roads" illustrate the importance on safety of good road design, and consistency in design speed that drivers should be able to expect:

> *"On roads designed for speeds of 100 km/hr or more, drivers will adopt a relatively uniform speed of travel which will generally be less than the speed assumed for the design of individual elements. A driver will expect to be able to maintain a high travel speed, and the design must be able to accommodate this along the entire length of the section. Increases in design standards are not likely to produce commensurate increases in travel speed, but will provide a higher level of safety and convenience to all road users."*
>
> *"The variance in travel speed must be considered in the design of individual elements. Provided the standards are in keeping with driver expectancies, a safe and adequate alignment will result."*
>
> *"Normally, design speeds should not differ by more than about 10km/h on successive geometric elements."*

Thus, in general, where speed environments of 100 kph and over are appropriate, high uniform travel speeds are expected, and as a rule design speeds should not differ by more than 10 kph on successive geometric elements. The significant difference in average 85%tile speeds over the different phases of merging indicate the greater potential for safety problems. While it is recognised that the volume of traffic on overtaking lanes influences average speeds, for the sites tested the traffic volumes used in the simulation was consistent for each scenario. Speed differentials were within the acceptable range for design consistency for all treatments at sites where

[6] Rural Road Design, Guide to the Geometric Design of Rural Roads. AustRoads, Sydney 1993

there was good forward visibility, while the more "challenging" sites showed speed differentials greater than that recommended for safe road design, as detailed above.

Tables listing the average speed and average 85%tile speed over the pre-merge, merge, and post-merge areas for the different treatments at each site are shown in Appendix E. The average speed table shows that the speed differential at "benign" merge situations, (Site West 3 – Straight and Site West 4 – Right) to be less than 10 kph change in average speeds, however for the more "challenging" merge situations such as Site East 1 – Post crest, Site East 2 – Left, Site West 5 – Blind, and the Slow Vehicle Bay, a greater than 10 kph variation in average speeds occurred. A consistency check for the average 85%tile speed (design speed), as shown on the table, shows the speed differential to be somewhat modified, with greater than 10kph speed variation for Site East 1 - post crest, Site West 5 - blind and differences with type of treatment at Site West 4 - right and the Slow Vehicle Bay. Speeds shown in the tables were averaged over the pre-merge, merge, and post merge sections of the merge areas.

6.4 Position of the merge area

It is apparent that the location of the merge area impacts on driver behaviour with regards to lane position, speed differential, and headway distances. Safety may be affected by these issues. Consideration needs to be given to ending an overtaking lane where forward visibility is not compromised either by a left, right, or crest curve.

6.5 Signage and sign position

Diverge area

At the diverge area, drivers consistently moved to the left faster with the Australian treatment, although road markings were the same for both the Australian and New NZ treatments. Both had a continuity line directing vehicles to the left side of the road. The differences between the two designs that may contribute to the differing test results include:

> ***Message wording*** – Australian design uses the word "overtaking lane" whereas the New NZ design uses "passing lane" in the signs.
>
> ***Location of signs*** – The Australian design locates advance warning signs "overtaking lane .... ahead" at 2km and 300m, plus a "keep left unless overtaking" sign at the end of the diverge taper, whereas the New NZ design has advance warning signs "passing lane ....ahead" at 2km and 200m plus a "keep left unless passing" sign 15m prior to the start of the diverge taper.

Merge area

The intention of the advisory merge sign 200m prior to the merge taper (Current & New NZ) and at 500m and 250m prior to the taper (Aust) is to warn drivers of an impending merge, allowing them to alter their speeds and prepare for a merging situation. From the lane position results, it appears that the pre-merge area is used for overtaking right up to the start of the taper. Thus the merge operation is taking place in the merge taper area only and therefore the length of the merge is restricted to that taper length.

6.6 Lane markings

Diverge area
The Australian and New NZ diverge markings with the continuity line directing traffic to the left, were much more efficient in moving traffic over sooner as compared to the Current NZ design. The earlier move to the left enabled following vehicles waiting to overtake to do so more quickly, and this was highlighted with the Australian design where vehicles moved left the soonest, the greater number of vehicles passed, and higher speeds were maintained.

Merge area
The Current NZ and New NZ design where the lane line discontinues and no priority is given appears to be more efficient and safer than the Australian design that gave priority to the overtaking lane. Headway distances were much reduced with the Australian design, and speeds were lower throughout the manoeuvre. This may have been caused by driver unfamiliarity with the lane continuity line, greater advance warning of the merge area, or the fact that the drivers were merging earlier. The close following distances with all treatments is cause for concern with regards to safety, although these may have been affected by the short merge taper lengths.

6.7 Crashes on existing sites

Investigation of Land Transport Safety Authority records in the vicinity of the sites show that the majority of crashes that occurred at the diverge / merge areas were "loss of control" or "loss of control – head on" types, with merge and overtaking type crashes also evident. Many crashes at the diverge / merge areas involved vehicles travelling in the opposite direction to the direction of the overtaking lane.

Appendix F shows a grouping of recorded crashes along the SH 29 route encompassing Sites 1-6, together with the listings for those crashes. A collision diagram of Site West 4 –right, in the vicinity of the merge area is also shown in Appendix F. From the collision diagram for Site West 4 – right, it can be seen that two westbound crashes occurred in merge taper area west of Valley View Road including an overtaking manoeuvre crash and loss of control type crash; and four crashes, including loss of control, loss of control-head on (2), and overtaking merge manoeuvre occurred in the pre merge area. Thus, while some crashes have been directly attributed to overtaking, it can be seen that other types of crashes also occur, and they too may well be the result of overtaking manoeuvres.

6.8 Steering committee review

The Steering Committee met to review the results of the human factors analysis, and to recommend the next steps. The Committee were of the opinion that the research results were consistent with what happens on the road from their experience, giving a high degree of confidence in use of the simulator to test road driving scenarios.
In looking at the results of the human factor analysis and the relationship to engineering road design, the Steering Committee felt that the research highlighted the need for good design at the merge area, and that the location of the merge area was an issue. In response to the more challenging sites, the Committee were of the opinion that good visibility is essential for safety reasons, and suggested that a

minimum of 200 metres clear visibility for the full length of the overtaking lane merge taper area should be available.

In general, it was felt that the New NZ treatment, that is the post-July 2000 New Zealand treatment, offered the better results of the three options tested with regards to safety and efficiency, however the short merge tapers, late merge manoeuvres, and the confusion with regards to lane priority were of concern. The committee felt that if drivers were to "merge like a zip" at the merge area, then there should not be any priority, however in the current New Zealand design, the driver in the "slower" kerb side lane often assumed priority to be with the overtaking vehicle.

The Steering Committee members were in agreement that more work was warranted on the human factors of design at the merge area of the overtaking lane, and that the next step should focus on location of the merge area, taper lengths and treatments at the pre merge, merge, and post merge areas. It was strongly recommended that funding be sought to further the research that is required.

The group felt that the lane markings for the post-July 2000 New Zealand and the Australian treatment at the diverge area were successful in moving vehicles to the left, however it was considered that further research into the sign message and sign position at the overtaking lane diverge area was warranted to establish the reasons for different driver behaviour for the Australian and New NZ treatments. This could be investigated as a separate issue, independent of this project.

7 Conclusion and Recommendations

7.1 Conclusion

The driving simulator has provided results that, in the opinion of the Steering Committee, are consistent with what happens on the road.

In comparing the effects of the three treatment types across the various overtaking sites we see that at sites with long approaches and high forward visibility the driving behaviour was approximately equivalent under the three treatments (e.g., sites West 3 and West 4). At sites with shorter approaches, or where visibility was somewhat more restricted due to the topography or road- geometry, there were pronounced differences in lane position, speed, and the number of vehicles overtaken.

The diverge continuity line used in the New NZ and Australian treatments did move more drivers to the left. The Australian treatment, however, achieved this effect sooner and at higher vehicle speeds that the New NZ treatment. This advantage is presumably attributable to the different approach signage as that was the only difference between these two treatments. Irrespective of the greater movement of drivers to the left lane, the higher speeds associated with the Australian treatment apparently resulted in greater rates of overtaking early in the passing lane. Towards the end of the lane, the presence of the early warning and merge continuity line in the Australian treatment had the effect of slowing drivers, reducing the overall overtaking rates, and actually producing shorter headway distances with concomitant concerns for safety as a result. The hatched runout at the end of the New NZ treatment was used by the participants, as reflected in their delayed move to the right lane in the merge section.

Results from this research indicate that while the diverge areas operate reasonably well, there are safety concerns with overtaking lane merge areas in challenging situations with limited forward visibility and short merge tapers. It was generally found that the merge taper lengths were significantly shorter than lengths recommended in New Zealand and Australian guidelines and standards.

In examining the more “challenging” sites, that is sites with poorer visibility or more taxing road geometry, it was found that the difference in the average speed travelled through the pre-merge / merge / and post-merge stages was greater than 10 km/h, which illustrated an inconsistency of design. The inconsistent speed environment was thought to be largely due to the shorter merge taper lengths, and the restricted visibility. This research has highlighted the potential for safety problems at these areas, and suggests the need to look at alternative locations or treatments for the merge area when the above restrictions impact on overtaking lane design. It has also shown that the placement of lane markings and signs does affect driver behaviour with regards to position in the lane, travel speed, and assumed lane priority in challenging situations.

Some caution needs to be taken in generalising these results to driver behaviour on the open road. The driving scenarios used in the research contained benign driving conditions in terms of weather, daytime visibility, and road surfaces. It maybe the case that under adverse weather, visibility, and road surface conditions that the differences between the treatment types may become even more pronounced (as was the case for the sites with poor forward visibility or challenging road geometry). Further, while our previous research comparing driving behaviour in the simulator to on-road measurements has shown the simulator to be very robust in affording "natural" driving behaviour[7][8], some caution should always be taken in generalising the results of laboratory-based work to driver behaviour on the open road (see also Appendix A).

While we and the steering committee members felt that the data are generally an accurate depiction of driver behaviour at overtaking sites, it would nonetheless be prudent to follow this research with on-site field measurements to verify the range and distribution of driving behaviour obtained with the simulator. Finally, it may be of interest in future work to focus on the overtaking behaviour of specific groups of at-risk drivers such as young males and those over the age of 65. While the present experiment contained drivers of all ages, the sample size was not large enough to afford specific comparisons of this type.

In summary, under the most benign conditions there were no differential effects of the three treatments. With poorer visibility or more taxing road geometry, the drivers relied more heavily on the road markings and signage and the effects of the treatments become more pronounced, and the sensitivity to the more "challenging" situations was borne out by the greater speed differential between merge area sections at these sites.

7.2 Recommendations

It is recommended that:

1. Where possible the full length of the diverge and merge tapers of overtaking lanes be clearly visible over their entire length from at least 200m from their start. There was little difference in driver behaviour for the three treatments at sites with good visibility. On the other hand when visibility was restricted or the geometry was more taxing, there were pronounced differences in lane position, speed, and the number of vehicles overtaken. At the more difficult sites, speed differences of more than 10km/h were recorded. This exceeds the AustRoads recommended design limit.

2. The road marking and signage introduced at the diverge areas after July 2000 be fully implemented. The new treatment has been effective in moving more vehicles over to the left-hand lane.

3. Further research on the design at the merge area of overtaking lanes be undertaken to investigate the effects of merge length, merge placement (within the existing road geometry), alternative marking schemes and sign placement, and the behaviour of oncoming traffic approaching the merge zones. It is considered to be premature to put forward recommendations for merge area

[7] Charlton, S.G., Mueller, T., and Baas, P.H. (1999, January). Field Trial of Drivers' Perception-Decision-Action Times. (Technical Report). Report contracted by Industrial Research Ltd. Hamilton, NZ: Transport Engineering Research NZ Ltd.

[8] Charlton, S.G. (2000, July). Driver Vehicle Interactions: Maintenance of Speed and Following Distances. (Technical Report). Report contracted by Foundation for Research Science and Technology. Hamilton, NZ: Transport Engineering Research NZ Ltd.

treatments, given the number of questions regarding taper lengths and location the research has raised. The steering committee and the research team consider that further investigation would be beneficial.

4. The peer reviewers recommended further research using a larger sample size in order to investigate the effect differences in driving populations, terrain and alignment sites have on overtaking lane design. The larger sample size will enable, for example, the behaviour of younger male drivers to be compared to the behaviour of a representative sample of a cross-section of the driving population as it is possible that younger mail drivers drive faster and closer and take more risks when overtaking. If this is the case, the design of overtaking lanes needs to take this take this into account. The current investigation was limited in the terrains and alignments considered. A larger sample would enable driver behaviour for a range of very different terrains and alignments to be investigated. Significant variations in overtaking behaviour may well exist in light of the finding that the visibility of diverge and merge areas plays an important role. The effect of having curves on overtaking lanes has also not been adequately addressed.

5. Any further research should include the "calibration" of the research findings against actual field conditions. Calibration should include the video recording of one of the overtaking lane merge areas showing lane position, lane changes, conflicts (brake lights and/or erratic movements), and use of the hatched run out area. In addition a speed gun could be used to obtain travel speed at a specific point.

6. The peer reviewers and steering committee also recommended that further research be undertaken into optimal signage and sign placement leading up to and at the diverge area in respect to diverge manoeuvre safety and efficiency for overtaking movements. It was found that the Australian treatment moved vehicles to the left lane earlier and vehicle speeds were higher during the diverge compared to the New NZ treatment even though the differences in signage were relatively minor. A controlled trial where the only one variable was changed at a time, for example by having the signs in the same location but with the New NZ and Australian wording, would provide an insight into the importance of signage and its placement.

Acknowledgements

We are particularly grateful for the time and effort provided by the drivers that participated. They all provided their time freely and willingly in the interest of improving road safety.

We are also extremely grateful for the assistance, guidance and expertise provided so willingly by the members of the Steering Committee, the Peer Reviewers and the organisations they represent. Their knowledge, judgement and openness to try new ideas were critical to the success of the research.

We would also like to thank Transit's regional highways engineers and their staff for their invaluable help in selecting the sites and LTSA staff for obtaining crash data.

Appendix A
Description of the Driving Simulator

The research used the driving simulator located at the University of Waikato as shown in Figure A-1 below. The simulator has been extensively upgraded for the FRST research on Vehicle/Road Interaction. The medium-fidelity driving simulator, as configured for the present study, was comprised of a 21 in CRT displaying coloured road scenes and steering wheel and foot pedal controls. A typical driving scene from the simulator is shown in Figure A-2 below. Measured 3-dimensional road geometry data, such as from RGDAS, was used to specify the roadway. The roadway geometry is represented by means of a series of 2 metre by 2 metre vertices in which can be embedded even smaller undulations and bumps in the road surface. Signs, roadside furniture, and other objects such as buildings and trees are entered as digital images from a digital camera. In this way specific road sections can be recreated on the simulator.

Vehicle dynamics were provided by interactive non-linear multi-body simulations based on AUTOSIM vehicle models. Factors such as non-linear tyre behaviour, steering geometry, and suspension dynamics can be varied for light vehicles through to large articulated vehicles. Other vehicles can be entered in the driving scenario and controlled enabling, for example, an overtaking situation to be created.

Human factors measures that are typically collected include lane positioning, braking, speed maintenance, headway distances, stopping times, and occurrence of collisions.

Figure A-1.
Driving simulator configuration.

Figure A-2.
Typical simulated road scene.

Our experience has shown that the driving simulation methodology affords a reasonably accurate depiction of driver behaviour on the open road. In one recent experiment[9], the driver speeds obtained in the simulator were compared to speeds on the actual highway depicted in simulation (the Gordonton Road on the Northeastern edge of Hamilton) using a Metrocount tube counter from the Hamilton City Council

[9] Charlton, S.G. (2000, July). Driver Vehicle Interactions: Maintenance of Speed and Following Distances. (Technical Report). Report contracted by Foundation for Research Science and Technology. Hamilton, NZ: Transport Engineering Research NZ Ltd.

Roads and Traffic Unit and a hand-held Marksman LTI 20.20 laser speed gun manufactured by Laser Technology Ltd. For the speed gun analysis, data from 150 cars, vans and light trucks were collected. For the tube counter analysis, data were separated into 10 km/hr speed bins and 12 vehicle classes using the AustRoads94 classification scheme. Data from 3,849 Class 1 vehicles (passenger cars) from the classification scheme were used in the analysis. As can be seen in Figure A-3, driver's speeds in the simulator were faster than the actual road. Drivers in the 100 km/hr traffic condition averaged 103.44 km/hr, or 1.22 km/hr faster than the speed gun average (102.22) and 2.96 km/hr faster than the average speed obtained from the tube counter (100.48). Drivers in the "*no traffic*" simulator condition had an average speed of 106.14 km/hr, the lack of any traffic in that condition may have resulted in somewhat elevated average speeds. Of note however is the striking correspondence of the 90th percentile speeds for all four categories, 116.20, 115.79, 115.00 and 110.47 for the two simulator conditions, the tube counter data, and the speed gun data respectively. The lower 90th percentile speeds obtained with the speed-gun measurement may be attributable to drivers sighting the telltale indications of their speed being monitored and thus reducing their speeds to avoid the possibility of receiving a speeding citation.

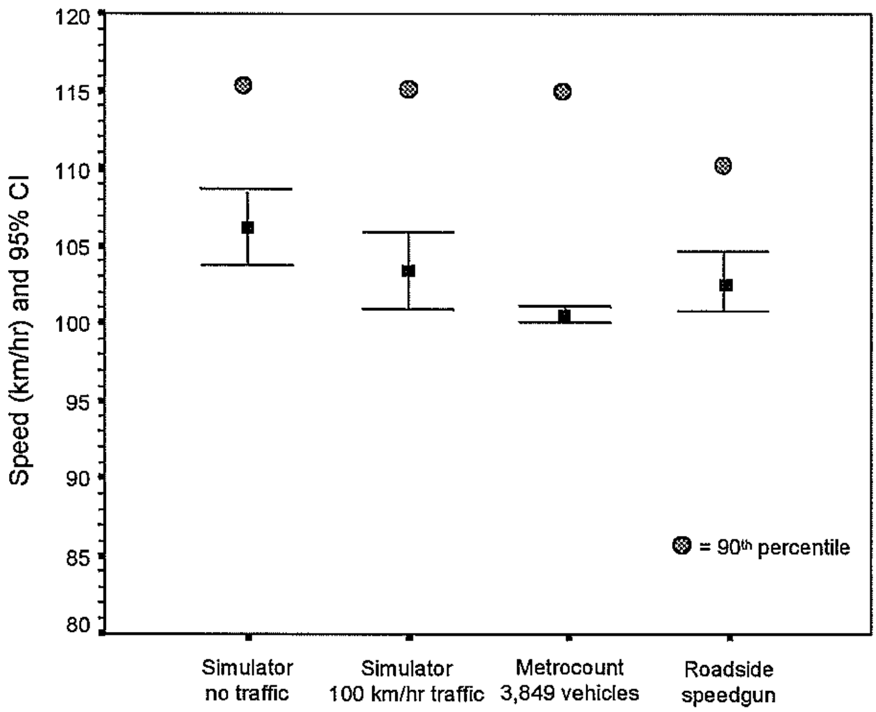


Figure A-3.
Speed in simulator compared to road measurements.

Appendix B
Steering Committee and Peer Review Information

Steering Committee

A steering group of traffic engineering professionals and was established to minimise risks involved with identifying the overtaking lanes to be investigated, the appropriate interventions, the simulation and testing parameters. The steering committee convened to discuss the approach taken for each technical task, review the progress of previous tasks, and physically inspect the simulated driving scenarios. The steering group's involvement will also be used to ensure the guidelines contained in the Advisory Document are in an appropriate and useable form.

The steering committee members included:

Mr Bob Gibson, Senior Traffic Engineer, LTSA Head Office
Mr Ian Cox, Regional Highways Engineer, Transit New Zealand
Mr Murray Noone, PROJENZ, Land Transport Consultant

Peer Reviews

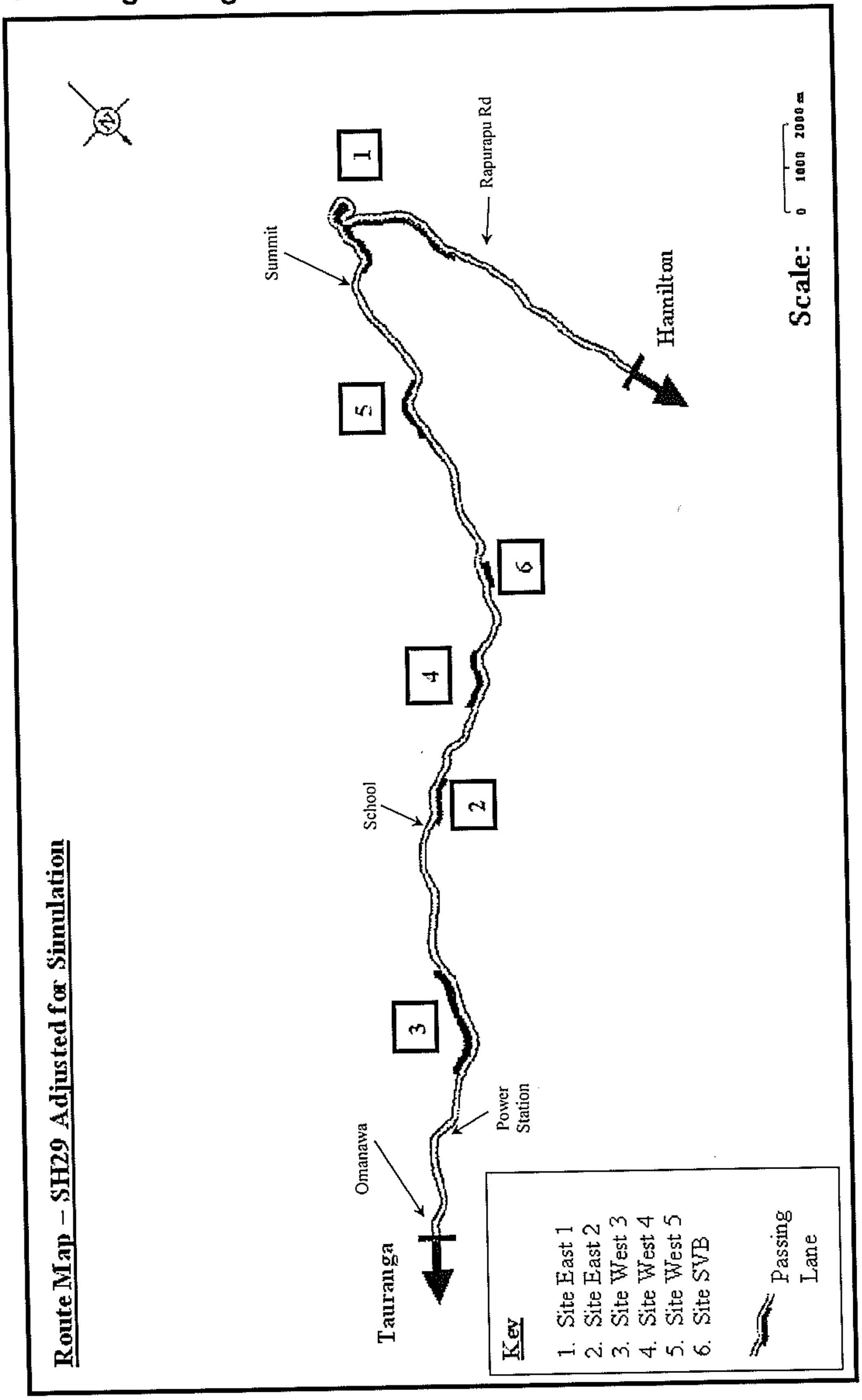
Two peer reviews were proposed:

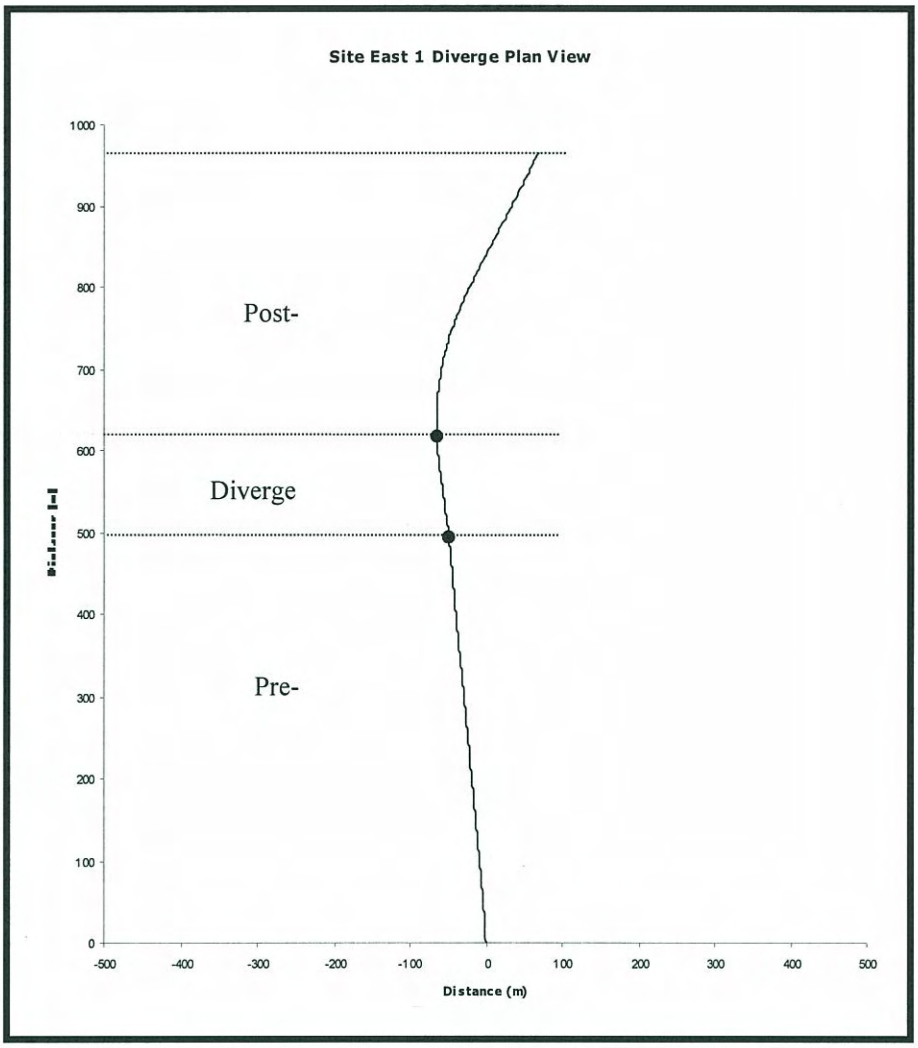
- Upon completion of task 1 to ensure the selection of road sites and alternative treatments are appropriate. This review was completed on 3 May 2000.
- Upon completion of the draft Advisory Document and associated research report.

