BACKGROUND TECHNICAL REPORT

for

Transit New Zealand's
Passing & Overtaking Policy

TRANSIT NEW ZEALAND

June 2006

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Note: For personal security reasons, electronic images of signatures are not provided.

Record of Amendments

Version No.	Subject	Effective Date	Updated By
1.	Title "Proposed Transit NZ Passing and Overtaking Strategy for Rural State Highways".	19 May 2006	L.J. Cameron
2.	New title "Background Technical Report for Transit New Zealand's Passing & Overtaking Policy". Additional options added and assessed. Revised Strategic & Policy Implications section.	20 June 2006	L J Cameron

Preface

This document is prepared for Transit staff and Transit's network consultants. It assumes that the reader has some technical knowledge and experience with development and operation of New Zealand's rural two-lane state highway network. It has not been written with the general public as its target readership.

This background technical report discusses many of the issues relevant to passing and overtaking behaviour and is intended to help with the development and implementation of a new Passing and Overtaking Policy by Transit NZ. The final version of Transit's Passing & Overtaking Policy may vary from content within this document.

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EXECUTIVE SUMMARY

1. This report identifies and evaluates treatments and measures for improving the efficiency of New Zealand's two-lane state highway network. Current Transit policies and procedures are also evaluated. Both passing and overtaking opportunities have been considered.

2. Passing relates to vehicles using specific passing facilities and overtaking relates to vehicles crossing into the opposing traffic lane to pass slower vehicles. This definition of overtaking and passing is commonly used throughout most of the world but some North American state highway (SH) agencies use the term overtaking lanes instead of passing lanes.

3. A passing strategy is proposed that will provide passing facilities as demand increases. An overtaking strategy is proposed that will reduce the need for new passing facilities and will run in conjunction with the passing strategy. Treatments are applied directly to the roading infrastructure, whereas measures act on driver behaviour. Supporting treatments/measures have been identified and assessed, such as centrelines, roadside/edgelines, intersections, resource planning, education and enforcement, travel demand management (TDM) and intelligent transport systems (ITS). Guideline issues have been identified for further discussion with relevant Transit Divisions.

4. A review of current peri-urban four-laned projects ($1,800 