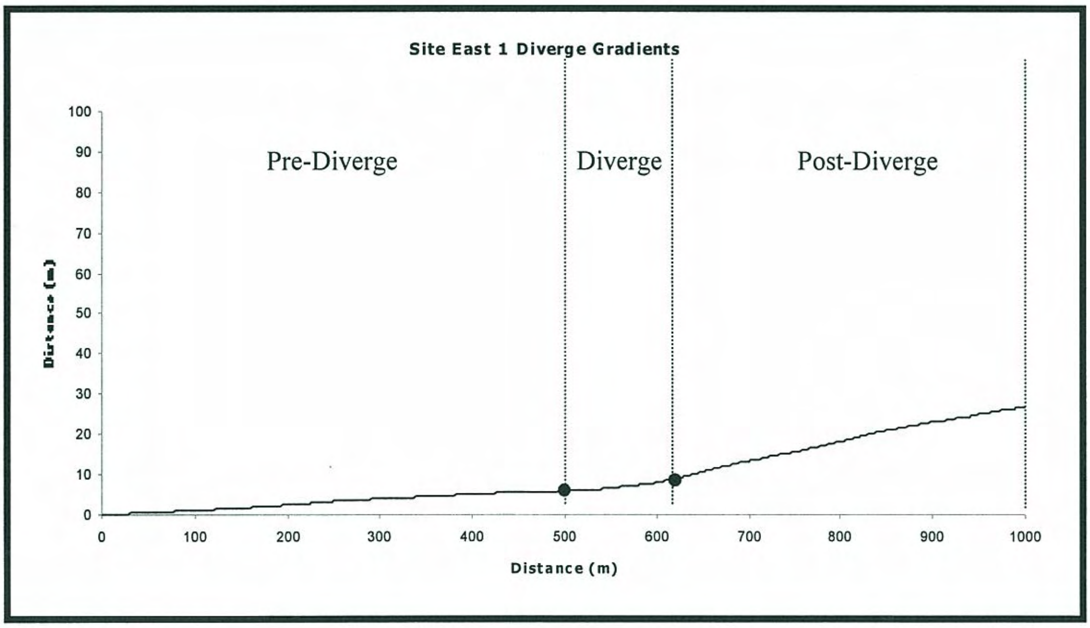
The peer reviewers were:

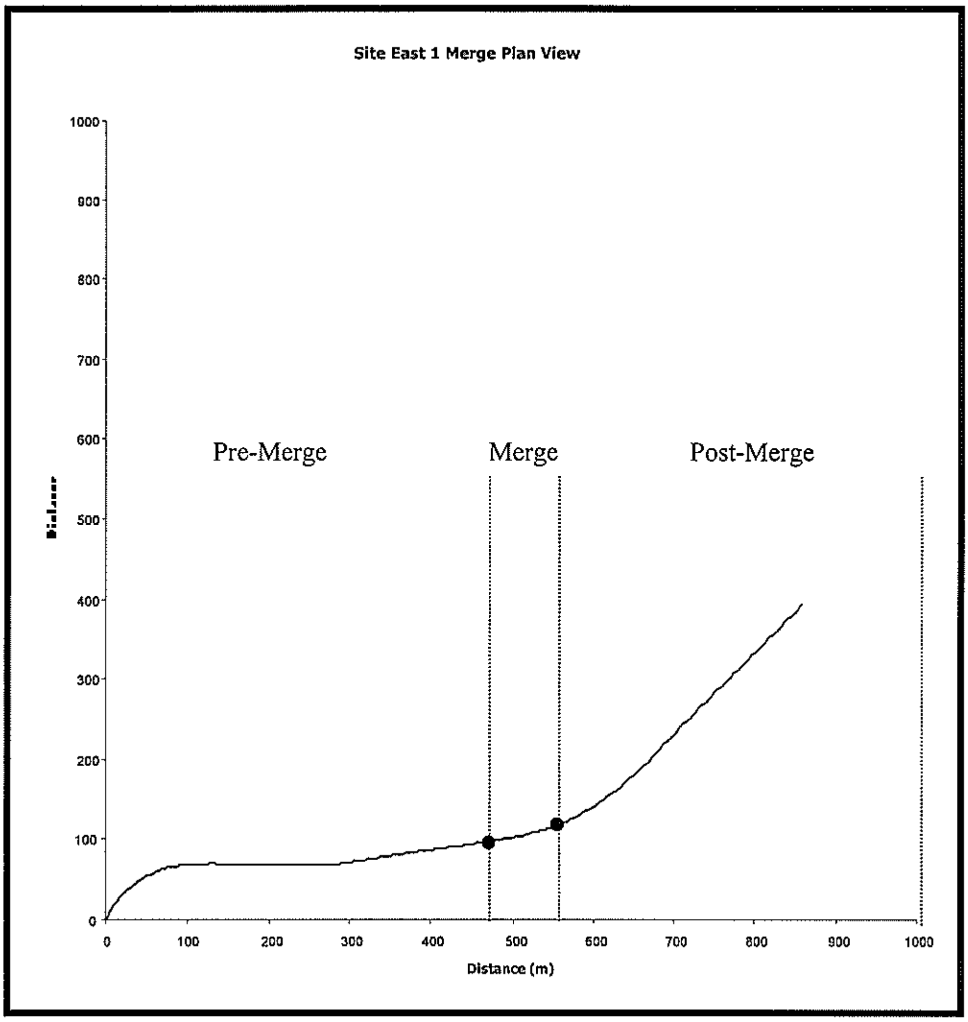
Dr Denis Davis, Traffic and Design Manager, Transit NZ Head Office
Mr J.P. Edgar, Manager Safer Roads, LTSA Head Office
Mr Jos Vroegop, Traffic Planning Consultants Ltd
Dr Barry Parsonson, Road Safety Consultant

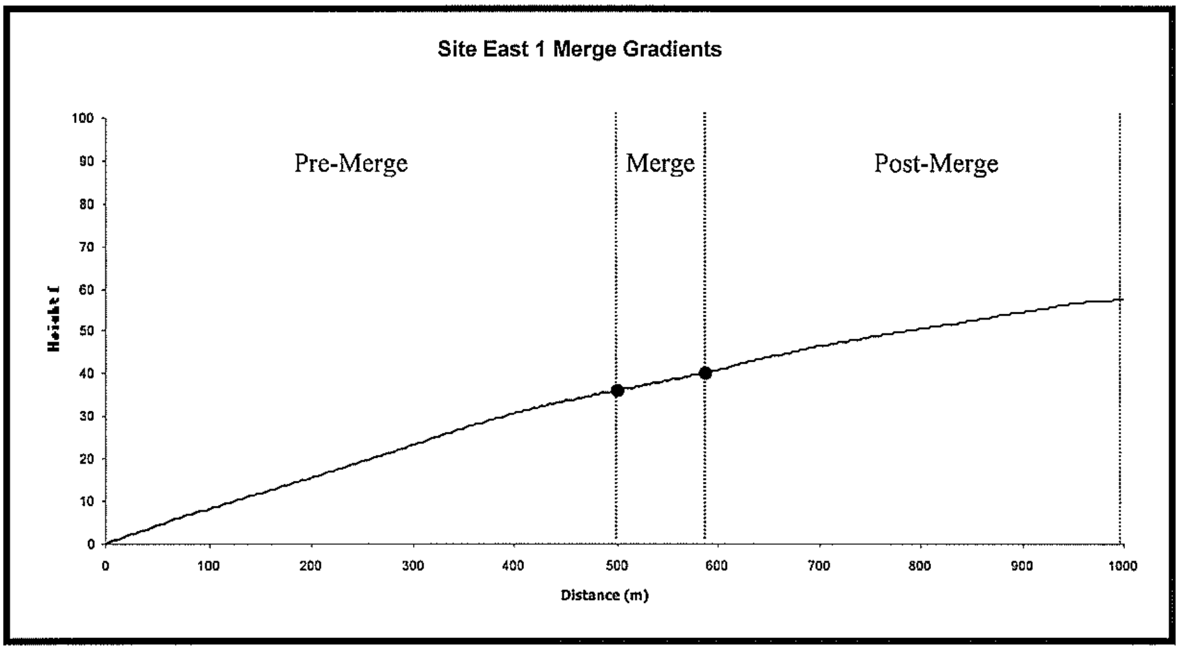
Appendix C
Recreated Route Maps and Gradients of Diverge/Merge Areas

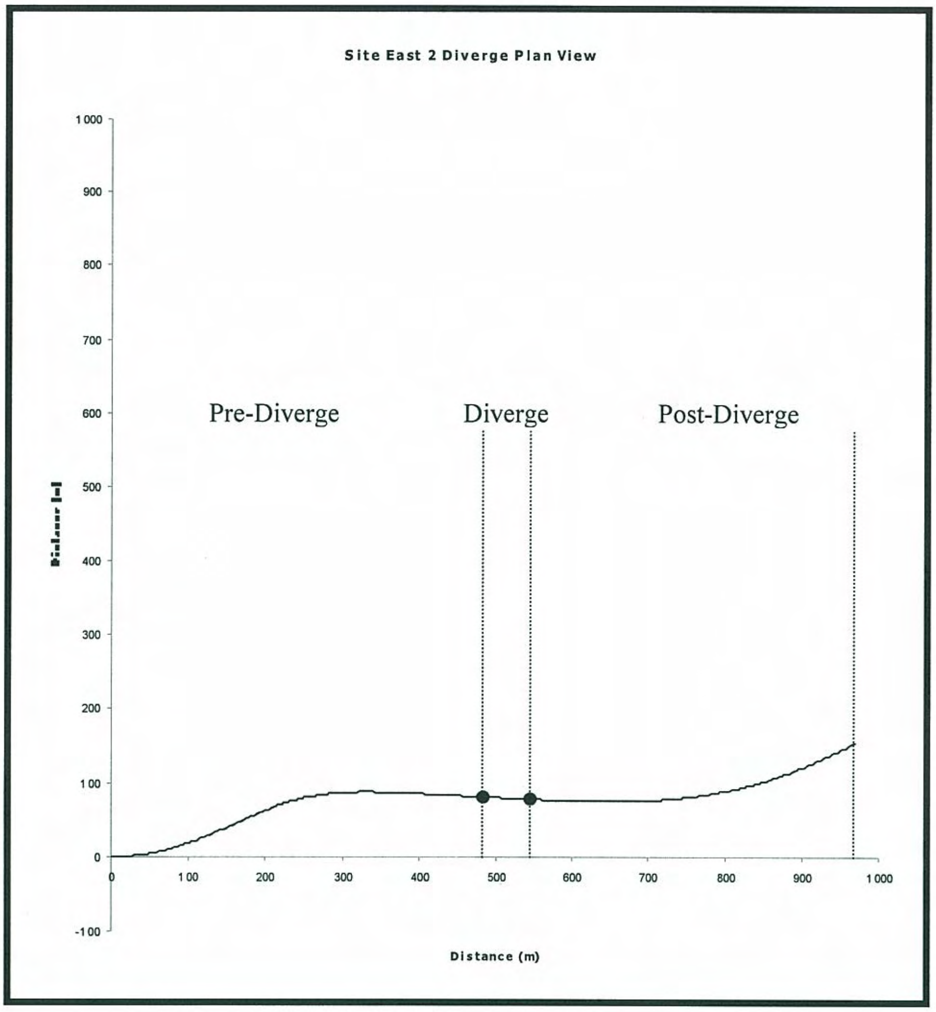


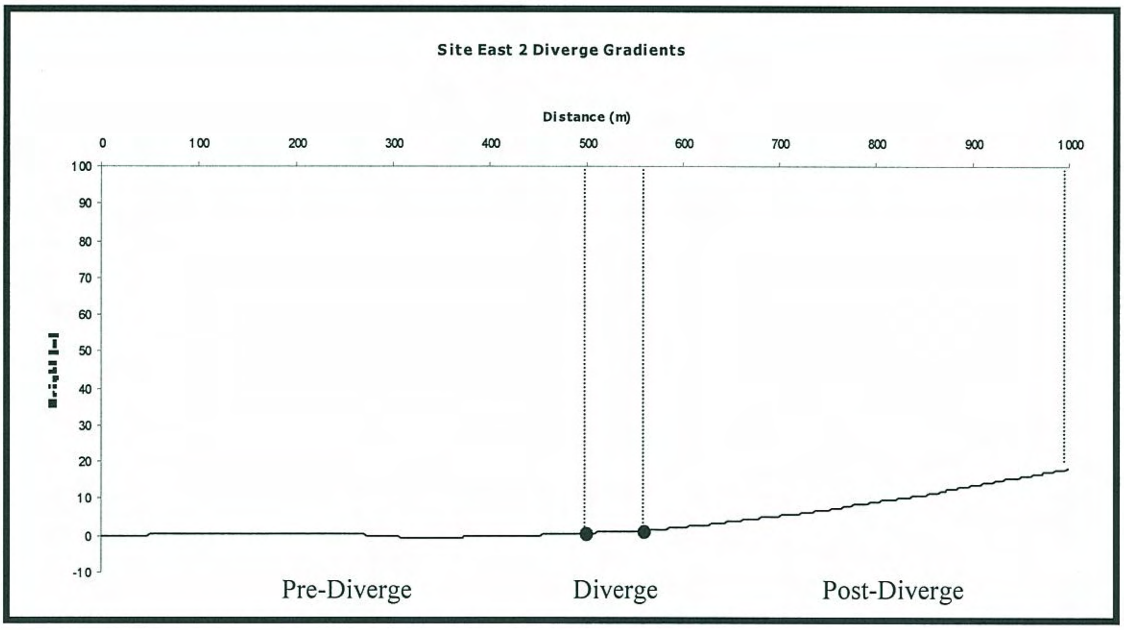

Site East 1 Diverge Plan View
Post-
Diverge
Pre-
Distance (m)

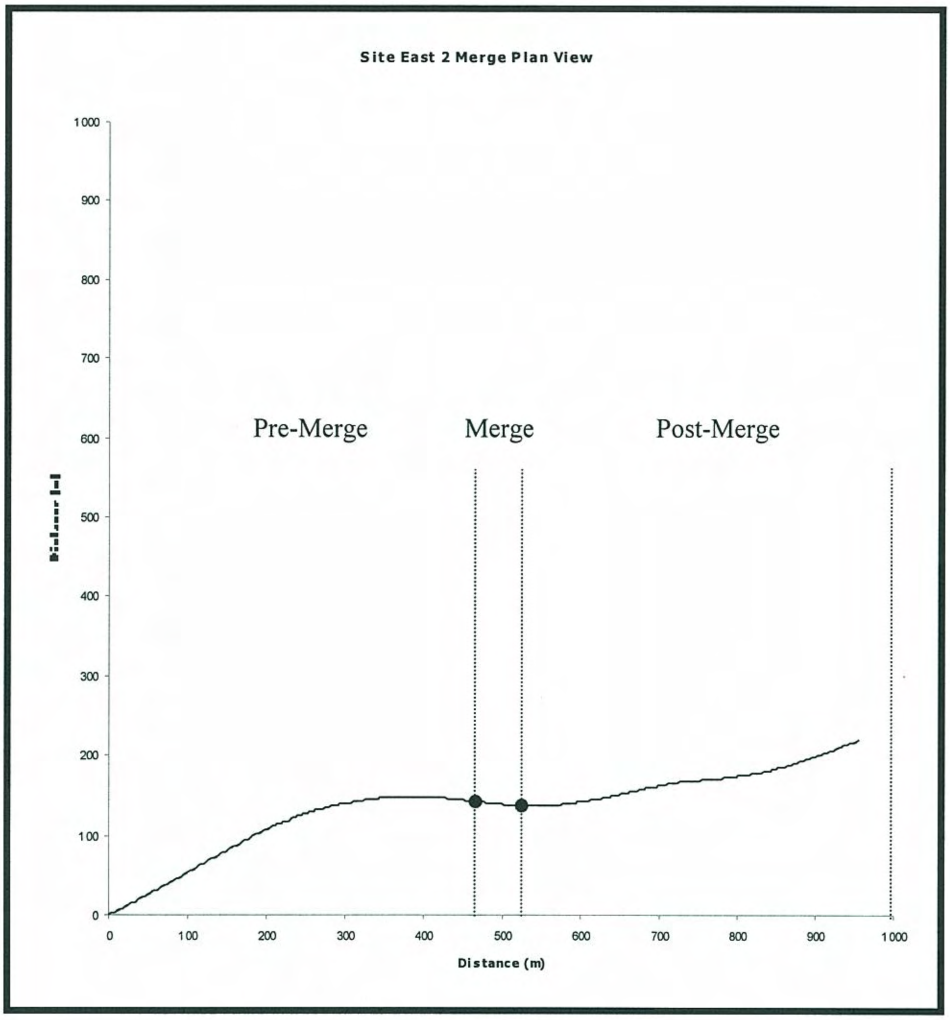

Site East 1 Diverge Gradients
Pre-Diverge
Diverge
Post-Diverge
Distance (m)

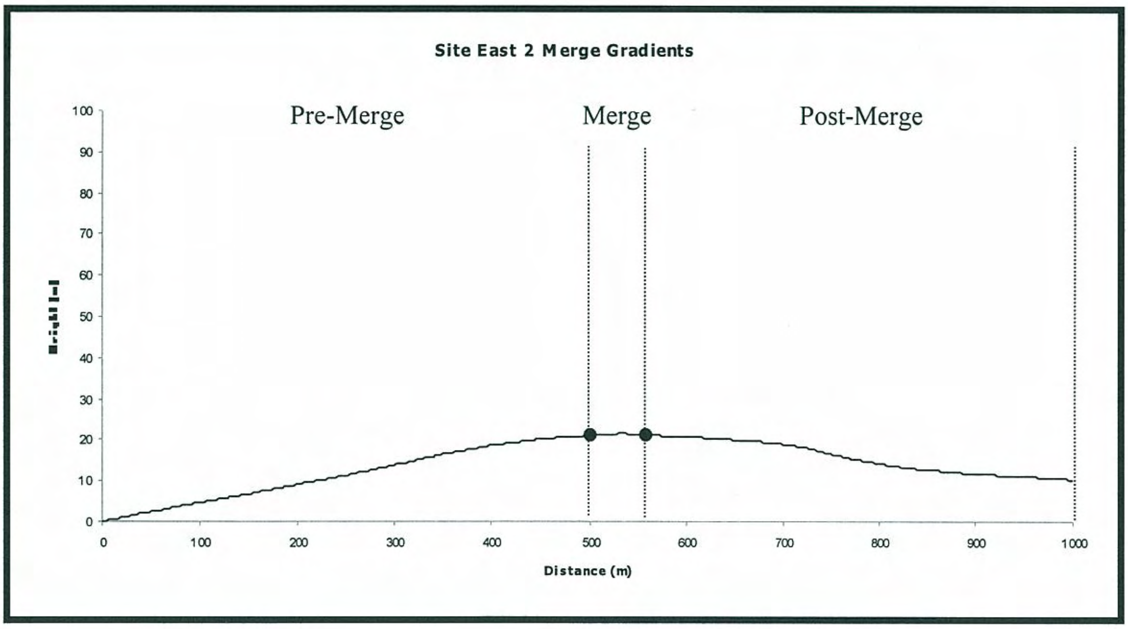

Site East 1 Merge Plan View
Pre-Merge
Merge
Post-Merge
Distance (m)
0
100
200
300
400
500
600
700
800
900
1000

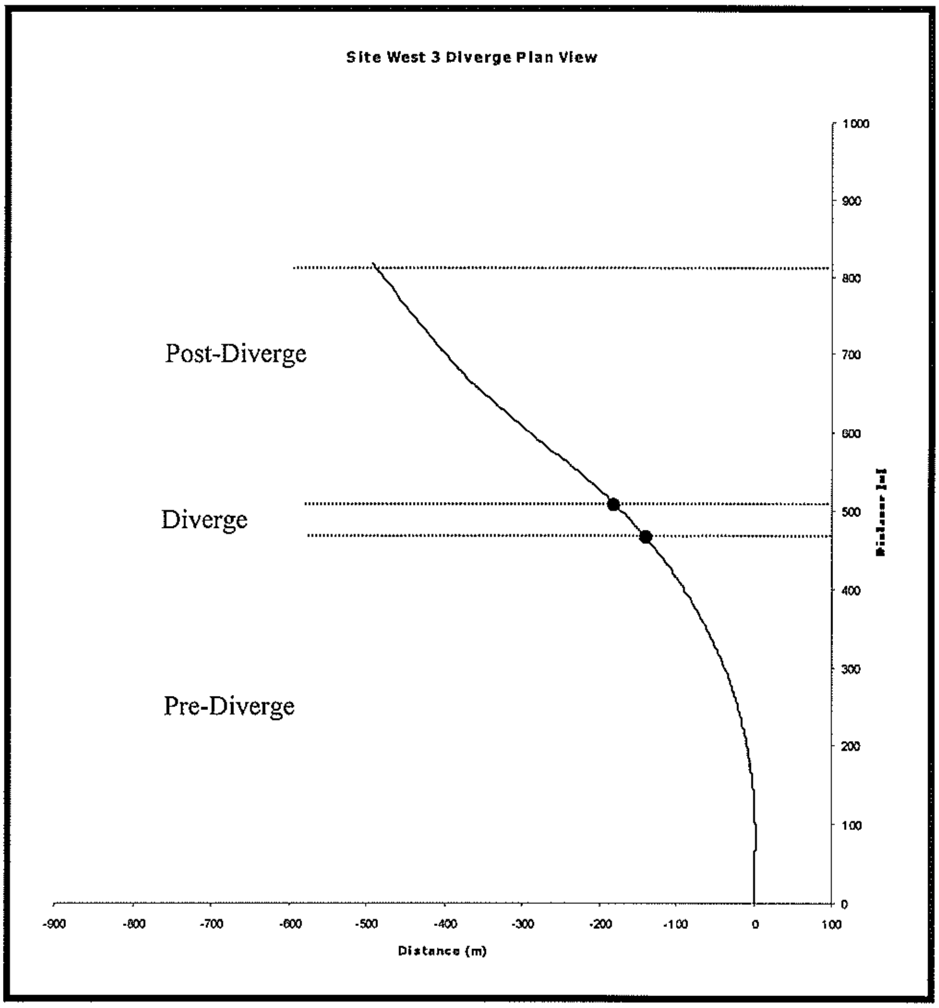

Site East 1 Merge Gradients
Pre-Merge
Merge
Post-Merge
Distance (m)
0
10
20
30
40
50
60
70
80
90
100
0
100
200
300
400
500
600
700
800
900
1000

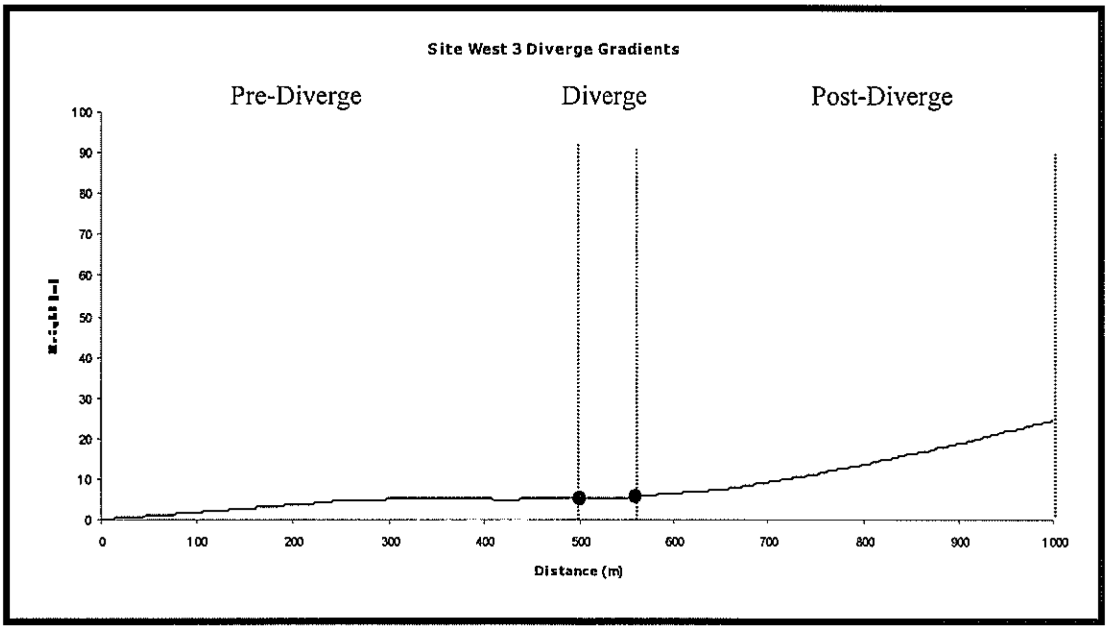

Site East 2 Diverge Plan View
Pre-Diverge
Diverge
Post-Diverge
Distance (m)
1 000
900
800
700
600
500
400
300
200
1 00
0
-1 00
0
1 00
200
300
400
500
600
700
800
900
1 000

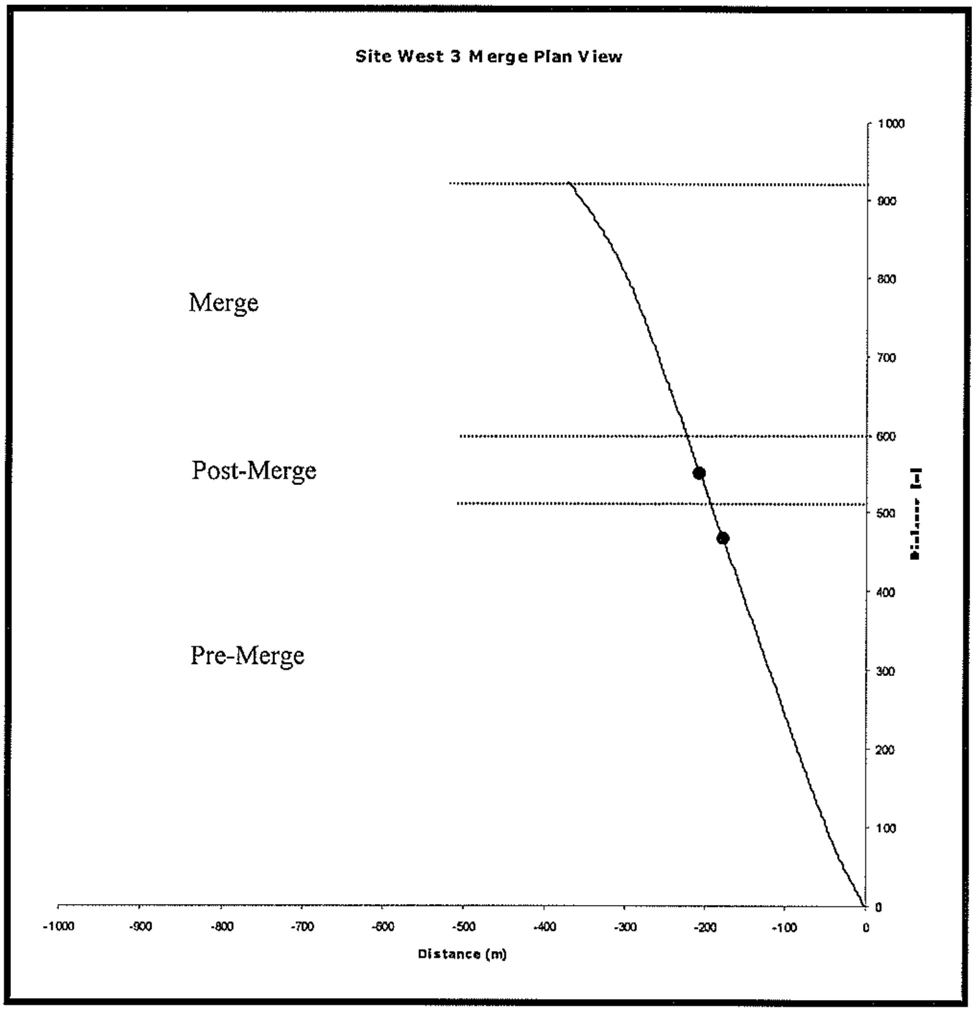

Site East 2 Diverge Gradients
Distance (m)
0
1 00
200
300
400
500
600
700
800
900
1 000
1 00
90
80
70
60
50
40
30
20
1 0
0
-1 0
Pre-Diverge
Diverge
Post-Diverge


Site East 2 Merge Plan View
Pre-Merge
Merge
Post-Merge
Distance (m)

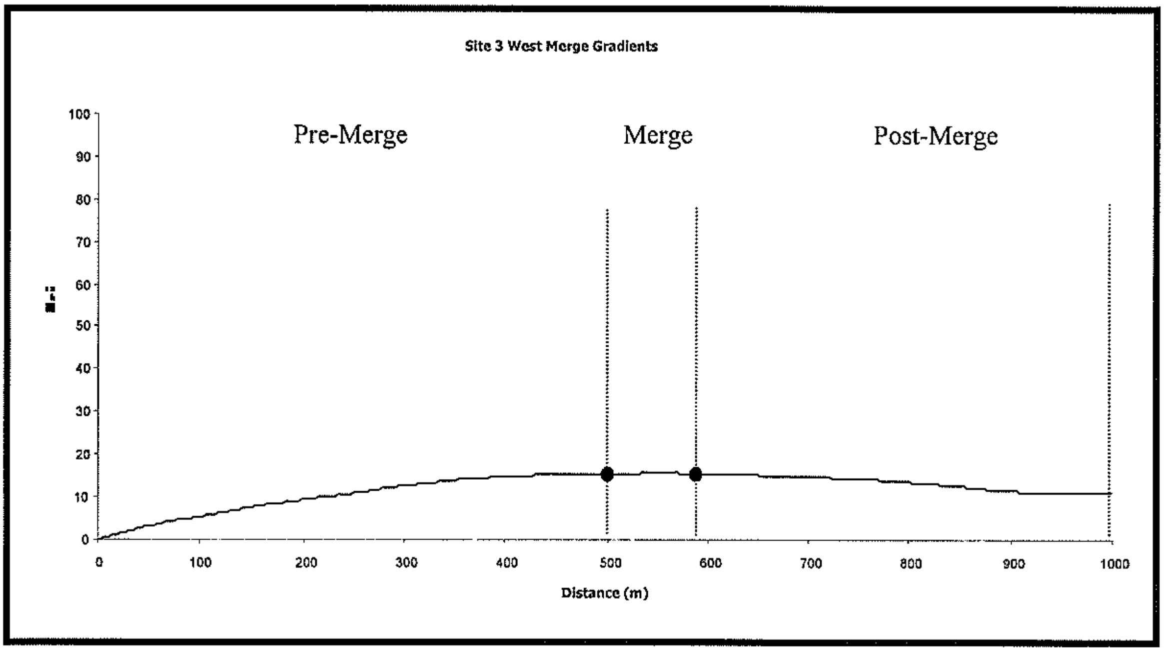

Site East 2 Merge Gradients
Pre-Merge
Merge
Post-Merge
Distance (m)


Site West 3 Diverge Plan View
Post-Diverge
Diverge
Pre-Diverge
1000
900
800
700
600
500
400
300
200
100
0
-900
-800
-700
-600
-500
-400
-300
-200
-100
0
100
Distance (m)

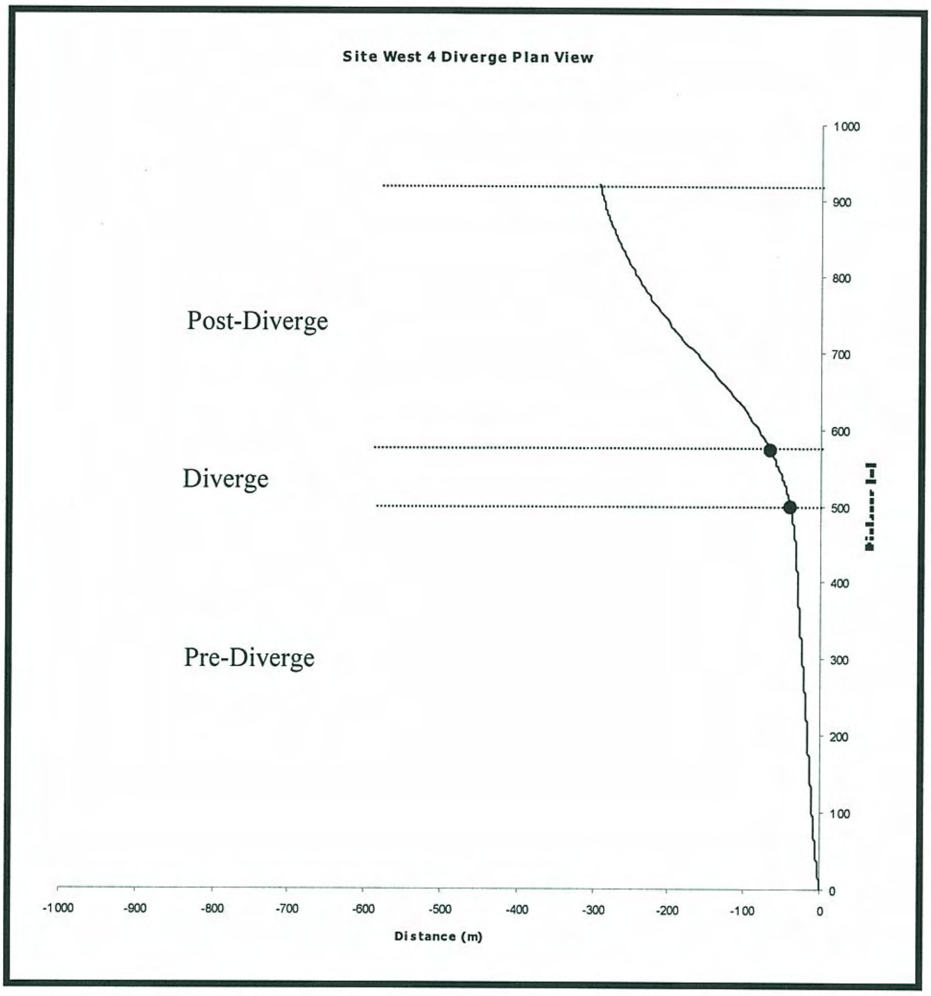

Site West 3 Diverge Gradients
Pre-Diverge
Diverge
Post-Diverge
100
90
80
70
60
50
40
30
20
10
0
0
100
200
300
400
500
600
700
800
900
1000
Distance (m)

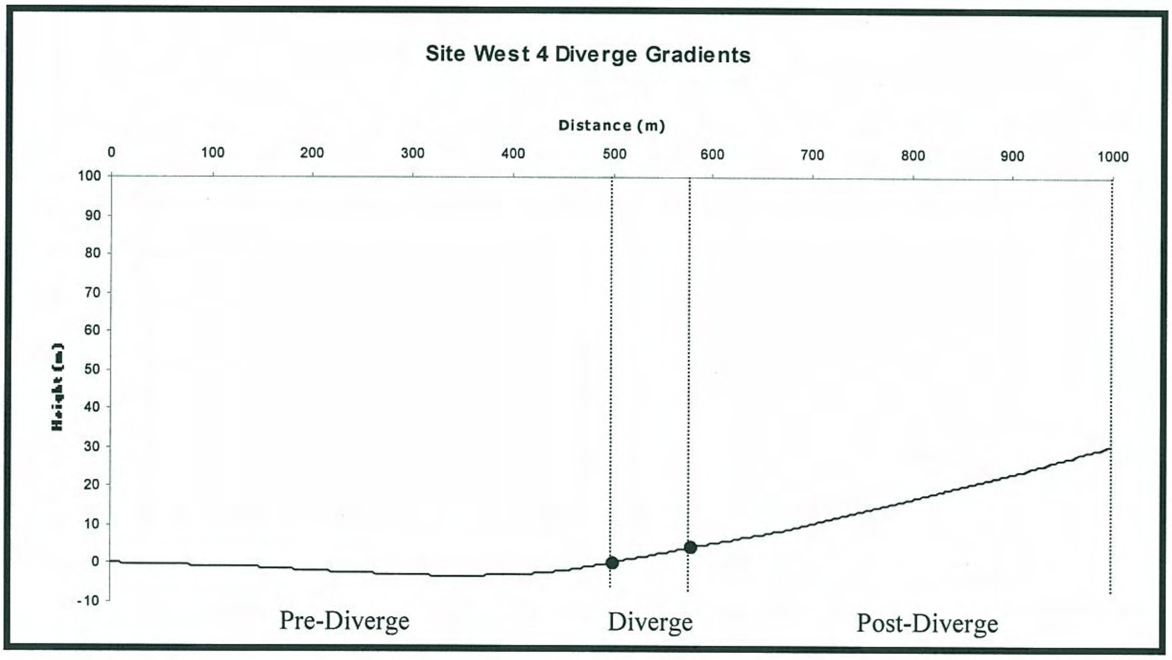


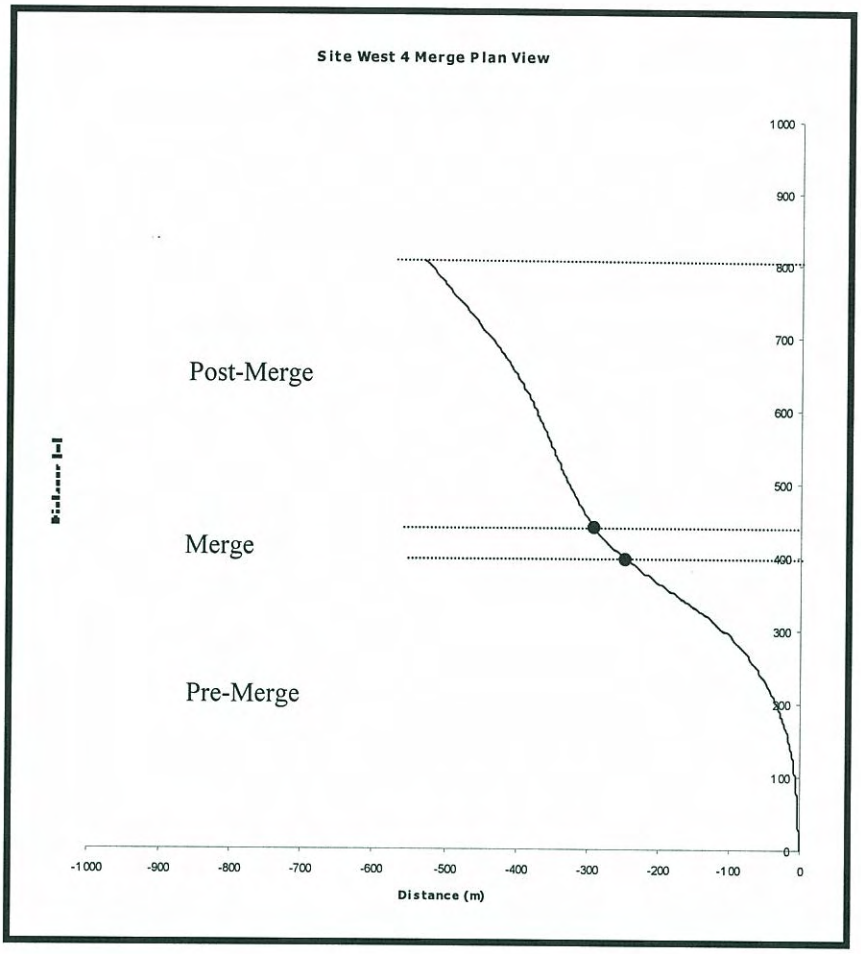
Site West 3 Merge Plan View
Merge
Post-Merge
Pre-Merge
Distance (m)

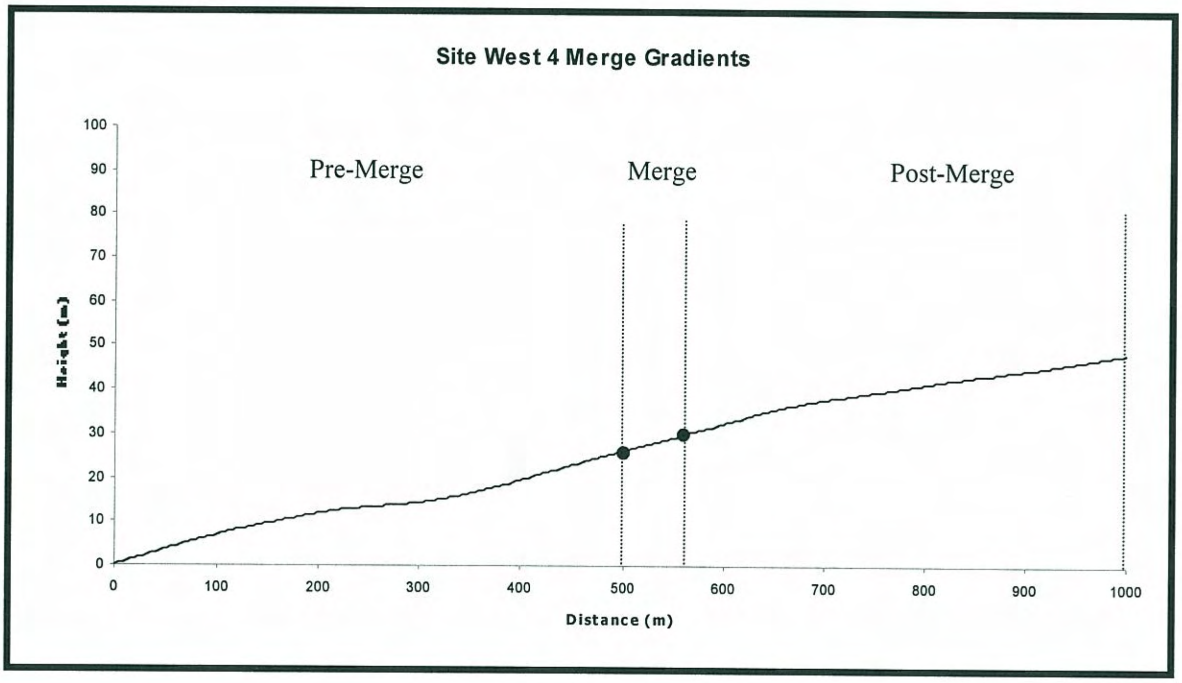


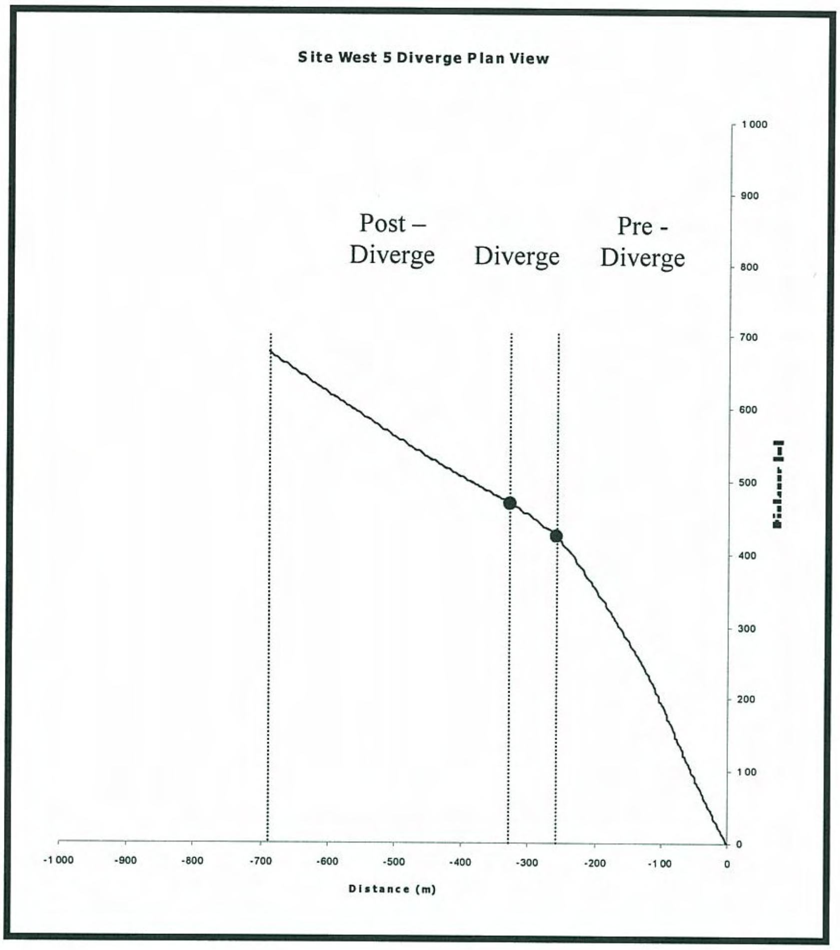
Site 3 West Merge Gradients
Pre-Merge
Merge
Post-Merge
Distance (m)

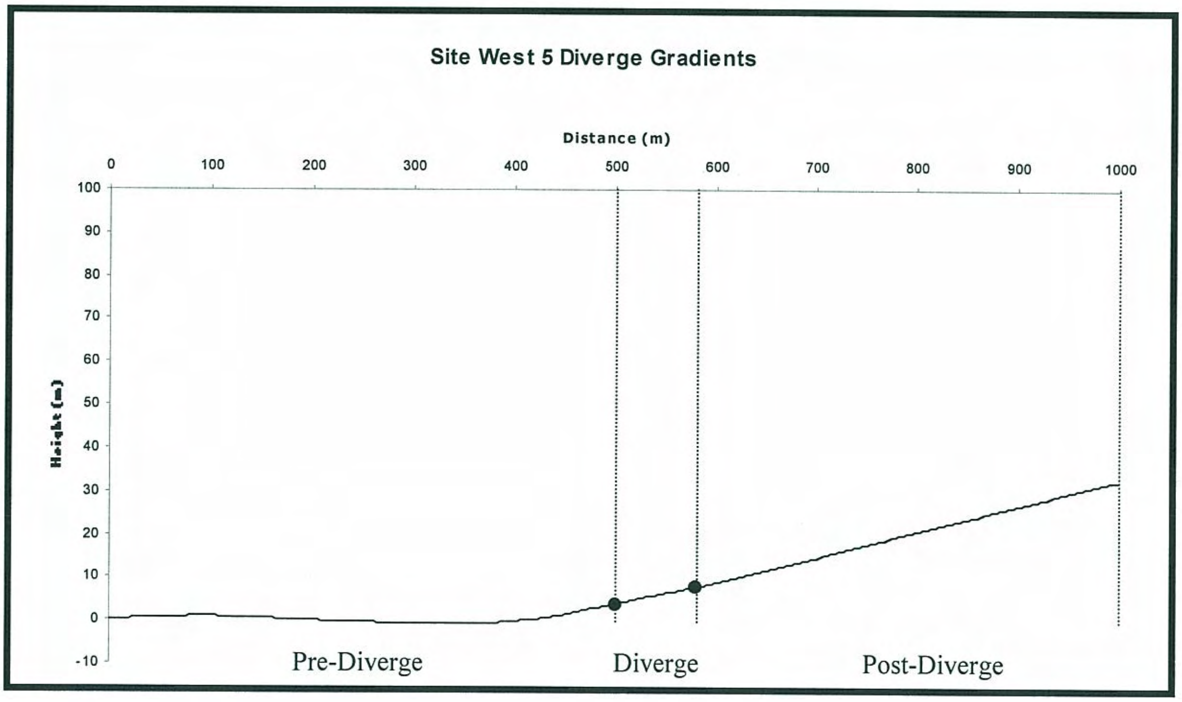

Site West 4 Diverge Plan View
Post-Diverge
Diverge
Pre-Diverge
Distance (m)
1000
900
800
700
600
500
400
300
200
100
0
-1000
-900
-800
-700
-600
-500
-400
-300
-200
-100
0

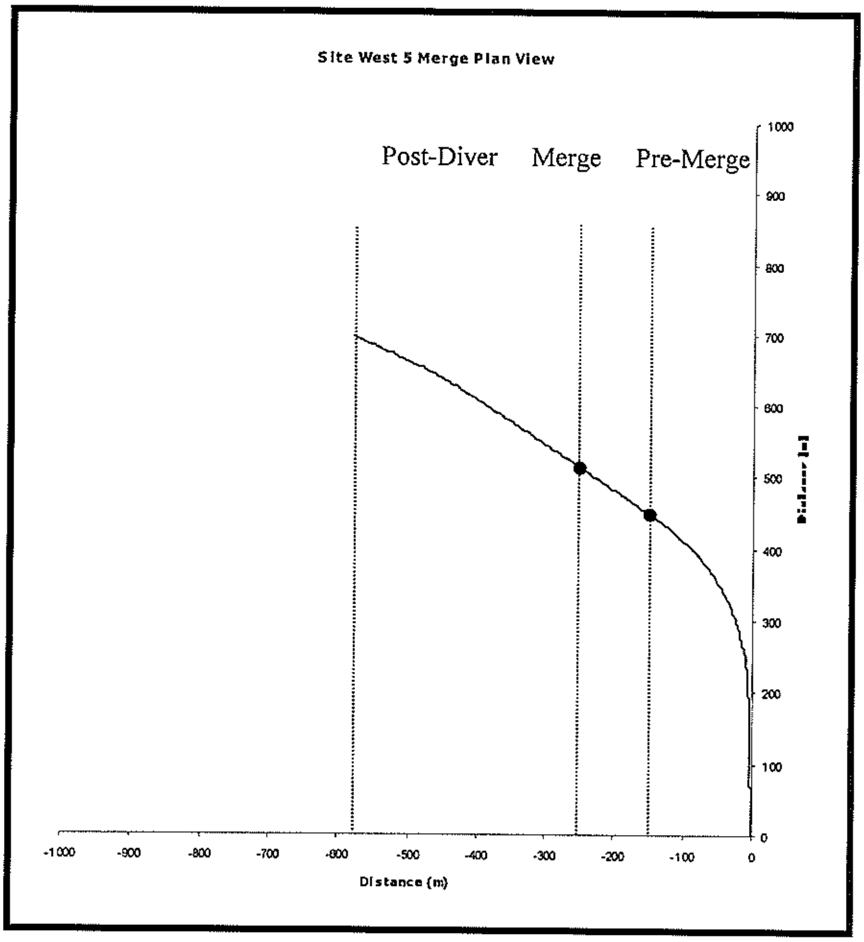

Site West 4 Diverge Gradients
Distance (m)
0
100
200
300
400
500
600
700
800
900
1000
Height (m)
100
90
80
70
60
50
40
30
20
10
0
-10
Pre-Diverge
Diverge
Post-Diverge

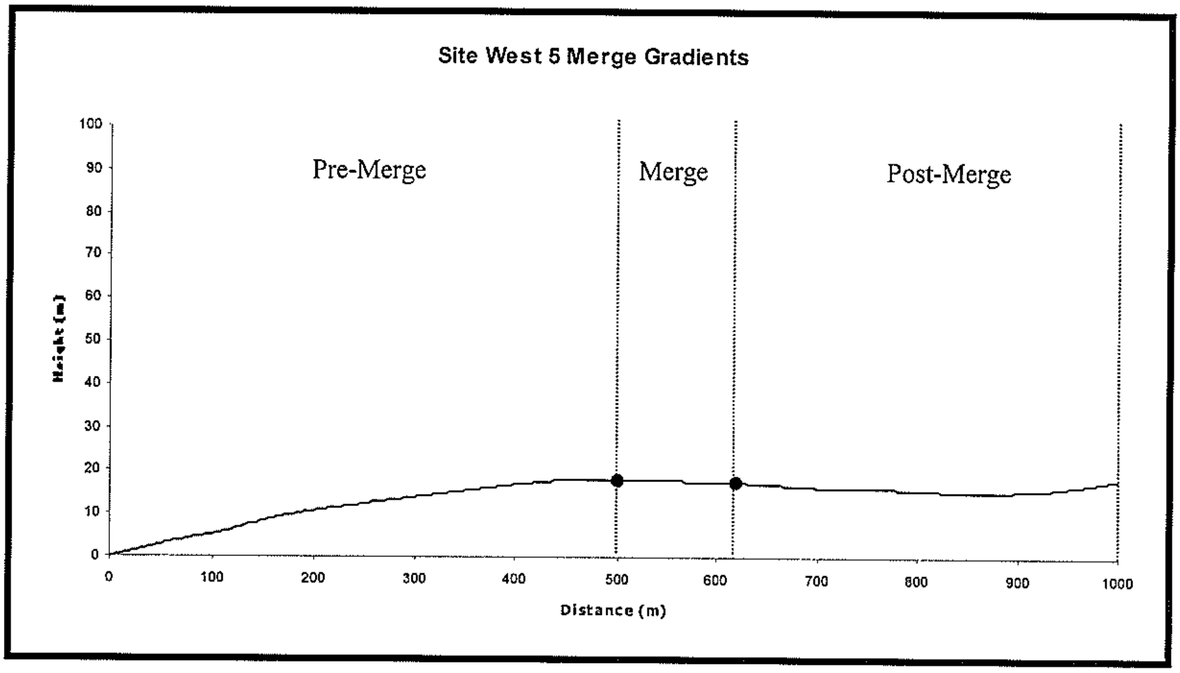

Site West 4 Merge Plan View
Post-Merge
Merge
Pre-Merge
Distance (m)
1000
900
800
700
600
500
400
300
200
100
0
-1000
-900
-800
-700
-600
-500
-400
-300
-200
-100
0

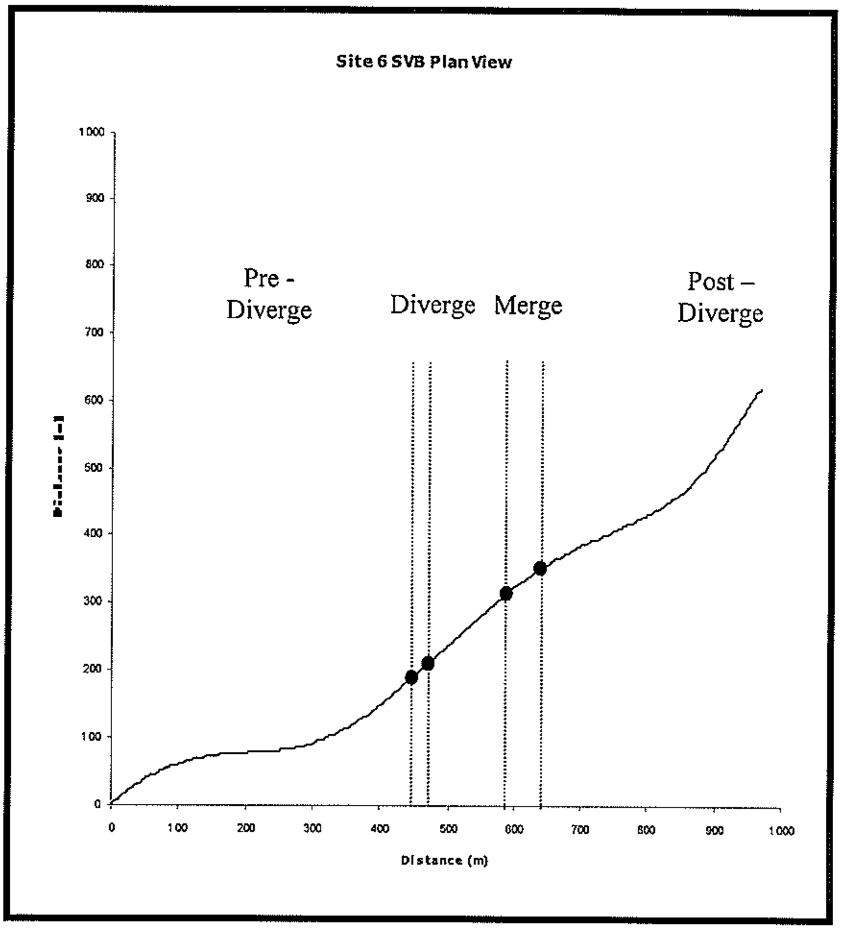

Site West 4 Merge Gradients
Pre-Merge
Merge
Post-Merge
Height (m)
Distance (m)
100
90
80
70
60
50
40
30
20
10
0
0
100
200
300
400
500
600
700
800
900
1000

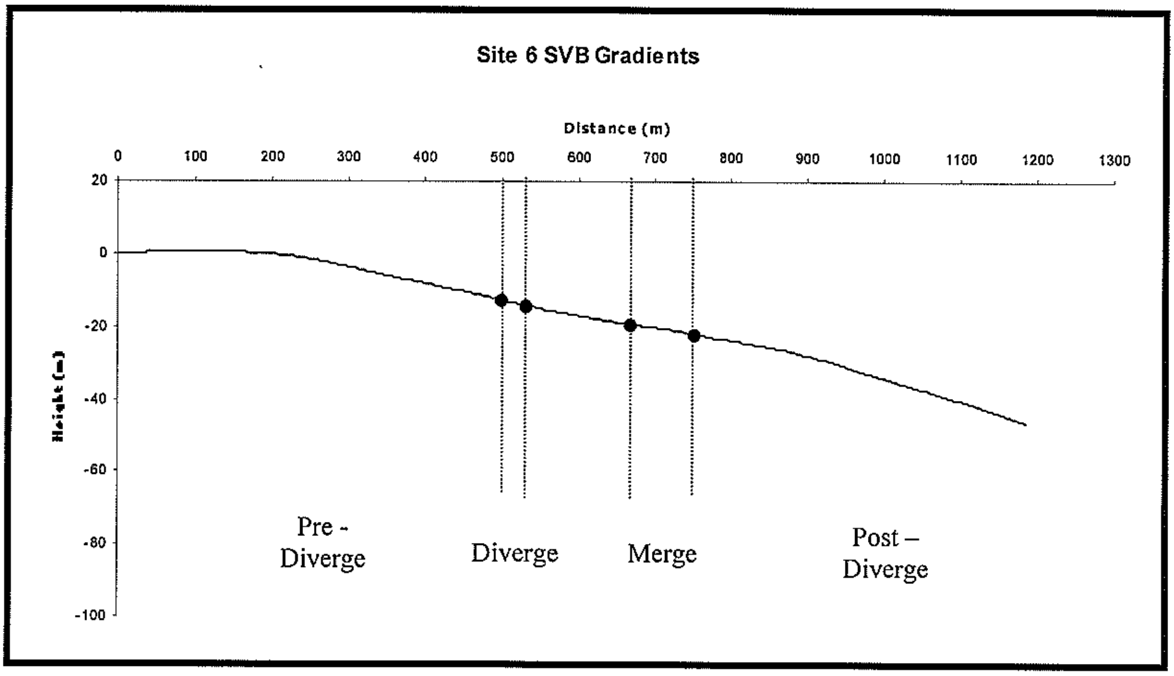

Site West 5 Diverge Plan View
Post –
Diverge
Diverge
Pre -
Diverge
Distance (m)


Site West 5 Diverge Gradients
Distance (m)
Height (m)
Pre-Diverge
Diverge
Post-Diverge


Site West 5 Merge Plan View
Post-Diver
Merge
Pre-Merge
Distance (m)


Site West 5 Merge Gradients
Pre-Merge
Merge
Post-Merge
Height (m)
Distance (m)


Site 6 SVB Plan View
Pre - Diverge
Diverge
Merge
Post – Diverge
Distance (m)
0
100
200
300
400
500
600
700
800
900
1000


Site 6 SVB Gradients
Distance (m)
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
20
0
-20
-40
-60
-80
-100
Pre - Diverge
Diverge
Merge
Post – Diverge

Appendix D
Taper Lengths Table

Diverge Tapers

Site	O/Lane length	Diverge length (m)			
		Simulated	Actual	TNZ Policy	Australian
East 1 Post crest	4km	120	123.4	70-100	70
East 2 Left	1km	60	60	70-100	90
West 3 Straight	3km	60	73.4	70-100	90
West 4 Right	1.5km	80	80	70-100	90
West 5 Blind	1.5km	80	90	70-100	70
Slow Veh. Bay	200m	32	30		

This table shows that the length of diverge tapers used are generally within the range set in the NZ Policy.

Merge Tapers

Site	O/Lane length	Merge length (m)				
		Simulated	Actual	TNZ Policy (March 2000)	Australian	AustRoads (T=VW/2)
East 1 Post crest	4km	88	90	115 - 160 (+150 shoulder taper)	150 (+60 shoulder taper)	170
East 2 Left	1km	60	67	115 – 160 (+150 shoulder taper)	150 (+60 shoulder taper)	179
West 3 Straight	3km	88	102.5	115 – 160 (+150 shoulder taper)	150 (+100 shoulder taper)	207
West 4 Right	1.5km	60	69	115 – 160 (+150 shoulder taper)	150 (+100 shoulder taper)	205
West 5 Blind	1.5km	120	128.2	115 – 160 (+150 shoulder taper)	150 (+100 shoulder taper)	201
Slow Veh. Bay	200m	64	60			

The above table comparing merge length with Transit NZ Policy show that actual merge lengths fall well short of the AustRoads formula for merge tapers and the Australian standards, and apart from Site West 5 are shorter than Transit NZ Policy guidelines.

Appendix E
Speed Differential Tables

Average speed differential at merge area

East 1 – post crest

	Pre merge	Merge	Post merge	Diff.	= <10
Current NZ	76	83	92	16	no
New NZ	76	81	90	14	no
Australian	76	78	88	12	no

East 2 – left

Current NZ	89	74	81	15	no
New NZ	89	75	79	14	no
Australian	87	70	78	17	no

West 3 – straight

Current NZ	103	97	100	6	yes
New NZ	101	96	100	5	yes
Australian	99	95	100	5	yes

West 4 – right

Current NZ	104	99	100	5	yes
New NZ	105	102	101	4	yes
Australian	95	93	95	2	yes

West 5 – blind

Current NZ	102	92	88	14	no
New NZ	101	93	89	12	no
Australian	97	89	91	8	yes

Slow Vehicle Bay

Current NZ	74	67	74	7	yes
New NZ	78	65	76	13	no
Australian	77	66	76	11	no

Note: The speed figures are averaged over the pre-merge, merge and post-merge sections of the merge areas.

Average 85%tile speed differential averaged over pre-merge, merge, and post-merge areas

East 1 – post crest

	Pre merge	Merge	Post merge	Diff	=<10
Current NZ	94.67	104.55	105.13	10.46	no
New NZ	97.19	107.33	106.94	10.14	no
Australian	99.14	107.24	106.89	8.10	yes

East 2 – left

Current NZ	100.99	104.53	104.43	3.54	yes
New NZ	105.41	108.56	106.56	3.15	yes
Australian	100.42	96.41	99.88	4.01	yes

West 3 – straight

Current NZ	118.96	111.65	109.20	9.76	yes
New NZ	115.37	109.52	109.94	5.85	yes
Australian	118.14	108.97	109.04	9.17	yes

West 4 – right

Current NZ	111.81	108.27	107.51	3.59	yes
New NZ	124.54	116.08	113.20	11.34	no
Australian	115.80	116.84	116.70	1.04	yes

West 5 – blind

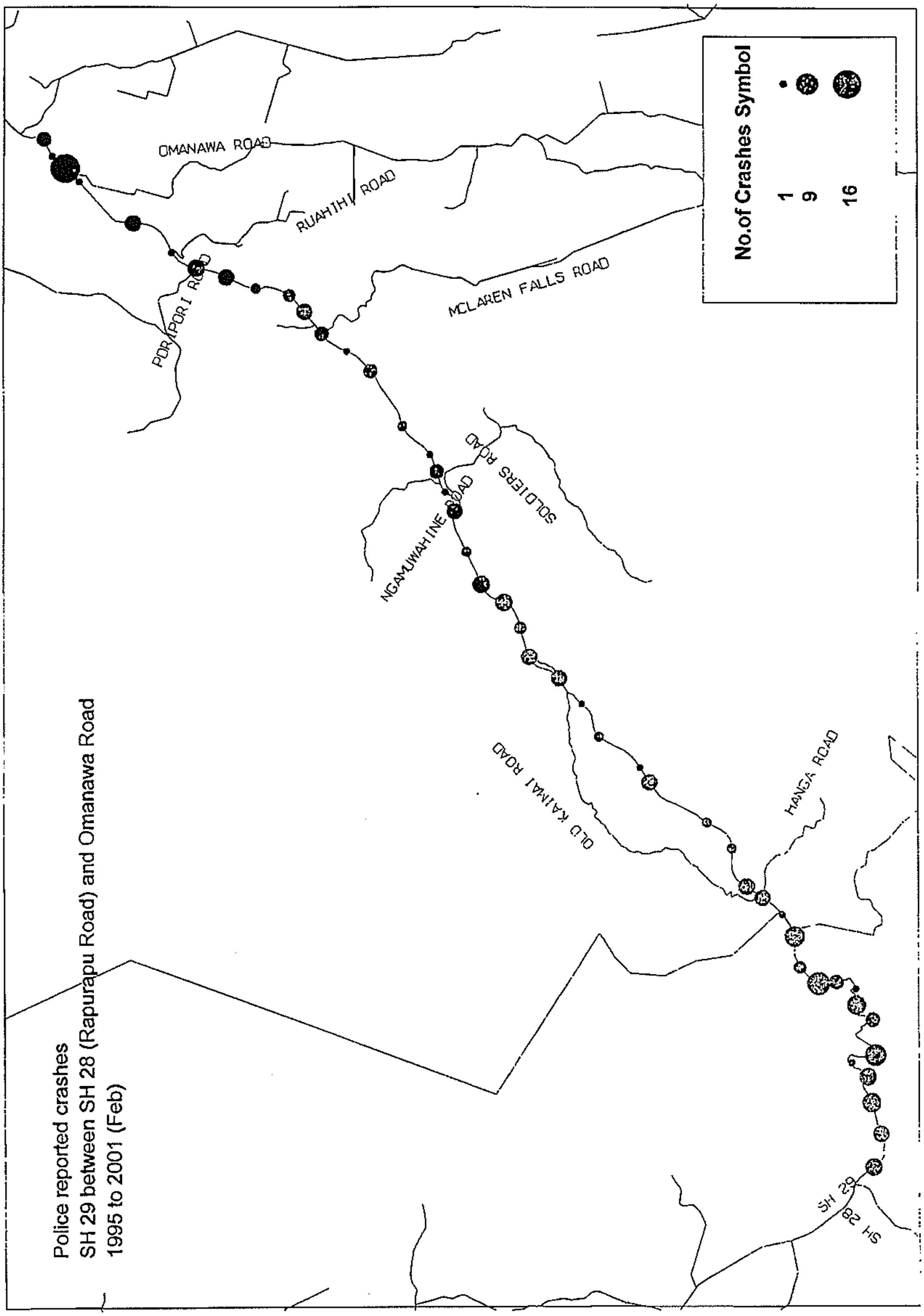
Current NZ	109.11	102.44	93.63	15.48	no
New NZ	115.40	107.95	93.77	21.63	no
Australian	120.59	108.16	106.32	14.27	no

Slow Vehicle Bay

Current NZ	85.00	91.92	85.97	6.92	yes
New NZ	88.70	97.64	85.58	12.06	no
Australian	89.78	93.90	86.35	7.55	yes

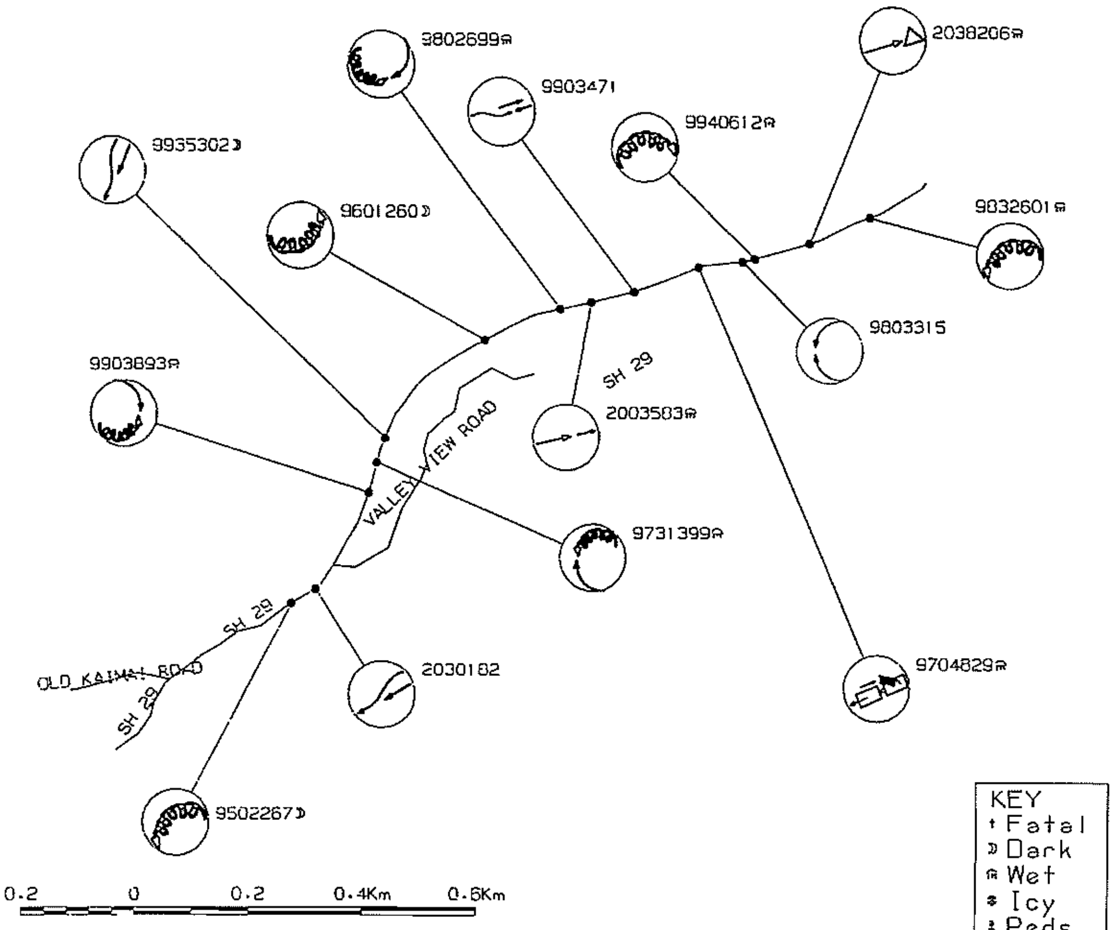
Note: The speed figures are averaged over the pre-merge, merge and post-merge sections of the merge areas.

Appendix F
Crash Diagrams and Listings



Collision Diagram

Police reported crashes
SH 29, in the vicinity of Valley View Road
Site West 4 – Right
Collision Diagram
1995 to 2001 (Feb)



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First Street	Distance / DIR	Second street or landmark	Crash Number	Date DD/MM/YYYY	Day DDD	Time HHMM	HVDVR / MVN VVV T 1 234	Factors and Roles (A is for vehicle 1, B is for veh 2 etc)		OBJECT	CURVE	WETNESS	LIGHT	NETHER	JUNCT	CONTRL	HARKST	SPDLMT	Total Inj F	Total Inj S	Total Inj M	P Ed Cage	C Y C a g e
Site Centre: 2764835E 6364839N																							
SH 29	300E	RAPURAPU ROAD	9901795	10/04/1999	Sat	0005	CC CN1	411A		FZ	R	D	DN	F		N	C	100			1		
SH 29	400E	RAPURAPU ROAD	9638682	29/08/1996	Thu	1920	BA CW1C				R	D	DN	F		N	C	100					
SH 29	500E	RAPURAPU ROAD	9702230	14/05/1997	Wed	0100	DA CN1	101A		C	E	D	DN	F		N	C	100			2		
SH 29	600E	RAPURAPU ROAD	9630926	07/02/1996	Wed	1410	CB CE1		806	P	R	W	BF	L		N	L	100					
SH 29	200W	RAPURAPU ROAD	9736525	30/07/1997	Wed	1440	DB CE1				H		BF	L		N	C	100					
SH 29	400W	RAPURAPU ROAD	9931810	06/04/1999	Tue	1245	QG CW1C				H	W	OH	H		N	C	100					
Site Centre: 2765352E 6364713N																							
SH 29	1000E	RAPURAPU ROAD	9703291	02/09/1997	Tue	0650	FD CE1T		904		R	D	OH	H		N	C	100			1		
SH 29	1000E	RAPURAPU ROAD	9803747	07/03/1998	Sat	0725	BF CE1C	131A	801	G	H	W	OF	H		N	L	100			3		
SH 29	1200E	RAPURAPU ROAD	9603468	09/07/1996	Tue	1650	BF CW1C	902A	601		H	W	OH	H		N	L	100			2		
SH 29	900W	RAPURAPU ROAD	9630164	14/01/1996	Sun	1420	CB CN1			EF	R	D	BF	F		N	C	100					
SH 29	1000S	RAPURAPU ROAD	9738182	30/07/1997	Wed	1700	BF CS1T				H	W	TF	L		N	L	100					
Site Centre: 2765829E 6364860N																							
SH 29	1300E	RAPURAPU ROAD	9733376	14/05/1997	Wed	0840	DA CW1			F	S	W	OH	L		N	C	100					
SH 29	1500E	RAPURAPU ROAD	9601031	14/01/1996	Sun	1650	DA CE1		801	ET	E	W	OF	H		N	C	100			1		
SH 29	1500E	RAPURAPU ROAD	9702620	08/03/1997	Sat	1600	BF CE1C	982A	801		E	W	BN	L		N	L	100			1		
SH 29	1600E	RAPURAPU ROAD	9635006	06/04/1996	Sat	1645	BF CW1C				H	W	O	H		N	L	100					
SH 29	1700E	RAPURAPU ROAD	9605336	07/12/1996	Sat	1520	DB NW1	330A			H	D	BN	F		N	L	100		1	1		
SH 29	3000S	SH 24	2000083	05/05/2000	Fri	1840	BF TS1C	613A 614A			S	D	DN	F		N	L	100		1	1		
SH 29	3000W	TAURANGA ROAD	9839987	25/10/1998	Sun	0930	CB CE1			V	R	D	OH	F		N	C	100					
Site Centre: 2766231E 6364923N																							
SH 29	1740E	RAPURAPU ROAD	9839990	03/11/1998	Tue	1500	BF CW1C				H	W	OH	HS		N	C	100					
SH 29	2000E	RAPURAPU ROAD	9738183	22/07/1997	Tue	1135	DB CN1			F	H	W	OH	H		N	C	100					
SH 29	2000E	RAPURAPU ROAD	9930538	16/01/1999	Sat	1800	DA CN1			F	H	W	OH	H		N	L	100					
SH 29	2000E	RAPURAPU ROAD	9904873	26/12/1999	Sun	0900	DB CE1		801	C	H	W	OH	L		N	L	100			3		
SH 29	2000E	RAPURAPU ROAD	9741282	29/11/1997	Sat	0900	BF CE1T				H	W	OH	L		N	L	100					
SH 29	2000E	SH 28	2034423	21/05/2000	Sun	0715	DB CW1		800	C	H	W	OH	L		N	L	070					
Site Centre: 2766445E 6365178N																							
SH 29	2400E	RAPURAPU ROAD	9505759	19/11/1995	Sun	0855	DB CN1		804		H	D	OH	F		N	L	100			2		

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First Street	Distance Dir Second street or landmark	Crash Number	Date DD/MM/YYYY	Day DDD	Time HHMM	MV / Type (T 1 234)	Factors and Roles (A is for vehicle 1, B is for veh 2 etc)		OBJECT	CURVE	WET	LIGHT	WEATHER	JUNCTION	CONTROL	MARK	SPEED	Total Inj F	S	M	PEDage	CYCage
Site Centre: 2766560E 6364800N																						
SH 29	50E LONE KAURI	9742402	25/12/1997	Thu	1720	DB CE1			F	M	W	ON	H		N	L	100					
SH 29	2800E RAPURAPU ROAD	9602401	19/04/1996	Fri	1110	BF CE1C	982A	806		H	W	ON	H		N	L	100		1	3		
SH 29	2800E RAPURAPU ROAD	9633322	09/04/1996	Tue	1635	BF CE1C		806 901		H	W	OH	H		N	C	100					
SH 29	3000E RAPURAPU ROAD	9904106	04/10/1999	Mon	1630	FA VS1T	181A			E	D	BN	F		N	C	100			1		
SH 29	3100E RAPURAPU ROAD	9504691	28/09/1995	Thu	1735	BF CW1T	982A			M	W	ON	L		N	L	100		2			
SH 29	3100E RAPURAPU ROAD	9742721	25/12/1997	Thu	1330	DB CN1C		801	M	M	W	ON	H		N	L	100					
SH 29	3200E RAPURAPU ROAD	9602822	25/05/1996	Sat	1550	BF CW1VC	982A	806		M	W	ON	L		N	L	100			1		
SH 29	3000N RAPURAPU ROAD	9831629	05/03/1998	Thu	2015	EB CS1T			Q	M	W	DN	L		N	L	100					
SH 29	3000E SH 28	2043653	27/12/2000	Wed	0925	BF CW1VC		801		M	W	ON	M		N	C	100					
Site Centre: 2766989E 6364975N																						
SH 29	4000W HANGA	9705209	25/12/1997	Thu	1010	BF CN1C	111A 982A		F	M	W	ON	L		N	L	100		1	1		
SH 29	3500E RAPURAPU ROAD	9638184	29/06/1996	Sat	1715	BF CW1C				M	W	DN	L		N	C	100					
SH 29	4000E RAPURAPU ROAD	9505726	03/12/1995	Sun	1850	DB TN1	613A		ET	S	D	BN	F		N	L	100			1		
SH 29	4000E SH 28	2031259	16/02/2000	Wed		AD VE1C		801 806		M	W	ON	L		N	C	010					
Site Centre: 2767347E 6365101N																						
SH 29	2800W OLD KAIHAI ROAD	9637235	03/07/1996	Wed	0940	AD CS1C		817		R	D	BN	F		N	L	100					
SH 29	3000W OLD KAIHAI ROAD	2043359	07/10/2000	Sat	1630	DB HN1		806		S	W	BN	L		N	C	100					
SH 29	4200E RAPURAPU ROAD	9930537	14/01/1999	Thu	1456	BF CN1C		801		M	W	ON	H		N	L	100					
SH 29	4500E RAPURAPU ROAD	9602852	23/02/1996	Fri	0745	FA VW1C	181A			R	W	ON	M		N	L	100			1		
SH 29	4500E RAPURAPU ROAD	9602860	27/02/1996	Tue	1200	BF TM1V	613A		E	M	D	BF	F		N	C	100		1	1		
SH 29	4670E RAPURAPU ROAD	9804392	27/09/1998	Sun	1130	BF CE1T	111A 131A			M	W	OF	L		N	C	100			1		
SH 29	4600W RAPURAPU ROAD	9930572	06/09/1999	Mon	0740	DA CE1				E	W	OF	F		N	L	100					
Site Centre: 2767602E 6365108N																						
SH 29	5000E RAPURAPU ROAD	9938434	06/09/1999	Mon	1010	DB CE1		801		M	W	ON	L		N	C	100					
Site Centre: 2767684E 6365697N																						
SH 29	1500S HANGA ROAD	9902059	22/04/1999	Thu	1520	MC CH1V	372B			E	D	BN	F		M	L	100			1		
SH 29	1600S HANGA ROAD	9935961	03/07/1999	Sat	1235	BF CE1C		801		M	W	ON	H		N	C	100					
SH 29	1700S HANGA ROAD	2031107	01/01/2000	Sat	1215	BF CN1C				M	W	ON	L		N	C	100					
SH 29	1600W HANGA ROAD	9939888	21/08/1999	Sat	1430	DA CE1		801 901	C	M	W	ON	H		N	L	100					
SH 29	1700W HANGA ROAD	9935960	03/07/1999	Sat	1200	DB CE1		801		M	W	ON	H		N	C	100					

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Coded Crash report of all sites, run on 08-May-2001, Page 3

First Street	Distance, Dir, Second street or landmark	Crash Number	Date DD/MM/YYYY	Day DDD	Time HHMM	MV DR (1 2)	VN VVV (1 234)	Factors and Roles (A is for vehicle 1, B is for veh 2 etc)		O B J E C T	C U R V E	W E T N E S	L I G H T	K E T H E R	J U N C T	C O N T R L	H A R K S	S P D L M T	Total Inj F A T	Total Inj S E R	Total Inj M I N	P E D Age	C Y C Age
SH 29	A LOOKOUT ENT	9536696	18/07/1995	Tue	0630	DA	CN1		802	F	S	I	DN	FF		N	L	100					
SH 29	1700W OLD KAIMAI ROAD	9803513	25/07/1998	Sat	1000	BF	CE1C	111A	801		M	W	ON	F		N	L	100			1		
SH 29	5800E RAPURAPU ROAD	9937953	25/06/1999	Fri	0700	DB	CN1		904		M	W	TN	M		N	L	100					
SH 29	6000E RAPURAPU ROAD	9901214	14/01/1999	Thu	1240	DB	CH1		806	E	M	W	ON	L		N	L	100			1		
SH 29	60W SUMMIT LOOKOUT	9835498	18/04/1998	Sat	0900	DB	CN1			E	S	W	ON	L		N	C	100					

Site Centre: 2767707E 6365416N

First Street	Distance, Dir, Second street or landmark	Crash Number	Date	Day	Time	MV DR	VN VVV	Factors and Roles		OBJECT	CURVE	WETNES	LIGHT	KETHER	JUNCT	CONTRL	HARKS	SPDLMT	FAT	SER	MIN	PED Age	CYC Age
SH 29	2000S HANGA ROAD	9832633	05/03/1998	Thu	2020	BF	TS1T				M	W	DN	L		N	L	100					
SH 29	2000W HANGA ROAD	9830644	12/01/1998	Mon	2035	DB	CS1		904	V	M	D	TN	M		N	C	100					
SH 29	2000W HANGA ROAD	9836057	16/05/1998	Sat	1910	BE	CH1C				E	W	DN	M		N	C	100					
SH 29	2000W OLD KAIMAI ROAD	9841029	04/10/1998	Sun	1045	BF	CH1C		806		S	W	ON	M		N	L	100					

Site Centre: 2768039E 6366029N

First Street	Distance, Dir, Second street or landmark	Crash Number	Date	Day	Time	MV DR	VN VVV	Factors and Roles		OBJECT	CURVE	WETNES	LIGHT	KETHER	JUNCT	CONTRL	HARKS	SPDLMT	FAT	SER	MIN	PED Age	CYC Age
SH 29	1200W HANGA ROAD	9603728	04/06/1996	Tue	0645	BF	CE1C	111A	802		E	I	DN	FF		N	C	100			1		
SH 29	1300W HANGA ROAD	9802257	25/01/1998	Sun	1600	DB	CH1	501A			M	D	BF	F		N	L	100			1		
SH 29	200S KAIMAI SUMMIT	9801765	28/03/1998	Sat	2145	BF	TN1C	104A 135A 400A	801	G	M	W	DN	L		N	C	100			3		

Site Centre: 2768421E 6366066N

First Street	Distance, Dir, Second street or landmark	Crash Number	Date	Day	Time	MV DR	VN VVV	Factors and Roles		OBJECT	CURVE	WETNES	LIGHT	KETHER	JUNCT	CONTRL	HARKS	SPDLMT	FAT	SER	MIN	PED Age	CYC Age
SH 29	1000S HANGA ROAD	9736526	28/07/1997	Mon	2020	DB	CS1		517		E	W	DN	M		N	L	100					
SH 29	50N KAIMAI SUMMIT	2042011	11/12/2000	Mon	1231	DB	CH1			T	E	W	ON	HS		N	L	100					
SH 29	100W KAIMAI SUMMIT	9842486	30/11/1998	Mon	1140	BF	CE1T		801 901		M	W	ON	M		N	M	100					
SH 29	200W KAIMAI SUMMIT	9842487	29/11/1998	Sun	1530	BF	CW1C		801 901 903		M	W	ON	HS		N	L	100					
SH 29	800W OLD KAIMAI ROAD	9605245	15/11/1996	Fri	1415	FA	CE1T		904		R	W	ON	M		N	L	100			3		
SH 29	800W OLD KAIMAI ROAD	9642343	30/12/1996	Mon	1015	DB	CH1		901 903	C	M	W	ON	HS		N	L	100					
SH 29	1000W OLD KAIMAI ROAD	9641878	07/12/1996	Sat	1345	OG	CE1		903		M	D	BN	FS		N	C	100					
SH 29	1000W OLD KAIMAI ROAD	9705073	25/12/1997	Thu	1930	BF	CH1V	111A 982A			M	W	ON	M		N	L	100			1		

Site Centre: 2768763E 6366260N

First Street	Distance, Dir, Second street or landmark	Crash Number	Date	Day	Time	MV DR	VN VVV	Factors and Roles		OBJECT	CURVE	WETNES	LIGHT	KETHER	JUNCT	CONTRL	HARKS	SPDLMT	FAT	SER	MIN	PED Age	CYC Age
SH 29	400W HANGA ROAD	9705208	14/09/1997	Sun	1100	BF	CH1H	111A 982A			S	D	BN	F		N	C	100		1			

Site Centre: 2769020E 6366563N

First Street	Distance, Dir, Second street or landmark	Crash Number	Date	Day	Time	MV DR	VN VVV	Factors and Roles		OBJECT	CURVE	WETNES	LIGHT	KETHER	JUNCT	CONTRL	HARKS	SPDLMT	FAT	SER	MIN	PED Age	CYC Age
SH 29	50E HANGA ROAD	9605589	27/11/1996	Wed	1740	AD	CN1C	112A		EP	R	W	ON	F		N	C	100			1		
SH 29	100E HANGA ROAD	9904561	07/11/1999	Sun	1515	AO	CE1C	150A 372A 692A 112B 151B			R	W	ON	M		N	C	100			1		
SH 29	50W HANGA ROAD	9939907	13/10/1999	Wed	1545	FB	CH1C				M	D	BN	F		N	C	100					
SH 29	I HANGA ROAD	9601316	15/02/1996	Thu	1040	GD	MS1T		902		M	D	BN	F	T	N	C	100			1		
SH 29	200E OLD KAIMAI ROAD	2038761	31/08/2000	Thu	0735	DB	CN1		904	C	M	W	ON	M		N	L	100					

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First Street	Distance / Dir / Second street or landmark	Crash Number	Date DD/MM/YYYY	Day DDD	Time HHMM	Movement / Vehicles (M D, V R, H VN VVV, T 1 234)	Factors and Roles (A is for vehicle 1, B is for veh 2 etc)	OBJECT	CURVE	WET	LIGHT	WEATHER	JUNCTION	CONTROL	MARKS	SPD LMT	Total Inj FAT	Total Inj SER	Total Inj MIN	PED age	CYC age
Site Centre: 2769359E 6366922N																					
SH 29	700E HANGA ROAD	9732798	18/04/1997	Fri	1940	DA CE1			M	W	DN	L		N	L	100					
SH 29	300N HANGA ROAD	9701048	02/01/1997	Thu	1150	BE CN1V	982A 801		R	W	ON	L		N	L	100		1	1		
SH 29	500E OLD KAIHAI ROAD	9836858	10/08/1998	Mon	0545	QG TE1		C	R	W	DN	H		N	C	100					
SH 29	600E OLD KAIHAI ROAD	9741743	30/11/1997	Sun	1530	BF CE1C			M	W	OF	LS		N	L	100					
SH 29	4000W OLD KAIHAI ROAD	2042239	08/12/2000	Fri	2200	DB CN1		CF	E	W	DN	H		N	C	100					
Site Centre: 2769980E 6367186N																					
SH 29	1000E HANGA ROAD	9630909	15/02/1996	Thu	1300	DA CS1		P	E	D	BN	F		N	C	100					
SH 29	1500E OLD KAIHAI ROAD	9642284	25/12/1996	Wed	0755	DB CH1			E	D	BN	F		N	L	100					
Site Centre: 2770289E 6367548N																					
SH 29	1900E OLD KAIHAI ROAD	9903062	01/07/1999	Thu	1210	DB CE1	802	C	E	I	ON	F		N	L	100			1		
SH 29	1600N OLD KAIHAI ROAD	9604891	03/11/1996	Sun	1514	DA CE1	129A 134A	C	E	D	BF	F		N	L	100			1		
Site Centre: 2770834E 6368329N																					
SH 29	2000N OLD KAIHAI ROAD	9539417	24/09/1995	Sun	0146	CC CH1		C	R	D	DN	F		N	C	100					
SH 29	2000W OLD KAIHAI ROAD	9831081	21/02/1998	Sat	1530	DB CH1	801	C	M	W	ON	N		N	L	100					
SH 29	2000W OLD KAIHAI ROAD	9731965	27/03/1997	Thu	1630	BF CN1C			M	D	ON	F		N	C	100					
SH 29	2000W OLD KAIHAI ROAD	9641509	16/11/1996	Sat	2145	CB VS1	801	V	R	W	DN	L		N	L	100					
SH 29	A TUAKOPAI STM BR	2036463	04/06/2000	Sun	0025	DA CE1	901 903	G	M	W	DN	MS		N	L	100					
Site Centre: 2771066E 6368480N																					
SH 29	3000E HANGA ROAD	9833679	01/05/1998	Fri	0810	FA CE1C			R	D	BF	F		N	L	100					
Site Centre: 2771660E 6369177N																					
SH 29	650S OLD KAIHAI ROAD	9839991	21/10/1998	Wed	0900	DB CE1		G	E	W	OF	F		N	C	100					
SH 29	900W OLD KAIHAI ROAD	9934751	28/05/1999	Fri	1715	DA CE1		C	M	W	TN	L		N	C	100					
Site Centre: 2772057E 6369403N																					
SH 29	300S OLD KAIHAI ROAD	2032390	26/03/2000	Sun	0920	DB CN1		C	M	D	BN	F		N	C	100					
Site Centre: 2772540E 6369910N																					
SH 29	500N OLD KAIHAI ROAD	9903893	19/09/1999	Sun	1400	BF CN1C	135A 901	C	M	W	ON	M		N	L	100		1	3		

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First Street	Distance, Dir, Second street or landmark	Crash Number	Date DD/MM/YYYY	Day DDD	Time HHMM	MV / Veh types (HD VR, T 1 234)	Factors and Roles (A is for vehicle 1, B is for veh 2 etc)	Objects		C W L H (Curve, Wet, Light, Weather)	J C M S (Junction, Control, Speed)	Total Inj F	S	M	P	C
SH 29	600N OLD KAIMAI ROAD	9935302	20/06/1999	Sun	1734	AC CS1C				E D DN F	N L 100					
SH 29	200E VALLEY VIEW ROAD	9731399	11/03/1997	Tue	1515	BF CS1CC				M W ON L	N L 100					
SH 29	100S VALLEY VIEW ROAD	9502267	18/03/1995	Sat	0245	DB CS1	103A	804	C	H D DN F	N C 100			1		
SH 29	50W VALLEY VIEW ROAD	2030182	16/01/2000	Sun	1750	AC CW1C				H D BN F	N C 100					
Site Centre: 2772983E 6370298N																
SH 29	1200N BOULDER BR	9903471	05/05/1999	Wed	1530	AB CE1C	154A			R D BN F	N L 100		2			
SH 29	1000E OLD KAIMAI ROAD	9802699	09/08/1998	Sun	1545	BF CE1C	111A			S W ON F	N L 100			1		
SH 29	500N VALLEY VIEW ROAD	9601260	06/02/1996	Tue	0235	DB CH1	111A 402A		C	E D DN F	N C 100			1		
SH 29	700N VALLEY VIEW ROAD	2003583	08/09/2000	Fri	1010	FA TE1T	110A 330A 380A			E W ON F	N L 100			1		
SH 29	900N VALLEY VIEW ROAD	9704829	29/11/1997	Sat	0920	QG CS1	615A 630A	800	CV	E W ON H	N L 100			3		
Site Centre: 2773306E 6370389N																
SH 29	1000S BOULDER BR	9803315	24/05/1998	Sun	1320	BC CS1C	111A			H D BN L	N C 100		2	4		
SH 29	1000E VALLEY VIEW ROAD	9940612	05/11/1999	Fri	0830	DA CN1			FV	E W ON HS	N C 100					
SH 29	1100E VALLEY VIEW ROAD	2038206	20/07/2000	Thu	0815	EC CE1		823	L	R W ON H	N L 070					
Site Centre: 2773649E 6370631N																
SH 29	300N BOULDER BR	9504651	10/01/1995	Tue	1151	BF CN1V	402A 982A 692B			E W ON L	N L 100			1		
SH 29	400N BOULDER BR	9836859	07/08/1998	Fri	1220	AA CE1T				E D BN F	N L 100					
SH 29	500N BOULDER BR	9500060	28/03/1995	Tue	1600	BF VN1VC	197A 982A			E D ON F	N L 100	1		1		
SH 29	500N BOULDER BR	9537678	28/03/1995	Tue	1600	DB TN1				E D ON F	N L 100					
SH 29	1800N SOLDIERS ROAD	9505837	29/09/1995	Fri	1120	FD CN1V		901		R W OF H	N C 100			2		
SH 29	2000N SOLDIERS ROAD	9832601	21/02/1998	Sat	1612	DB CW1			C	H W BN L	N L 100					
Site Centre: 2773934E 6370992N																
SH 29	15S BOULDER BR	9830809	16/01/1998	Fri	1905	DA CN1		801	C	H W ON H	N L 100					
SH 29	15S BOULDER BR	9837504	16/09/1998	Wed	1230	DA CN1		801	B	H W ON H	N C 100					
SH 29	150S BOULDER BR	9832335	21/02/1998	Sat	1040	AF CH1		801		H W ON L	N L 100					
SH 29	30N BOULDER BR	9830854	11/02/1998	Wed	1245	BF CE1C			P	H W ON L	N L 100					
SH 29	100N BOULDER BR	9841123	21/10/1998	Wed	0730	DA CE1		801	G	E W OF H	N L 100					
SH 29	A BOULDER BR	9901178	26/01/1999	Tue	1345	BB LE1CC	420A			H D BN F	N L 100			2		
Site Centre: 2774531E 6371269N																
SH 29	1200N NGAMUWAHINE ROAD	9931968	25/03/1999	Thu	0750	DB CS1			C	H D ON F	N C 030					
SH 29	500W SOLDIERS ROAD	2036611	06/07/2000	Thu	1345	CB CN1			TZ	R D BN F	N C 100					

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First Street	Distance / DIR	Second street or landmark	Crash Number	Date DD/MM/YYYY	Day DDD	Time HHMM	MVD / VR / KVN VVV / T 1 234	Factors and Roles (A is for vehicle 1, B is for veh 2 etc)	OBJECT	C U R V E	W E T	L I G H T	W E T H E R	J U N C T	C O N T R L	M A R K S	S P D L M T	Total Inj F	S	M	PED age	CYC age
Site Centre: 2775086E 6371410N																						
SH 29	90E	SOLDIERS ROAD	9632590	16/04/1996	Tue	2305	DA CW1			E	D	DN	F		N	C	100					
SH 29	100E	SOLDIERS ROAD	2037545	21/07/2000	Fri	2320	DA CW1		G	M	W	DN	M		N	C	100					
SH 29	I	SOLDIERS ROAD	2033033	25/04/2000	Tue	1600	XB CN1C			M	D	BN	F	T	S	C	100					
SH 29	I	SOLDIERS ROAD	9743029	27/12/1997	Sat	1044	GD CN1C			R	D	BN	F	T	N	C	100					
SH 29	I	SOLDIERS ROAD	9605375	29/11/1996	Fri	0940	MA CE1T	372B		E	W	ON	S	T	N	C	100			1		
Site Centre: 2775380E 6371567N																						
SH 29	150N	NGAMUWAHINE ROAD	9704494	16/11/1997	Sun	1015	DA CE1	801	E	E	W	ON	H		N	C	100		1			
Site Centre: 2775702E 6371697N																						
SH 29	20E	NGAMUWAHINE ROAD	9702188	19/04/1997	Sat	1400	DA CE1	801 806	T	E	W	OF	H		N	C	100			1		
SH 29	200E	NGAMUWAHINE ROAD	2130256	21/01/2001	Sun	0145	DB CW1		C	E	D	DW	F		N	C	100					
SH 29	200E	NGAMUWAHINE ROAD	9642317	20/12/1996	Fri	1635	DB CE1			M	W	ON	L		N	C	100					
SH 29	150N	NGAMUWAHINE ROAD	9938809	30/08/1999	Mon	1830	AC VS1T			R	D	DN	F		N	C	100					
Site Centre: 2775967E 6371808N																						
SH 29	1000S	SOLDIERS ROAD	2036602	05/07/2000	Wed	0645	AA TE1T			R	D	DN	F		N	L	100					
Site Centre: 2776493E 6372265N																						
SH 29	2020W	MCLAREN FALLS ROAD	9532017	03/02/1995	Fri	0830	DB CS1C	930	M	M	W	ON	L	D	N	N	100					
SH 29	1800N	SOLDIERS ROAD	9830808	16/01/1998	Fri	0940	DB CN1			E	D	BN	F		N	C	100					
Site Centre: 2777283E 6372747N																						
SH 29	1000S	MCLAREN FALLS ROAD	9933313	14/05/1999	Fri	1310	DA CN1			E	W	ON	L		N	C	100					
SH 29	1000W	MCLAREN FALLS ROAD	2042240	11/12/2000	Mon	0750	QG CS1		C	R	W	OF	F		N	C	080					
SH 29	1000W	MCLAREN FALLS ROAD	9640977	01/11/1996	Fri	1800	CB TE1			R	W	ON	L		N	L	100					
SH 29	2000E	NGAMUWAHINE ROAD	9902493	08/06/1999	Tue	1020	DB CE1	195A	C	E	D	BN	F		N	C	100			1		
Site Centre: 2777593E 6373130N																						
SH 29	500W	MCLAREN FALLS ROAD	2042518	31/12/2000	Sun	0330	CC CW1		CV	R	W	DN	L		N	C	100					
Site Centre: 2777874E 6373532N																						
SH 29	I	MCLAREN FALLS ROAD	9604218	22/09/1996	Sun	1413	GC MN1C	174B		R	D	BN	F	T	S	L	100		1	2		

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First Street	D I R / Distance / Second street or landmark	Crash Number	Date DD/MM/YYYY	Day DDD	Time HHMM	H D V R / H VN VVV / T 1 234	Factors and Roles (A is for vehicle 1, B is for veh 2 etc)		OBJECT	CURVE	HILL	LIGHT	WTHR	JUNC	CNTRL	HSE	SPD LMT	Total Inj F	Total Inj S	Total Inj M	PED age	CYC age
SH 29	I MCLAREN FALLS ROAD	9642302	28/12/1996	Sat	1445	CB CH1C			O	R	D	ON	F	T	S	L	100					
SH 29	I MCLAREN FALLS ROAD	9931515	13/03/1999	Sat	1030	GD CN1C				R	D	BF	F	T	S	L	100					
SH 29	I MCLAREN FALLS ROAD	9734448	23/06/1997	Mon	1330	KB CN1C				R	D	N	F	T	N	N	100					

Site Centre: 2778220E 6373812N

First Street	Second street or landmark	Crash Number	Date	Day	Time	Movement	Factors and Roles		OBJECT	CURVE	HILL	LIGHT	WTHR	JUNC	CNTRL	HSE	SPD LMT	F	S	M	PED age	CYC age
SH 29	250E THORN ROAD	2033067	19/04/2000	Wed	1855	DB CE1			F	E	W	DN	L		N	C	100					
SH 29	250E THORN ROAD	2042517	30/12/2000	Sat	1305	DB CE1				E	W	ON	L		N	C	100					
SH 29	300E THORN ROAD	9732571	14/04/1997	Mon	1330	DB TE1				M	W	ON	L		N	L	100					
SH 29	250N THORN ROAD	9830807	01/01/1998	Thu	1345	BE VH1C				R	D	BF	F		N	C	100					
SH 29	500N THORN ROAD	9938967	13/08/1999	Fri	2020	BF CN1C				E	D	DN	F		N	L	100					

Site Centre: 2778519E 6374143N

First Street	Second street or landmark	Crash Number	Date	Day	Time	Movement	Factors and Roles		OBJECT	CURVE	HILL	LIGHT	WTHR	JUNC	CNTRL	HSE	SPD LMT	F	S	M	PED age	CYC age
SH 29	800E MCLAREN FALLS ROAD	9901740	04/04/1999	Sun	1330	EC TE1	137A		CW	R	D	BN	F		N	L	100		1			
SH 29	1000E MCLAREN FALLS ROAD	9540154	27/10/1995	Fri	2200	CC VN1			C	R	W	DN	L		N	L	100					
SH 29	2000S RUAHIHI ROAD	9502885	22/02/1995	Wed	1515	CB CS1	132A 615A	801	ET	R	W	ON	L		N	C	100			1		

Site Centre: 2778617E 6374695N

First Street	Second street or landmark	Crash Number	Date	Day	Time	Movement	Factors and Roles		OBJECT	CURVE	HILL	LIGHT	WTHR	JUNC	CNTRL	HSE	SPD LMT	F	S	M	PED age	CYC age
SH 29	1600E MCLAREN FALLS ROAD	9502873	09/01/1995	Mon	0845	DA TS1		801		M	W	ON	L		N	C	100			1		
SH 29	1000S PORIPORI ROAD	9931966	03/04/1999	Sat	1050	FD CN1CC				R	D	BN	F		N	L	100					

Site Centre: 2778764E 6375046N

First Street	Second street or landmark	Crash Number	Date	Day	Time	Movement	Factors and Roles		OBJECT	CURVE	HILL	LIGHT	WTHR	JUNC	CNTRL	HSE	SPD LMT	F	S	M	PED age	CYC age
SH 29	400S PORIPORI ROAD	9701224	15/02/1997	Sat	1750	GE VS1C	160A	929		R	D	BN	F	D	N	L	100			1		
SH 29	500S PORIPORI ROAD	2037307	15/06/2000	Thu	0640	EC CS1			J	R	D	DN	F		N	L	100					
SH 29	500S PORIPORI ROAD	2037308	15/06/2000	Thu	0635	EC CS1			P	R	D	DN	F		N	L	100					
SH 29	500S PORIPORI ROAD	9802644	15/07/1998	Wed	0430	EC CS1		822	L	E	W	DN	HS		N	C	100			4		
SH 29	500S PORIPORI ROAD	2037309	15/06/2000	Thu	0629	QO TN1			P	R	D	DN	F		N	L	100					

Site Centre: 2778911E 6375520N

First Street	Second street or landmark	Crash Number	Date	Day	Time	Movement	Factors and Roles		OBJECT	CURVE	HILL	LIGHT	WTHR	JUNC	CNTRL	HSE	SPD LMT	F	S	M	PED age	CYC age
SH 29	20E PORIPORI ROAD	9904688	20/11/1999	Sat	1140	FD HH1CV	111A 181A			E	D	BN	F		N	C	100		1			
SH 29	10N PORIPORI ROAD	2000190	09/12/2000	Sat	1145	BF VS1T	132A 331A 692A 692B			E	D	BN	F	T	N	C	100	1				
SH 29	150N PORIPORI ROAD	2001286	13/02/2000	Sun	1604	CB CS1E	129A 134A 402A			R	D	ON	F		N	L	100			1	32	
SH 29	25S PORIPORI ROAD	9836860	05/08/1998	Wed	1910	EA TS1C			H	E	D	DN	F		N	C	100					
SH 29	25W PORIPORI ROAD	9901759	21/03/1999	Sun	1345	MC CN1C	372B			R	D	BN	F		N	L	100			1		
SH 29	I PORIPORI ROAD	9904731	26/12/1999	Sun	0945	GC CS1C	174B 351B 372B			E	D	ON	F	T	G	L	100		1	2		

Site Centre: 2779164E 6375904N

First Street	Distance	Second street or landmark	Crash Number	Date DD/MM/YYYY	Day DDD	Time HHMM	M D V R H VN VVV T 1 234	Factors and Roles (A is for vehicle 1, B is for veh 2 etc)		O B J E C T	C W L W J C M S (Cur Wet Lgt Wth Jnc Ctl Mkg Spd)	Total Inj F S M	F E D a g e	C Y C a g e
SH 29	30W	RUAHIHI ROAD	9904104	24/10/1999	Sun	1205	LB CE1C	303B	930		E D BN F D N C 100	5		
Site Centre: 2779625E 6376507N														
SH 29	1300W	OMANAWA ROAD	9930428	03/02/1999	Wed	2205	DB CW1				E D DN F N C 100			
SH 29	1500W	OMANAWA ROAD	9931965	14/03/1999	Sun	1345	MC CW1V				R D BN F N C 100			
SH 29	700E	RUAHIHI ROAD	9903842	29/09/1999	Wed	2040	EC VS1		862 912	N	E D DN F N C 100	1		
SH 29	800N	RUAHIHI ROAD	9505729	08/12/1995	Fri	1230	DB CS1	358A			E D BN F N C 100	1		
SH 29	800N	RUAHIHI ROAD	9937052	23/07/1999	Fri	2130	DB CS1			C	M W DN L N C 100			
Site Centre: 2780280E 6377340N														
SH 29	300W	OMANAWA ROAD	9536954	26/07/1995	Wed	1745	AB VN1C				R W TN L N C 100			
Site Centre: 2780490E 6377554N														
SH 29	50E	OMANAWA ROAD	9641877	07/12/1996	Sat	1200	LB CE1C		930		R D BN E D N 100			
SH 29	60E	OMANAWA ROAD	9930071	14/01/1999	Thu	1642	EB CN1C			Q	M W ON L N C 100			
SH 29	60E	OMANAWA ROAD	9930072	14/01/1999	Thu	1640	DA CN1			C	M W ON L N C 100			
SH 29	100E	OMANAWA ROAD	9643163	06/12/1996	Fri	1800	CB CE1			C	R D BN F N L 030			
SH 29	250E	OMANAWA ROAD	9640599	27/10/1996	Sun	1610	DA CE1				E W OF N C 100			
SH 29	120N	OMANAWA ROAD	9931517	23/03/1999	Tue	0940	QG VS1			P	E D BN F N C 100			
SH 29	150N	OMANAWA ROAD	2035028	03/06/2000	Sat	2210	CC VN1		821 832 901	T	R W DN HS N N 100			
SH 29	200N	OMANAWA ROAD	9700231	02/12/1997	Tue	0750	BF VN1V	111A 982A	801		M W ON L N C 100	1 1		
SH 29	20S	OMANAWA ROAD	9642301	06/12/1996	Fri	1955	BC VN1C			Q	M D BN F T S 100			
SH 29	150S	OMANAWA ROAD	9938808	18/09/1999	Sat	1800	CB CS1			C	R D TN F N C 100			
SH 29	100W	OMANAWA ROAD	9602819	05/06/1996	Wed	1329	CB CW1	198A 515A		CY	R D BN F N C 100	1		
SH 29	120W	OMANAWA ROAD	9902571	27/05/1999	Thu	0600	CB CS1	101A 112A		CV	R W DN L N C 100	1		
SH 29	200W	OMANAWA ROAD	9630133	08/01/1996	Mon	1445	BE CE1C			C	R W ON L N L 100			
SH 29	I	OMANAWA ROAD	9501919	12/03/1995	Sun	1040	JA CS1C	101B 302B			E W ON L T G L 100	1		
SH 29	I	OMANAWA ROAD	9702915	05/07/1997	Sat	1355	JA CW1C	301B			R D F F T S L 100	3		
SH 29	I	OMANAWA ROAD	9902509	23/05/1999	Sun	1800	GD CN1V	333A	832		R D DN F T N L 100	1		
Site Centre: 2780686E 6377757N														
SH 29	700S	BELK ROAD	9601126	21/01/1996	Sun	1430	DA CE1	410A		C	E D BF F N C 100	1		
Site Centre: 2780951E 6377886N														
SH 29	350S	BELK ROAD	9640275	23/10/1996	Wed	1840	DB CS1				M W OF L N C 100			
SH 29	400S	BELK ROAD	9537852	19/08/1995	Sat	1020	DB CS1C				S D BN F N C 100			

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First Street        | D |Second street         |Crash  |Date       Day Time |        | Factors and Roles        |O  C W L H J C H S  Total  P  C
                    | I |or landmark           |Number |                  |        |                          |B  U E I E U O A P   Inj   E  Y
                    | R |                      |       |                  |        |                          |J  R T G T N H R D         D  C
                    |   |                      |       |                  |M  D    |A is for vehicle 1        |E  V N H H C T K L  F S M  a  a
                    |   |                      |       |                  |V  R    |B is for veh 2 etc        |C  E E T E T R S H  A E I  g  g
           Distance |   |                      |       |DD/MM/YYYY DDD HHMM|T 1 234 |                          |T    S   R   L   T  T R H  e  e
SH 29                400S BELK ROAD              9605587 27/10/1996 Sun 1255 BF CN1C  982A                        C  S W ON L   N C 100  2 1
SH 29                150N OMANAWA STM BR         9641390 22/11/1996 Fri 2245 DB CE1                                  M W DN L   N C 050
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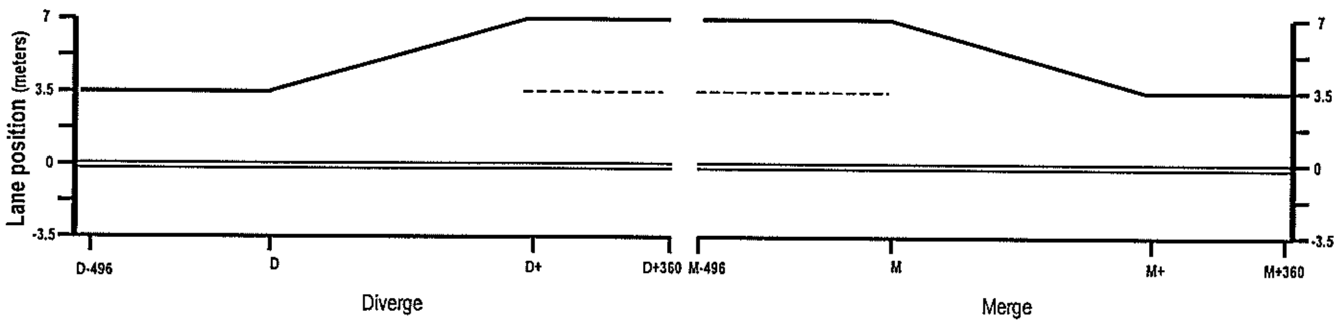
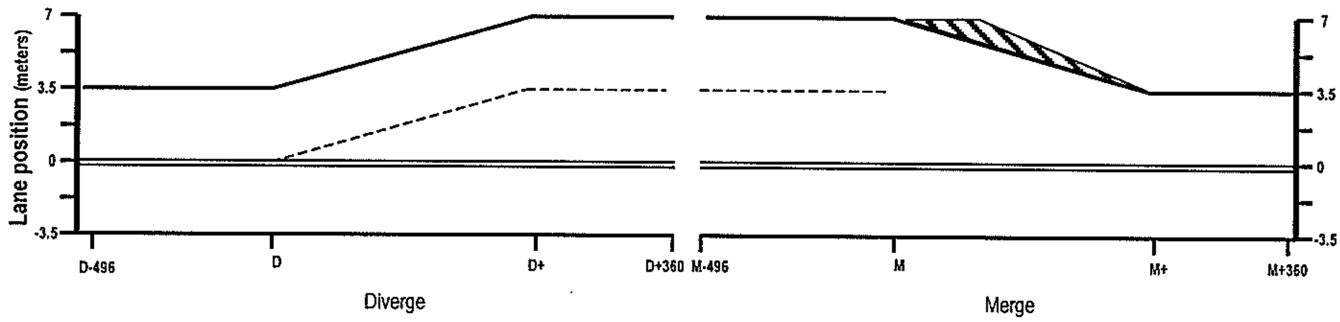
Figures

Current NZ



New NZ



Australian

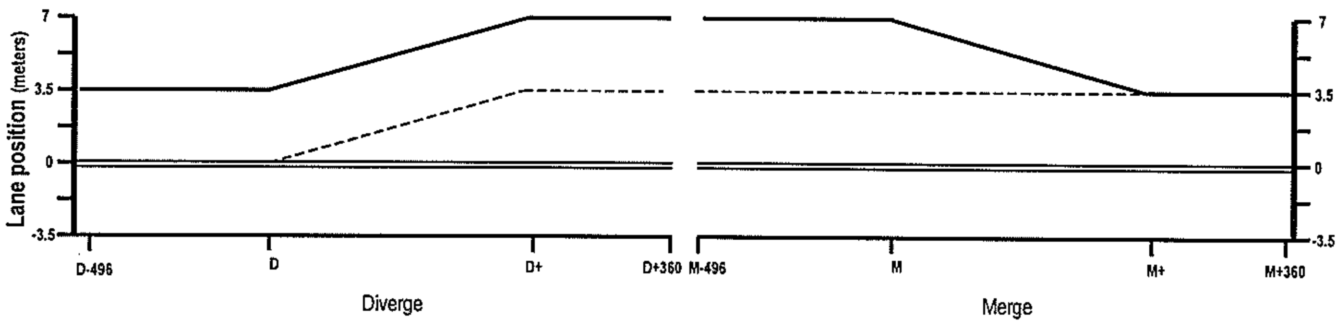


Figure 1. The three overtaking lane treatments selected (not including the slow vehicle bay treatment).

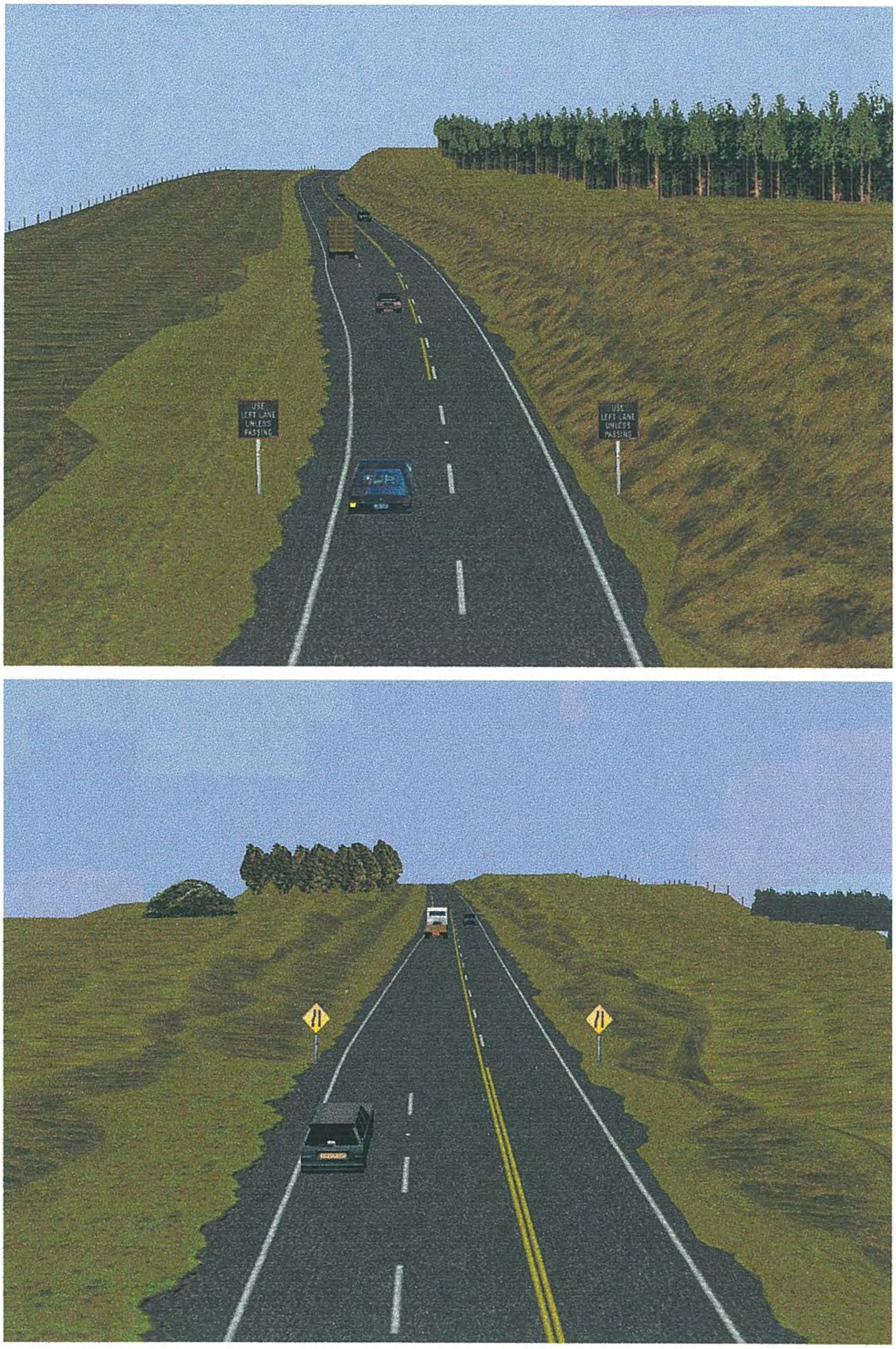


Figure 2. Current NZ Overtaking Lane Treatment
as depicted in simulation

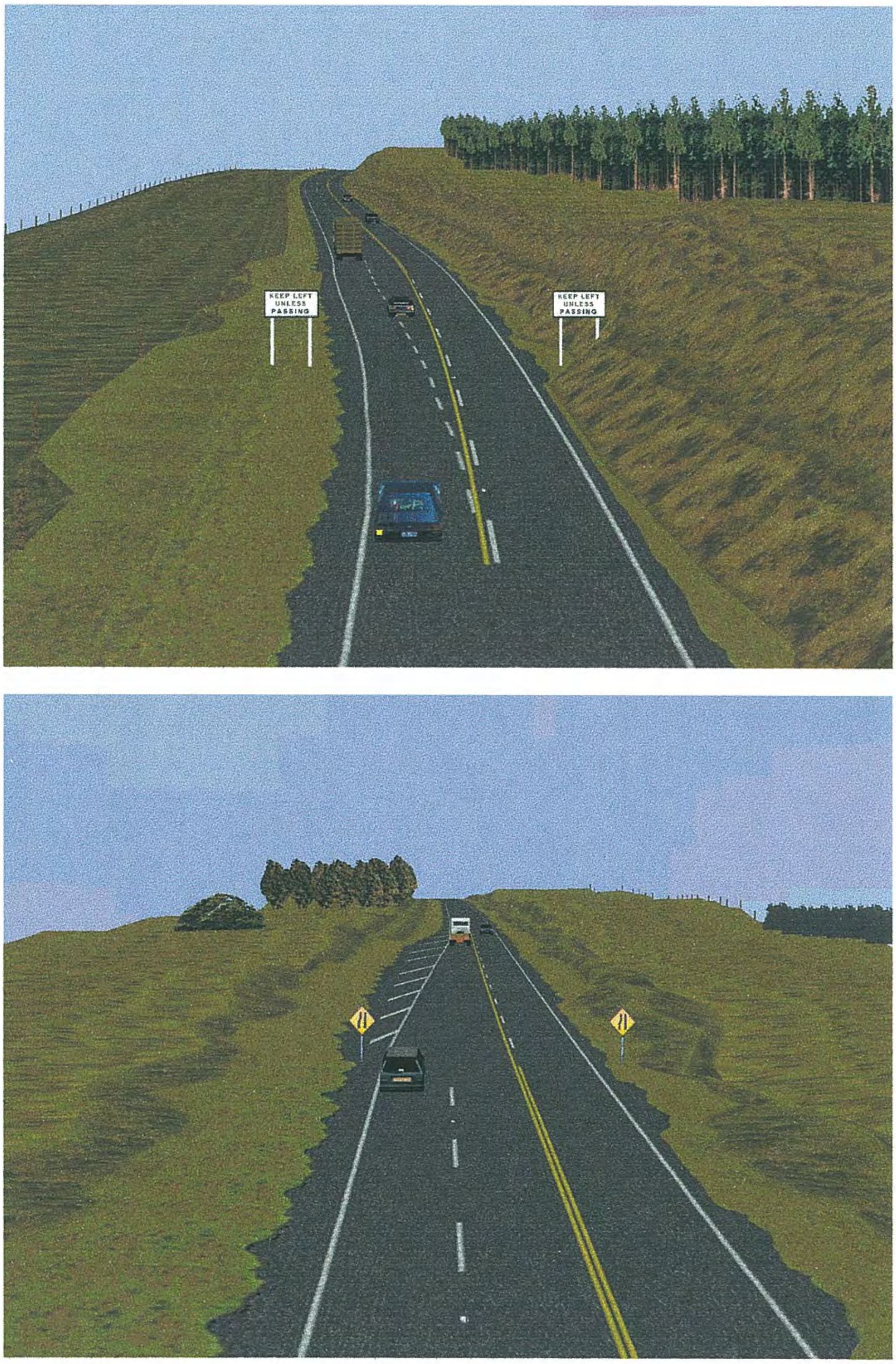


Figure 3. New NZ Overtaking Lane Treatment as depicted in simulation

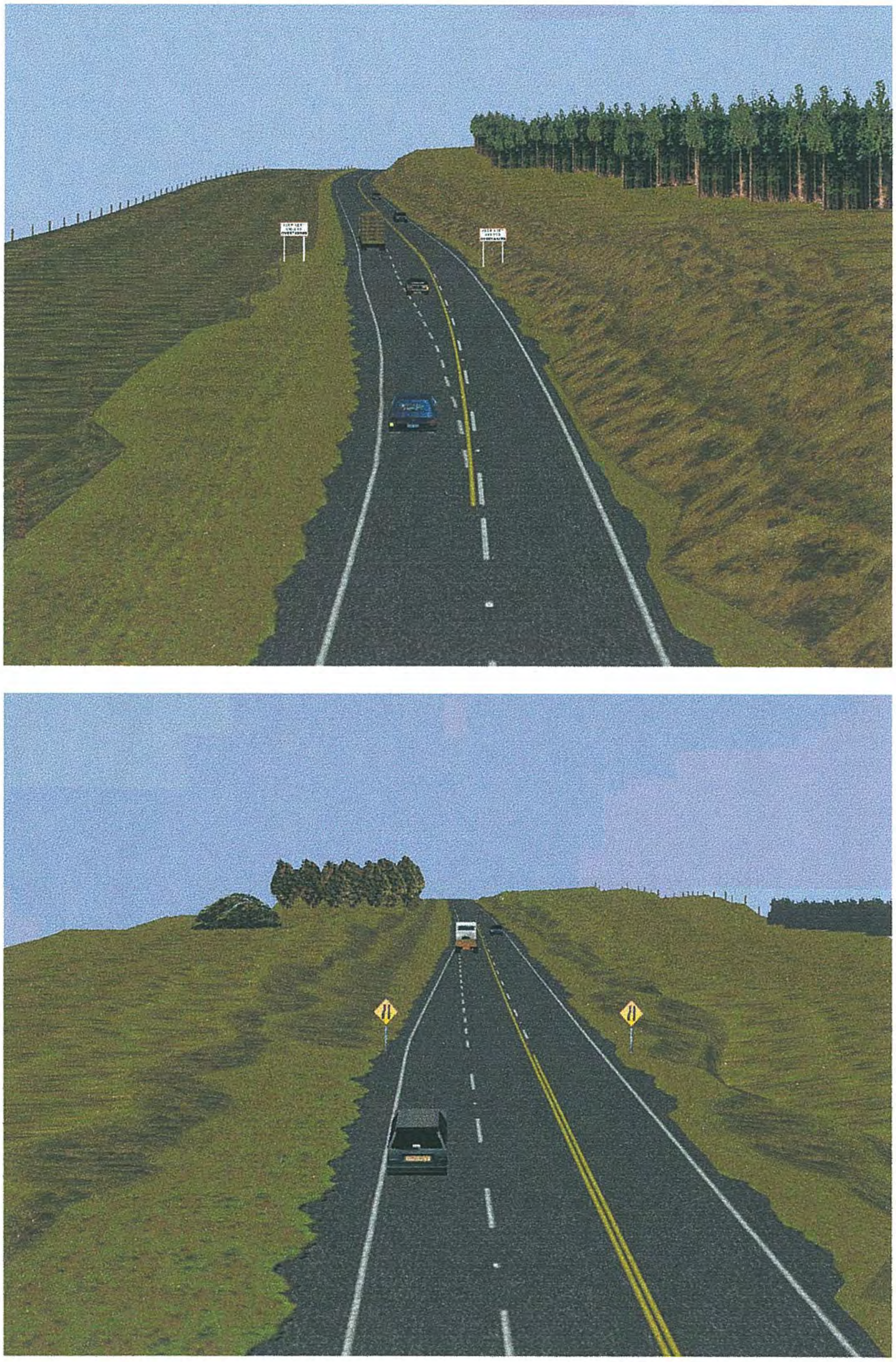


Figure 4. Modified Australian Overtaking Lane Treatment as depicted in simulation

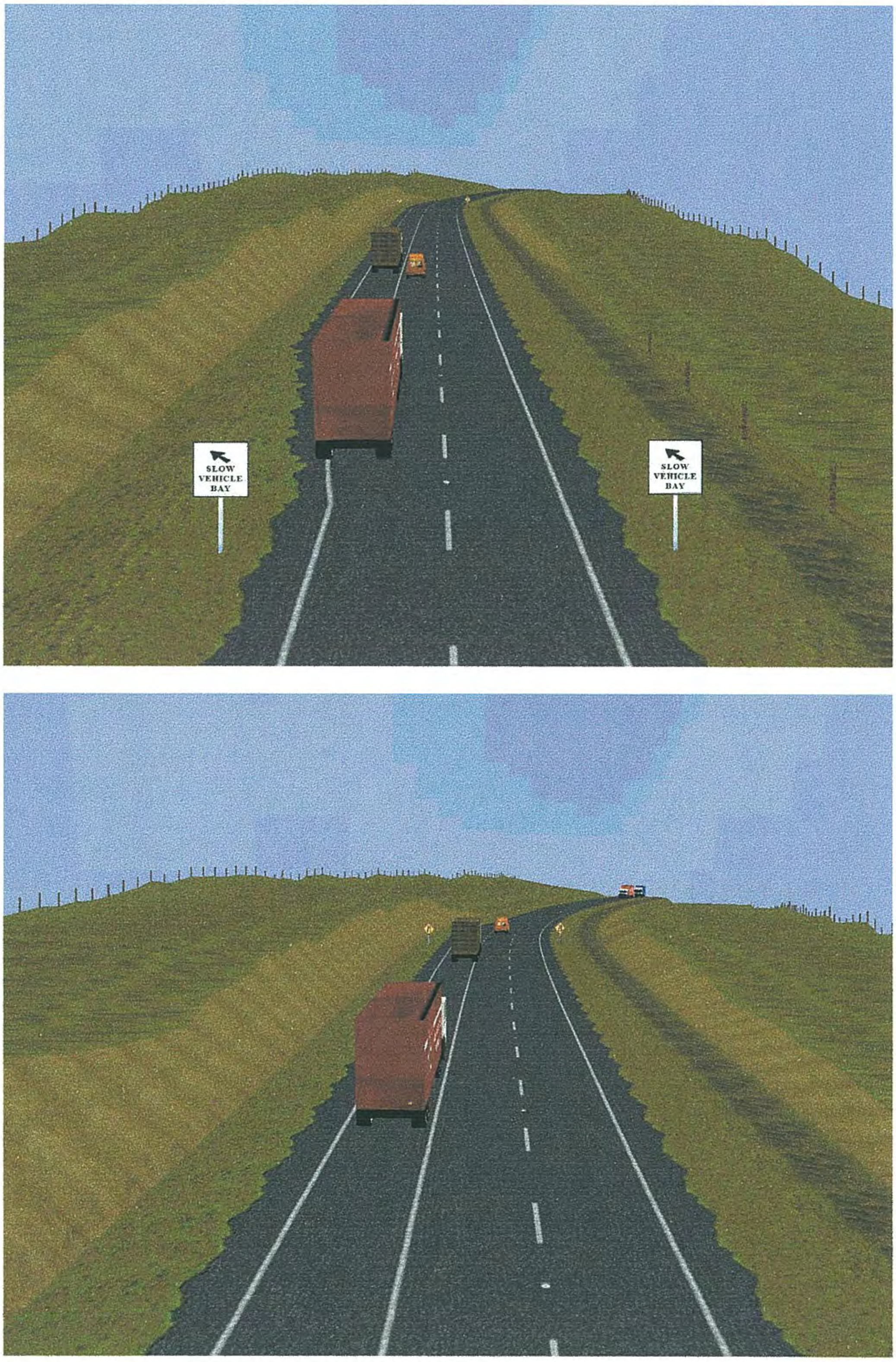


Figure 5. Slow Vehicle Bay Treatment
as depicted in simulation

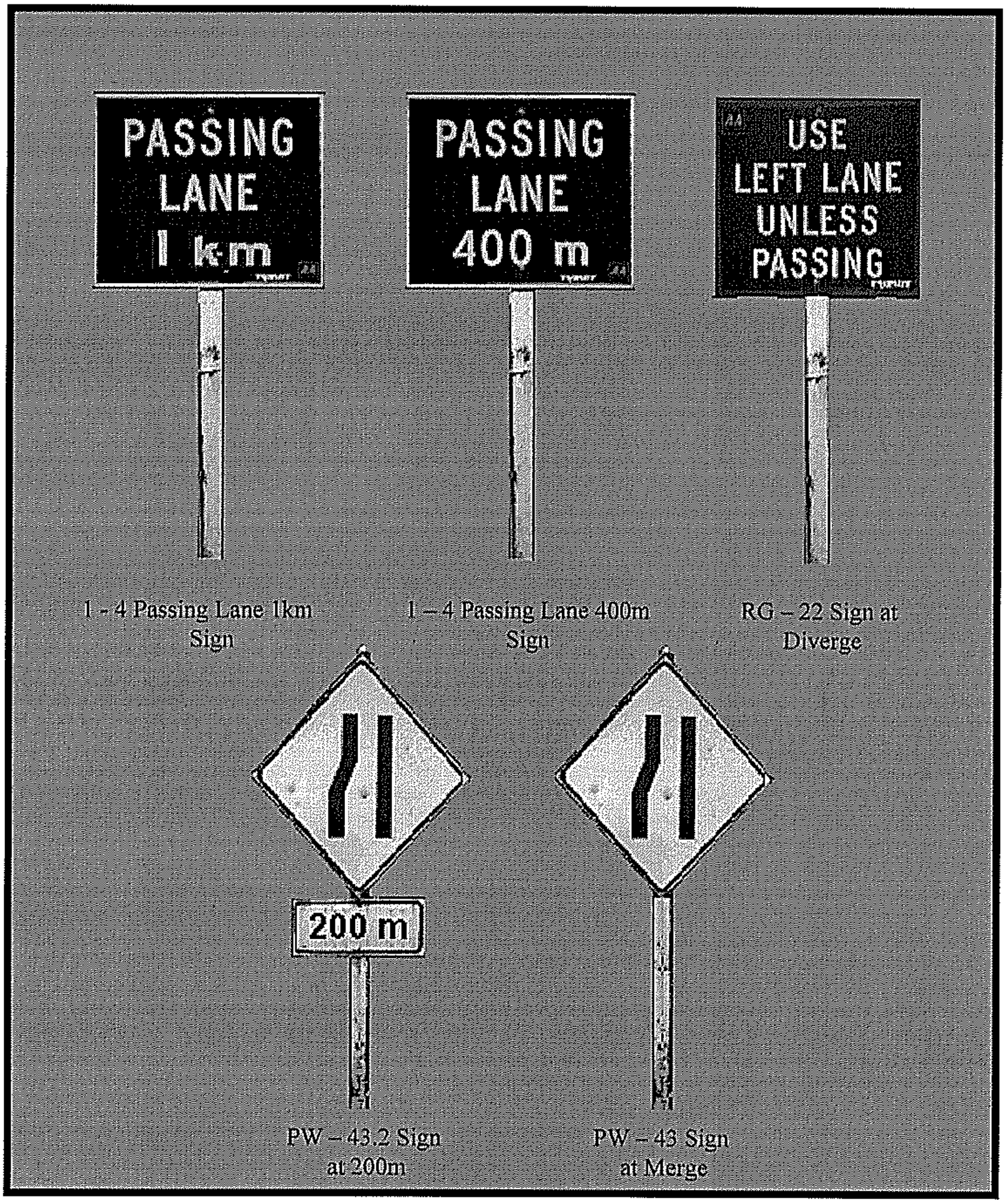


Figure 6. Signage for the Current NZ treatment.

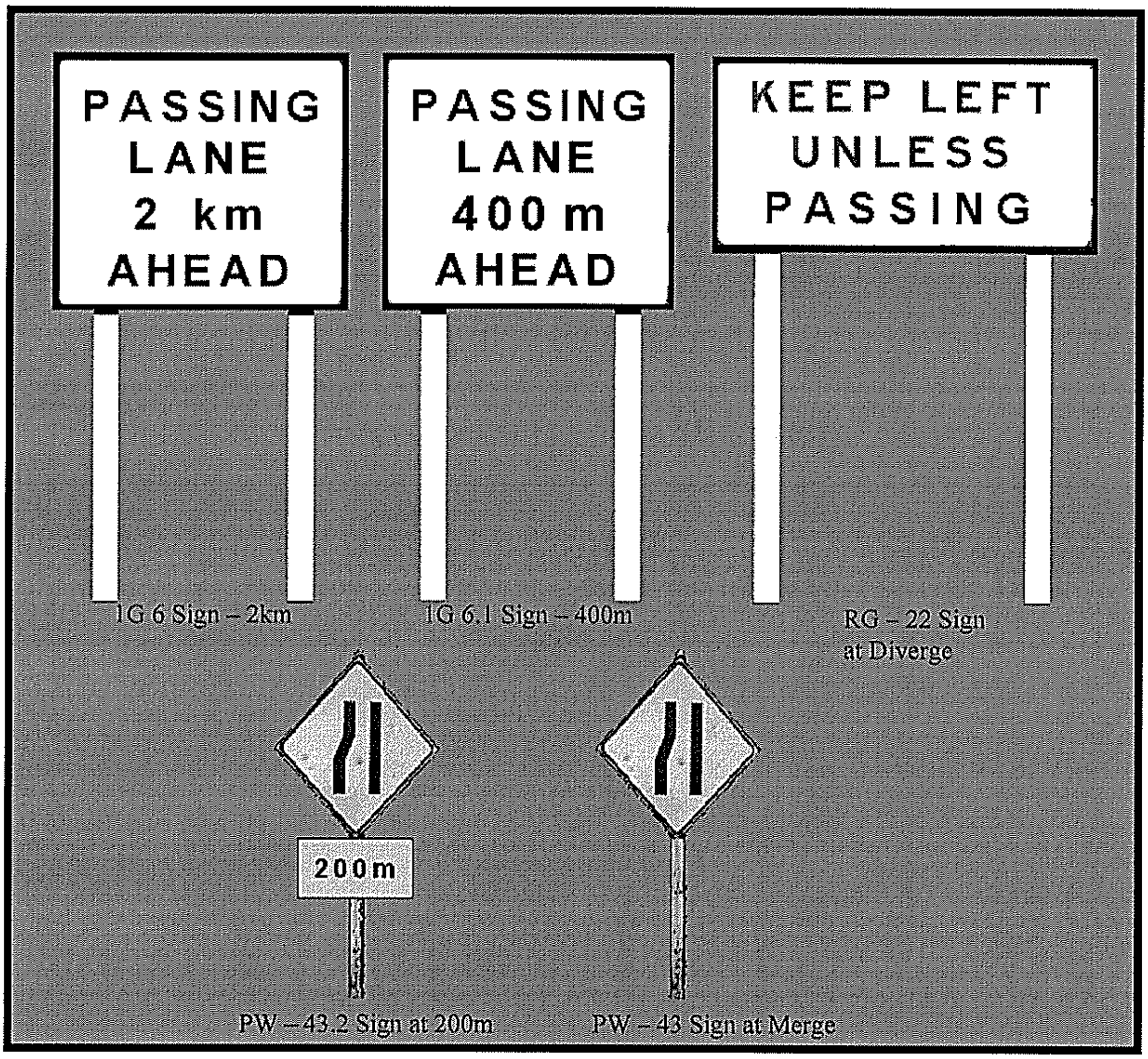


Figure 7. Signage for the New NZ treatment.

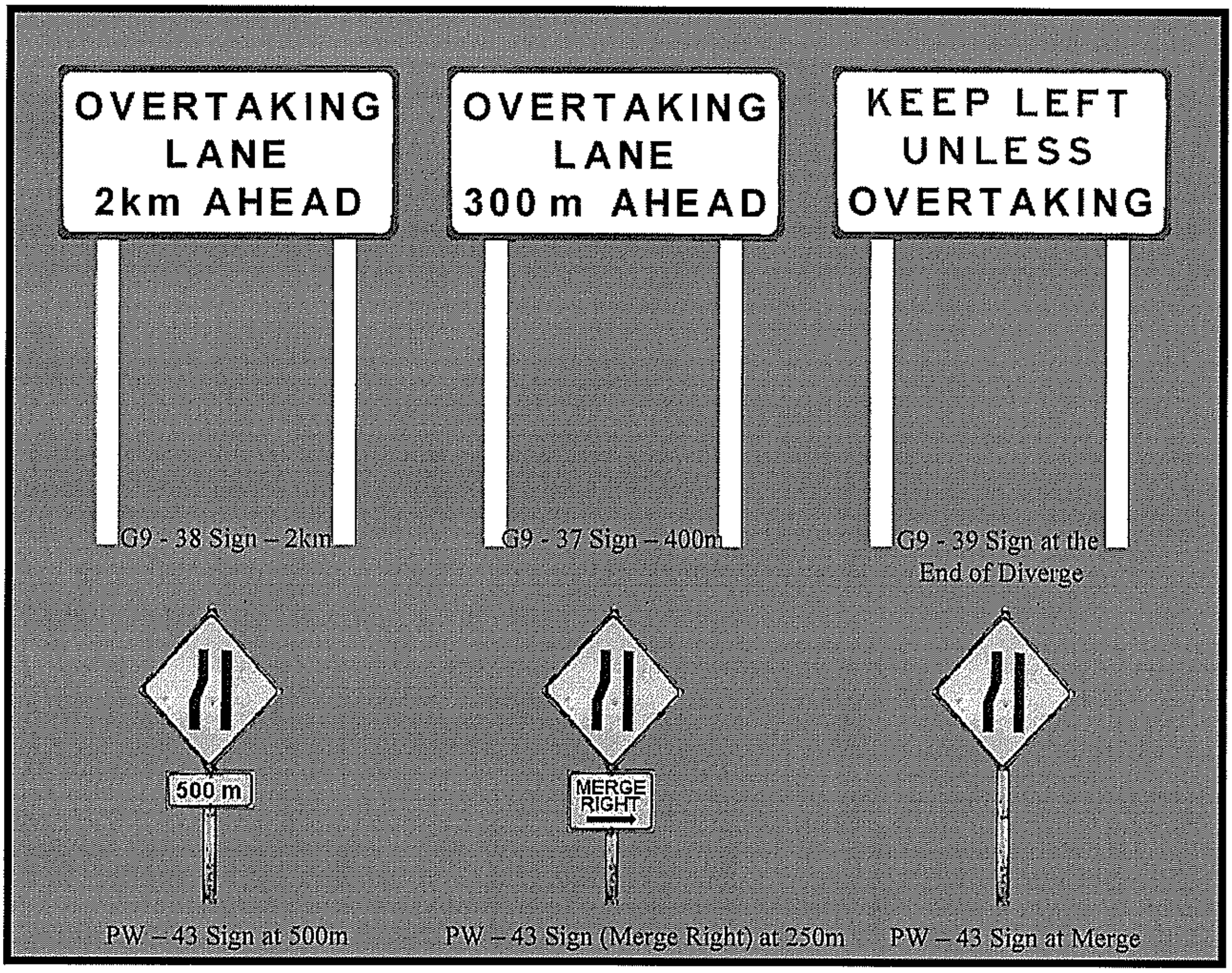


Figure 8. Signage for the Australian treatment

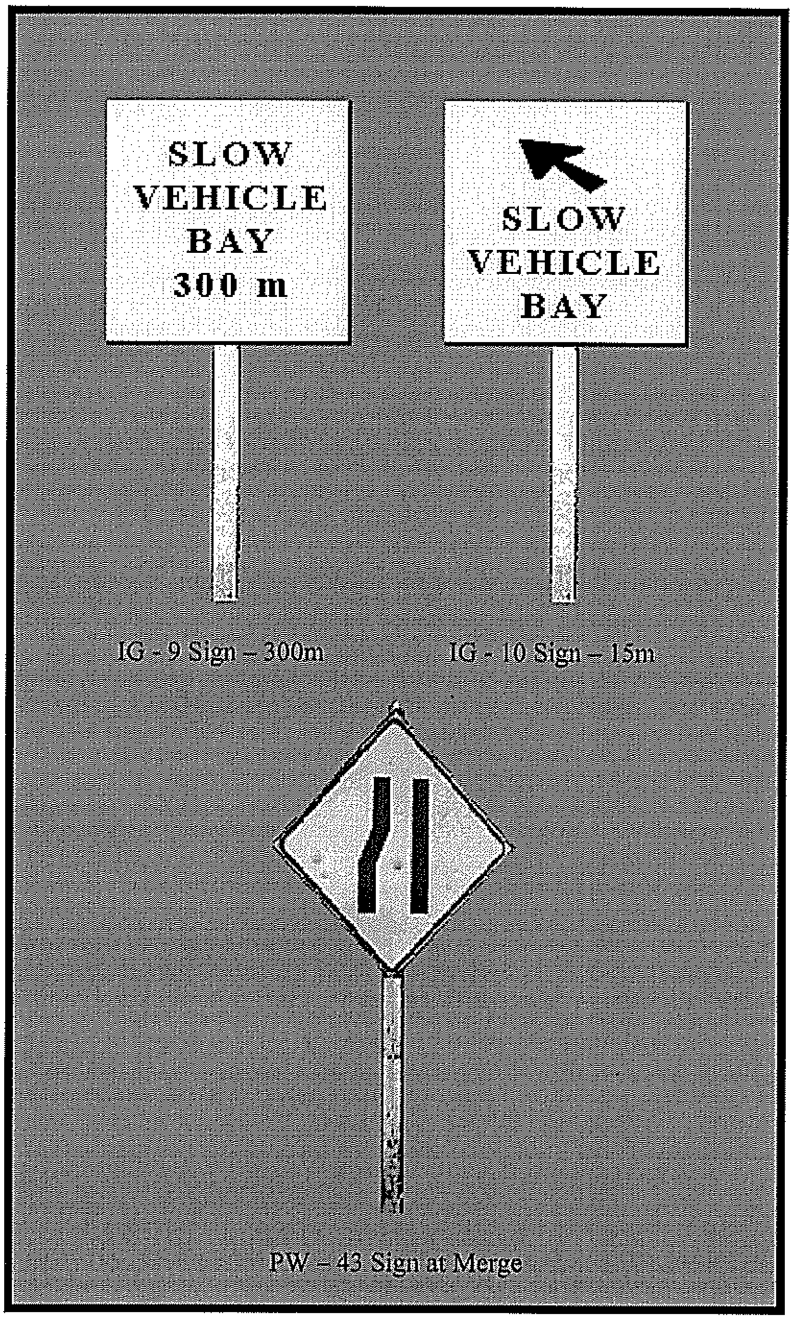
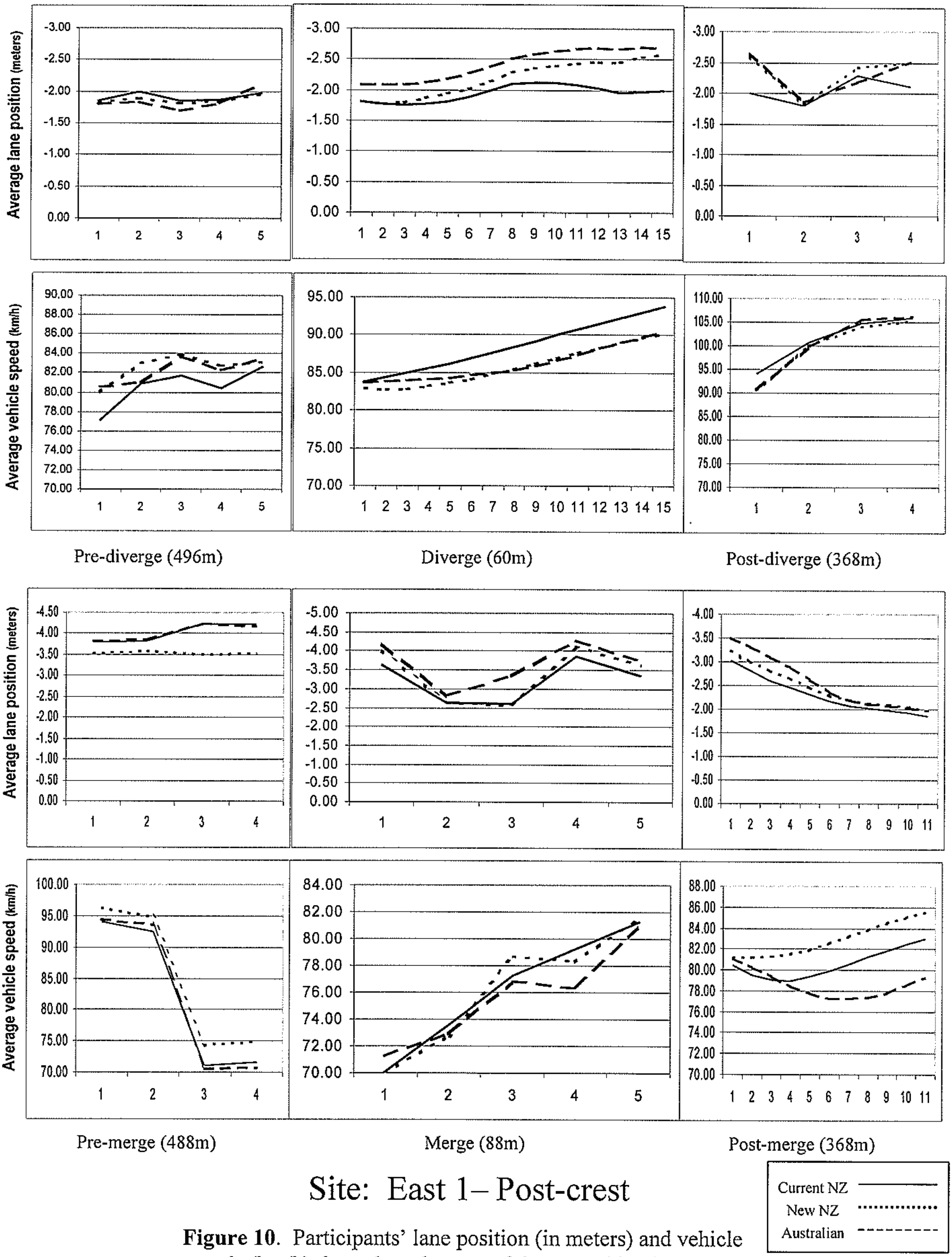
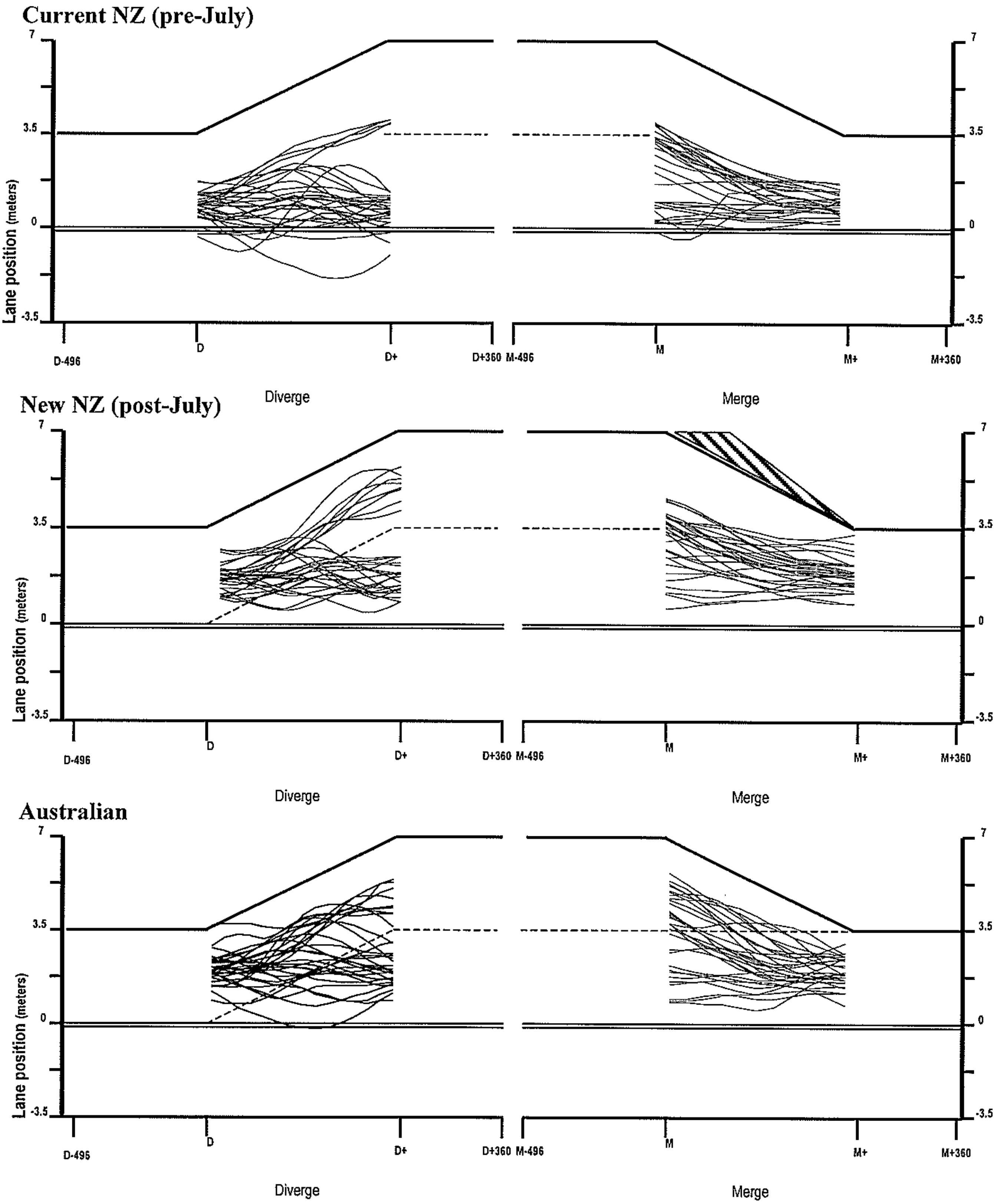


Figure 9. Signage for the Slow Vehicle Bay



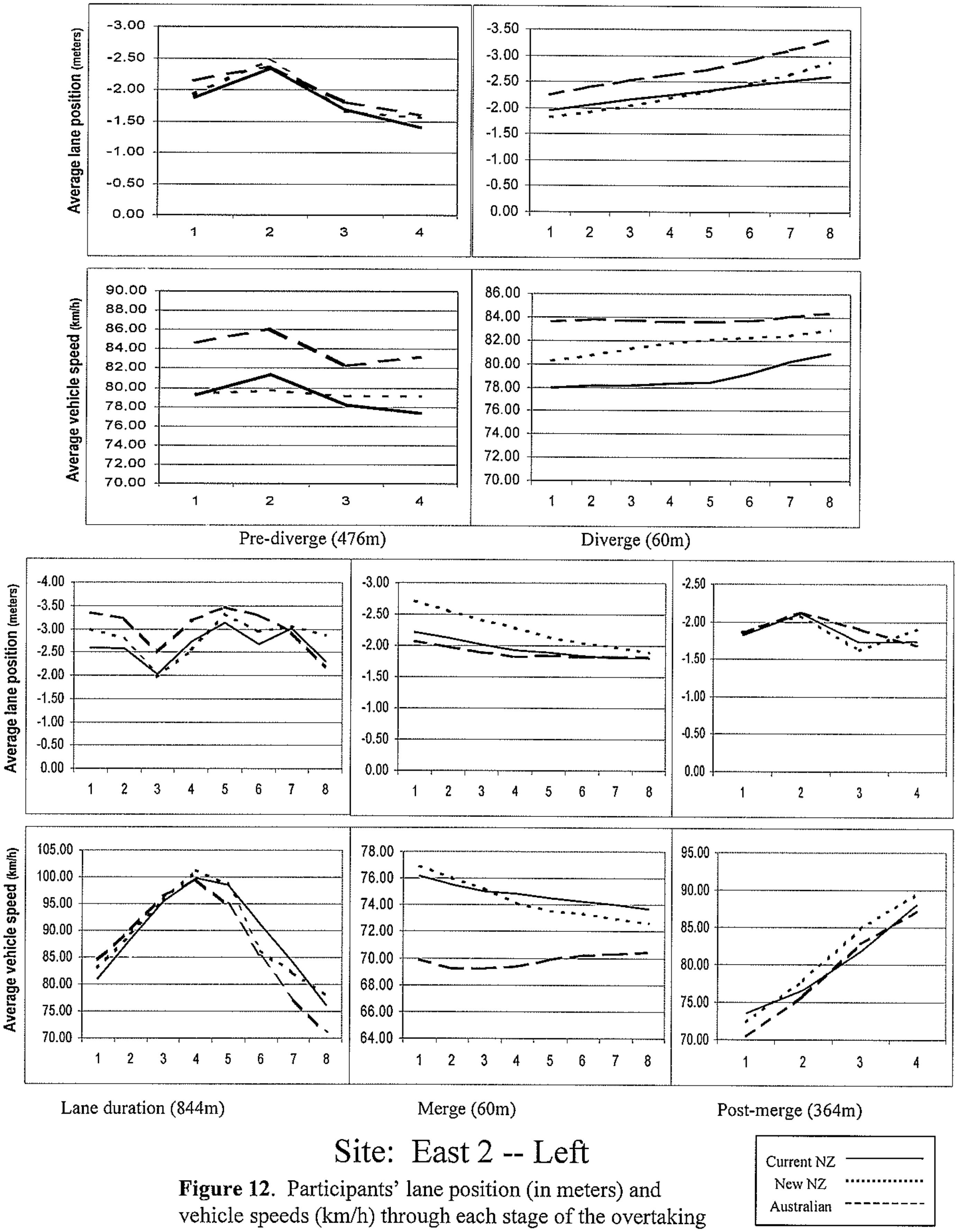
Site: East 1– Post-crest

Figure 10. Participants' lane position (in meters) and vehicle speeds (km/h) through each stage of the overtaking lane.



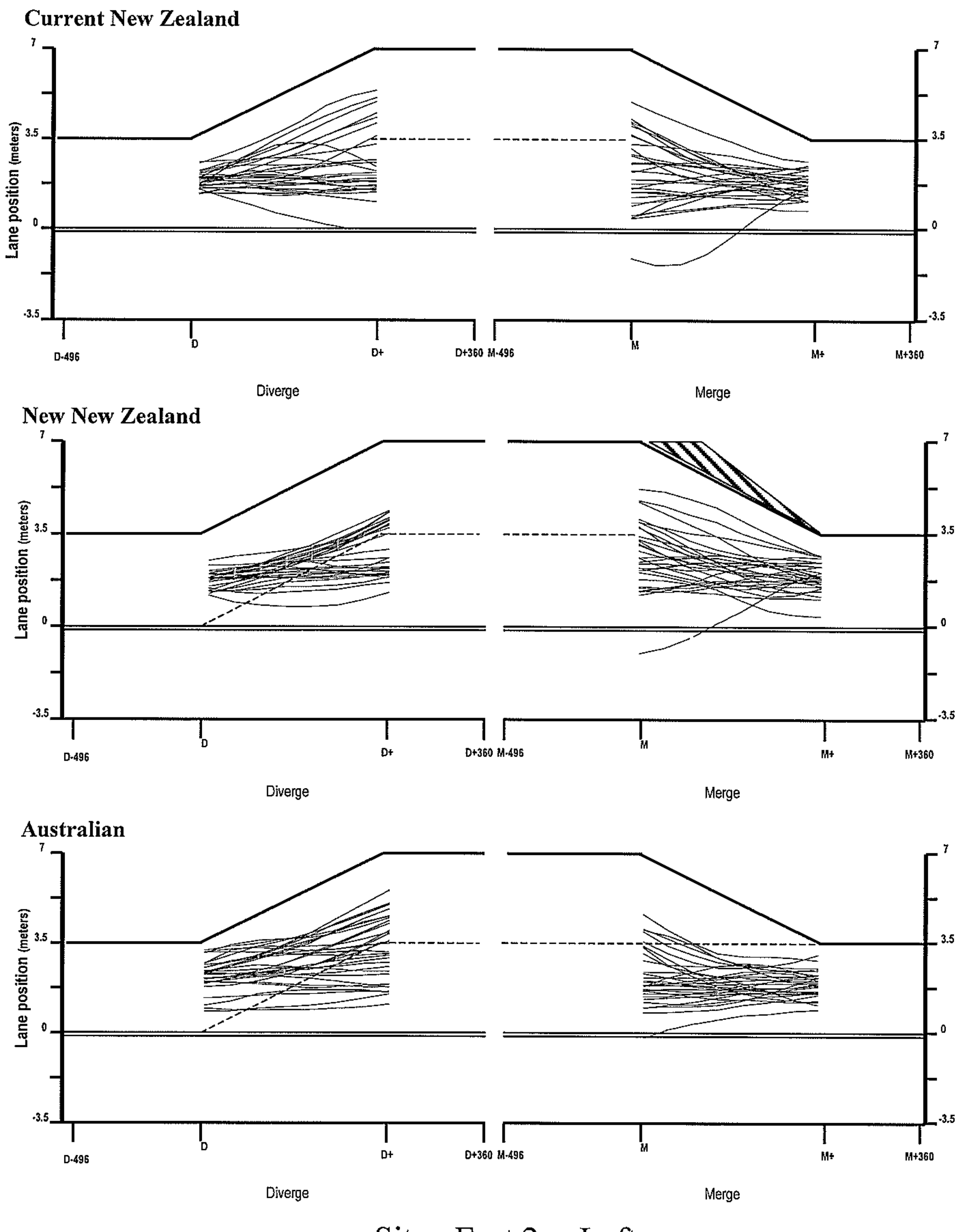
Site: East 1– Post-crest

Figure 11. Individual participants' paths through overtaking lane.



Site: East 2 -- Left

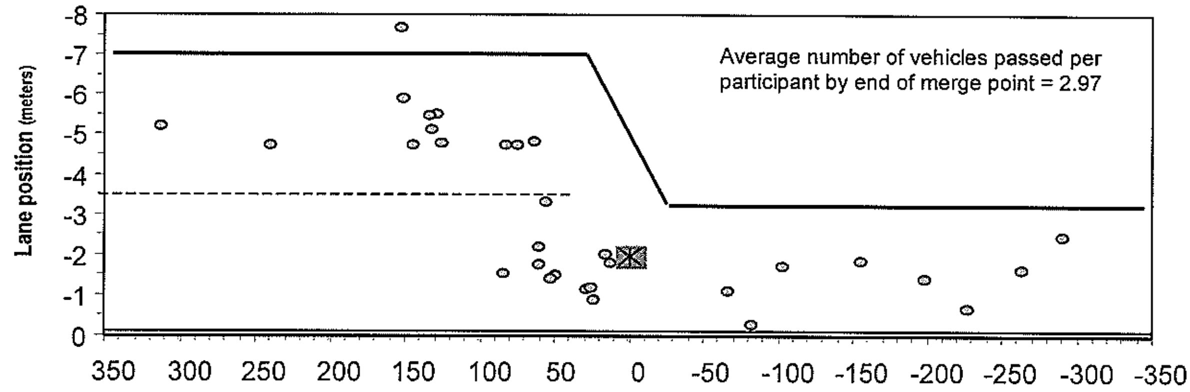
Figure 12. Participants' lane position (in meters) and vehicle speeds (km/h) through each stage of the overtaking lane.



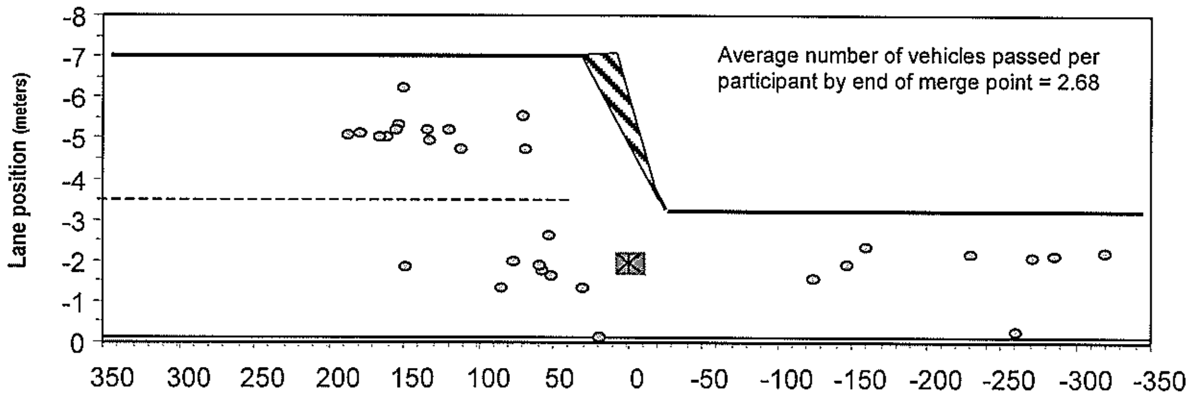
Site: East 2 -- Left

Figure 13. Individual participants' paths through overtaking lane.

Current New Zealand



New New Zealand



Australian

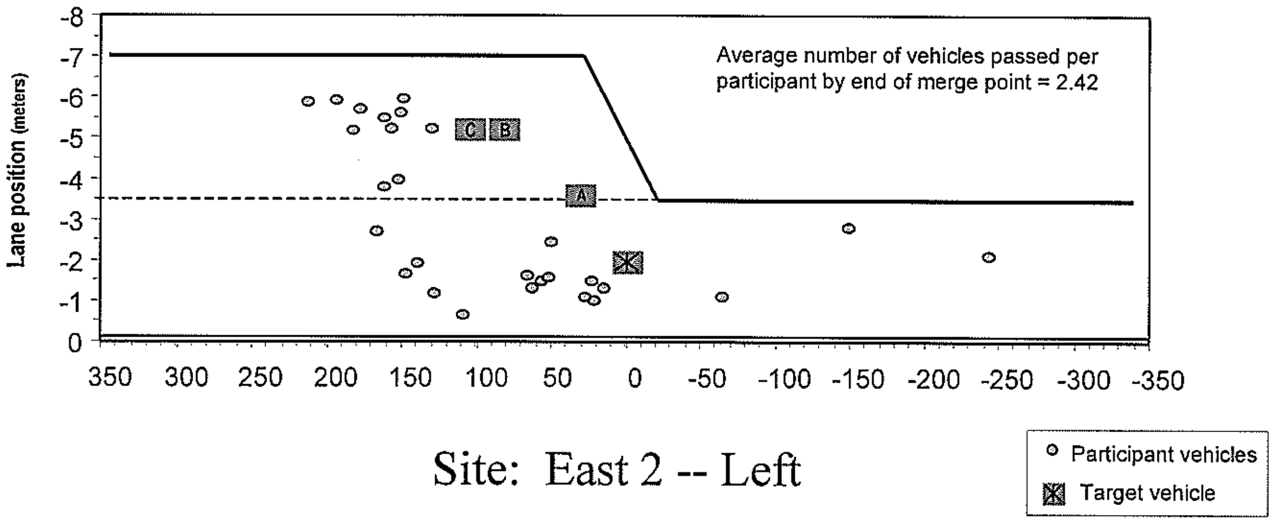
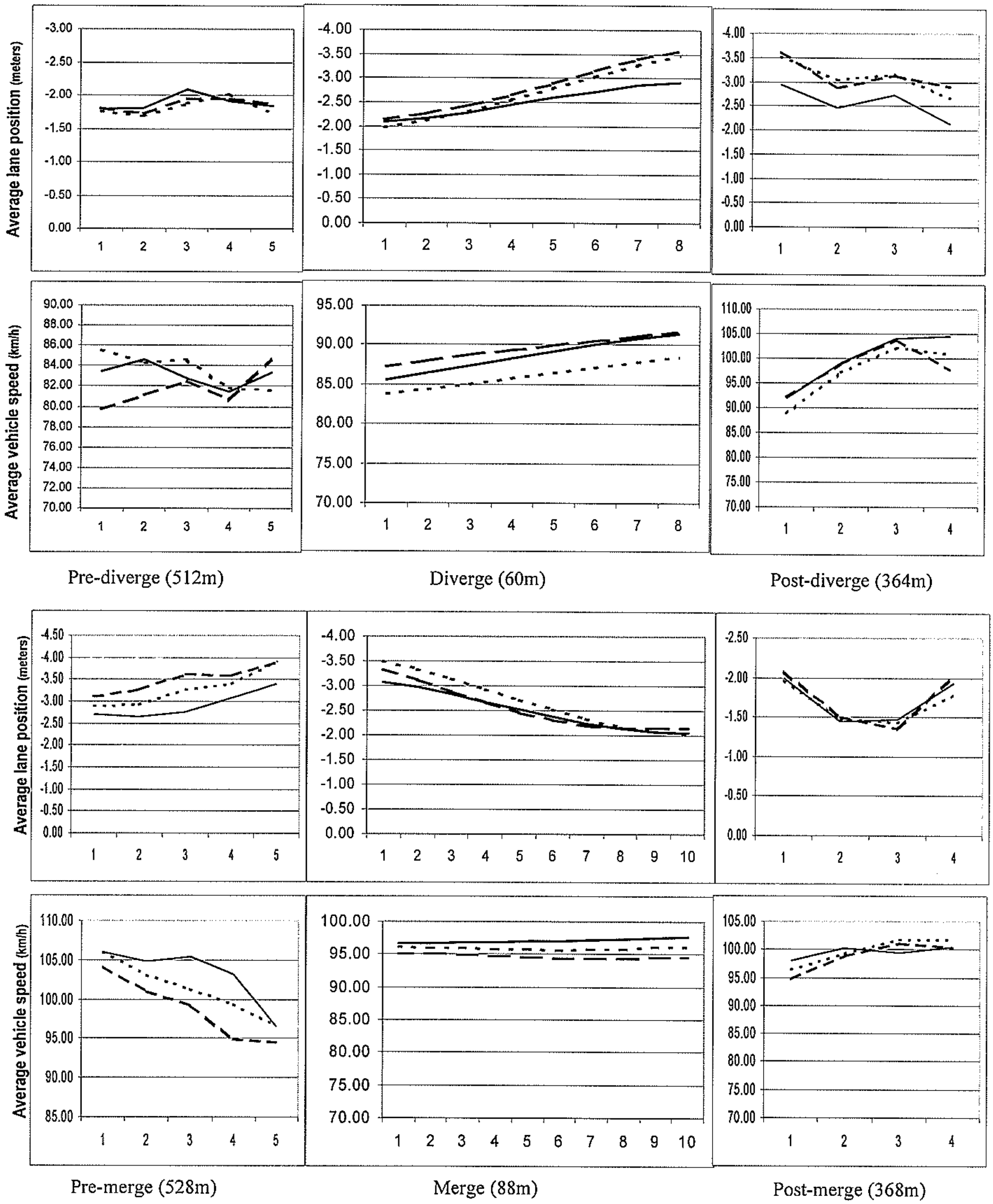


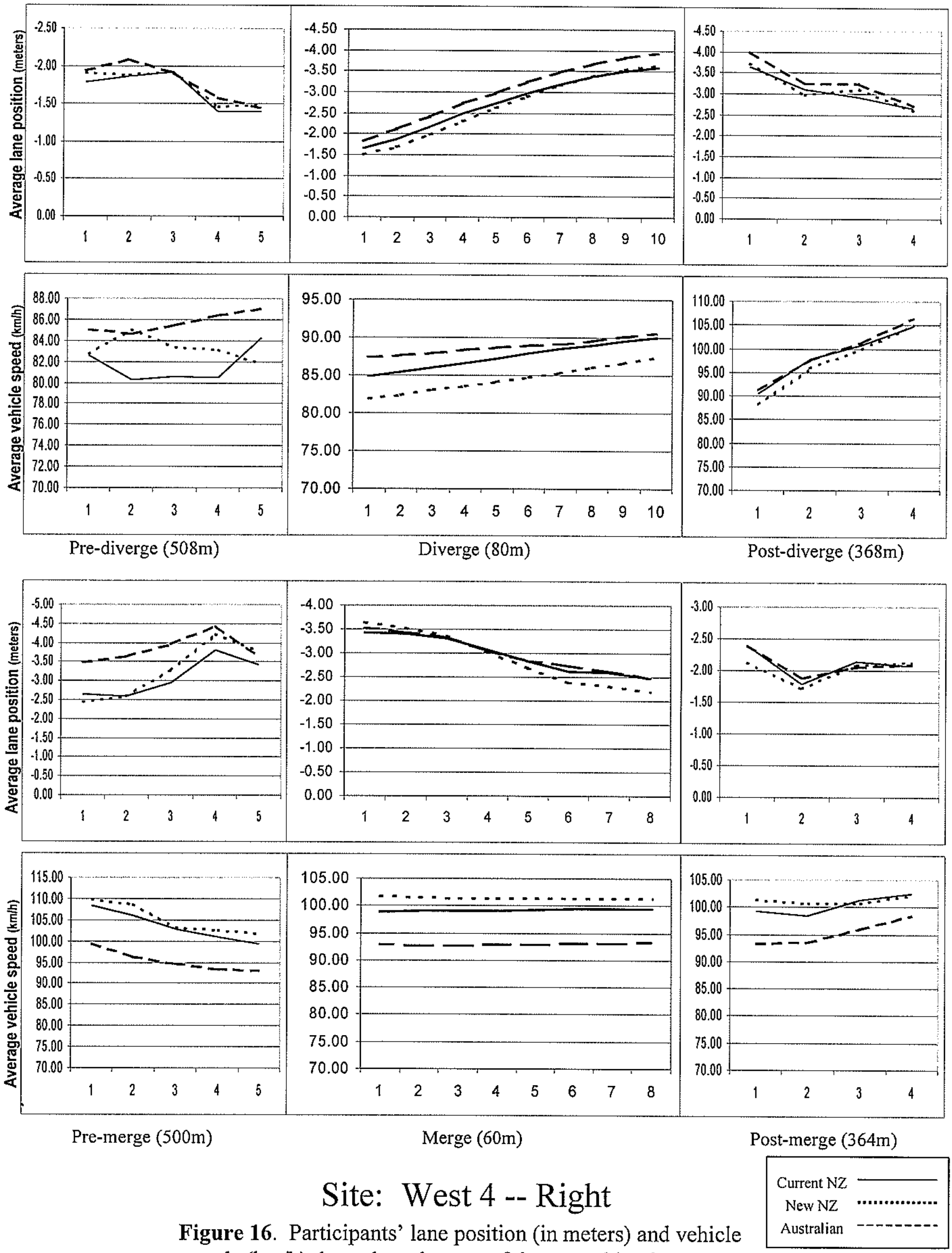
Figure 14. Distance from participants' vehicles to target vehicle as target vehicle completes merge from left lane. Target vehicle was fifth of five vehicles ahead of the participants through the overtaking lane. The positions of three other vehicles in the simulation (A, B, & C) are also shown for reference in the bottom panel.

Note: Not shown on above scale, 1 participant at –571.88 meters ahead for New NZ treatment, and 3 participants at –492.83, -650.54, and –804.13 for Australian treatment.



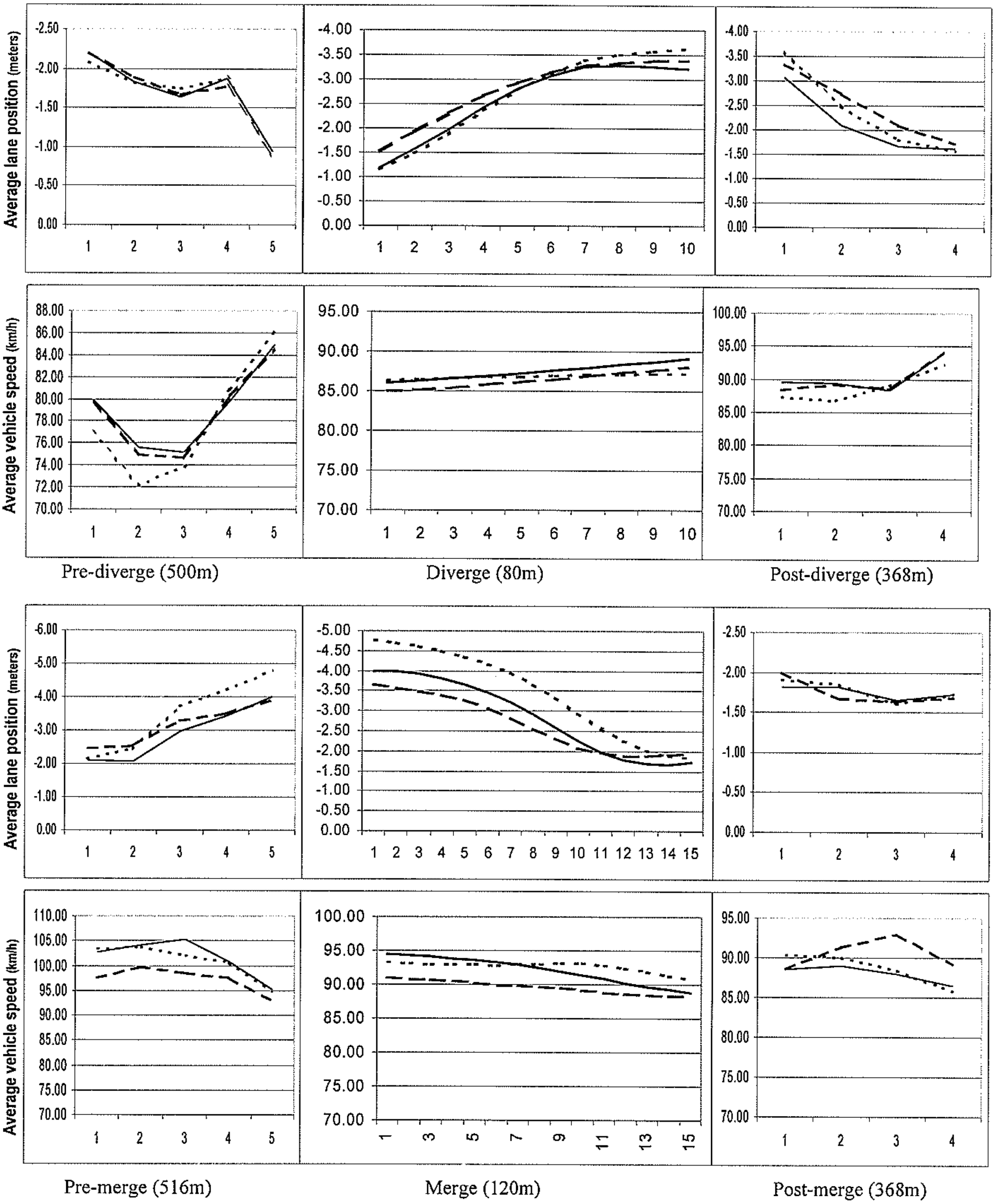
Site: West 3 -- Straight

Figure 15. Participants' lane position (in meters) and vehicle speeds (km/h) through each stage of the overtaking lane.



Site: West 4 -- Right

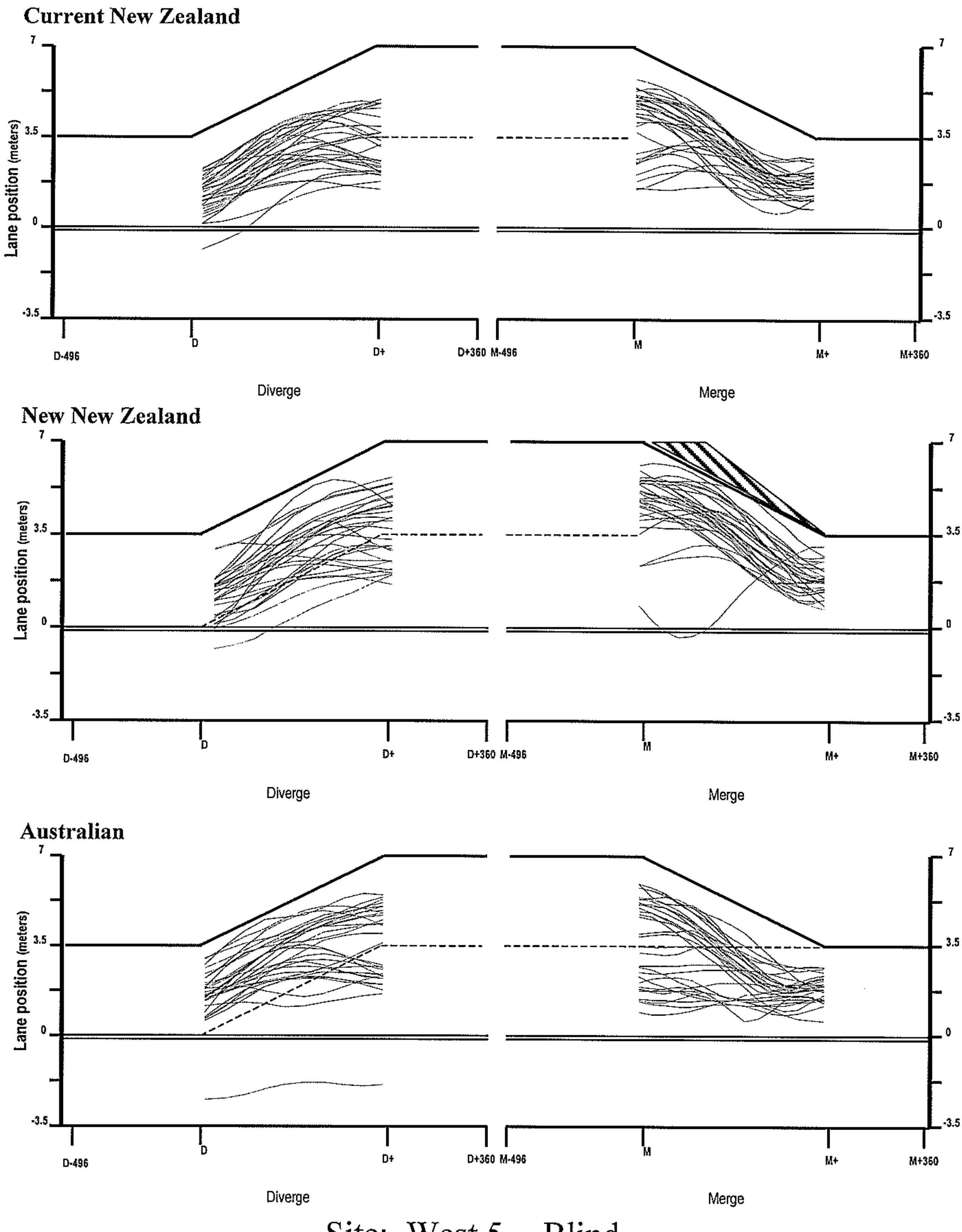
Figure 16. Participants' lane position (in meters) and vehicle speeds (km/h) through each stage of the overtaking lane.



Site: West 5 -- Blind

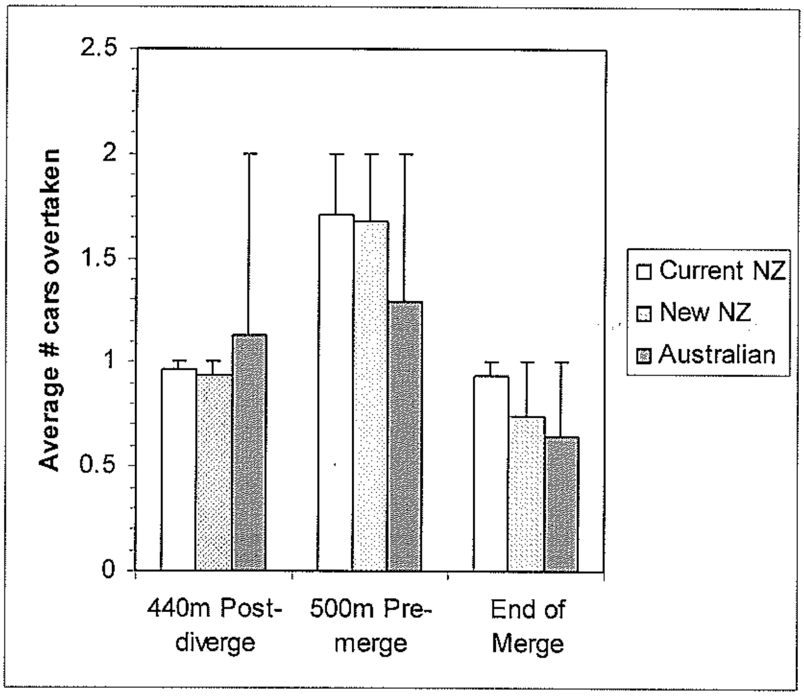
Figure 17. Participants' lane position (in meters) and vehicle speeds (km/h) through each stage of the overtaking lane.

Current NZ
New NZ
Australian



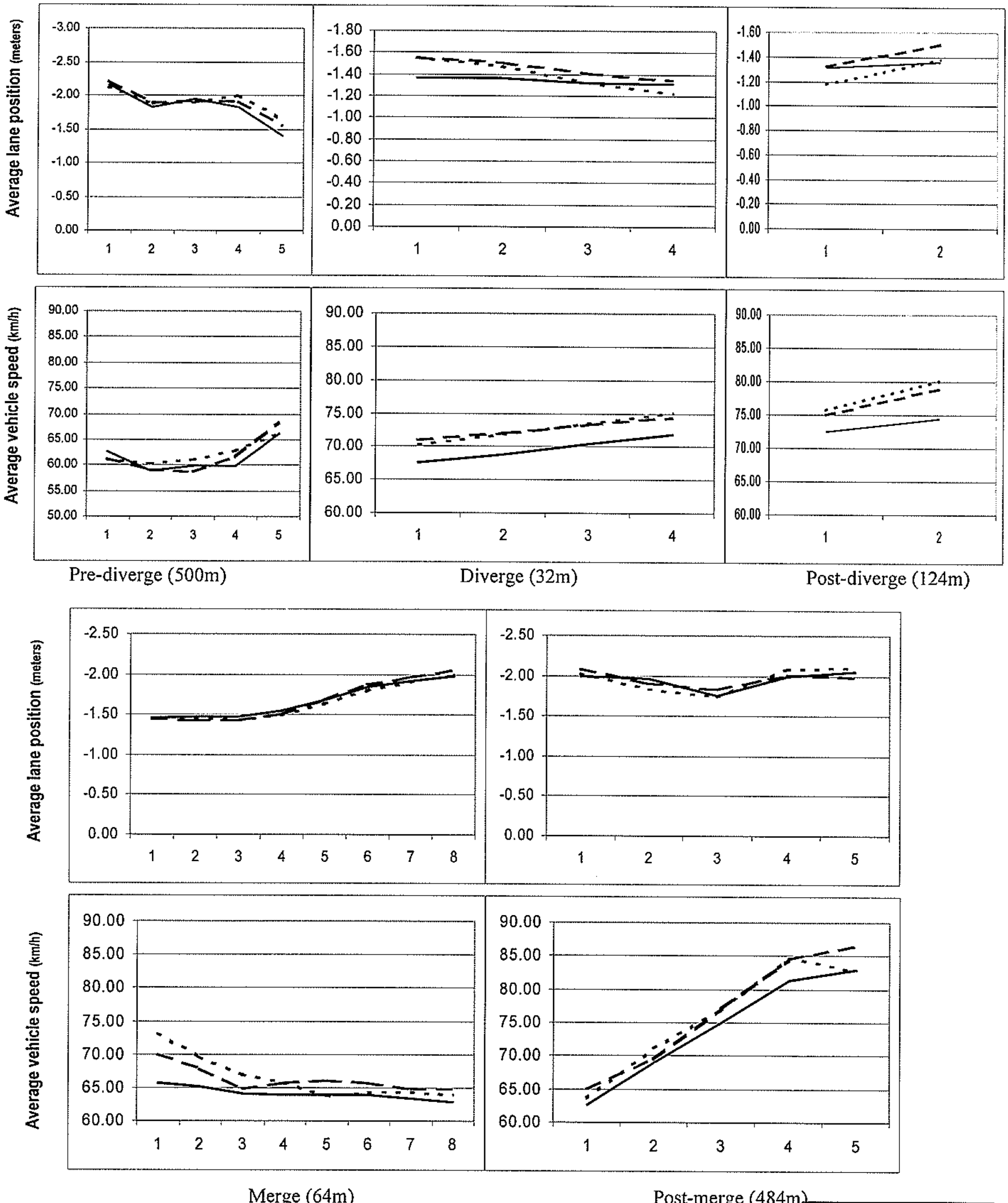
Site: West 5 -- Blind

Figure 18. Individual participants' paths through overtaking lane.



Site: West 5 -- Blind

Figure 19. Average number of cars overtaken by participants during each phase of passing lane. Five vehicles were ahead of the participants at the beginning of the overtaking lane. The "whiskers" depict the 75th percentiles for each treatment type.



Site: Slow Vehicle Bay

Figure 20. Participants' lane position (in meters) and vehicle speeds (km/h) through each stage of the overtaking lane.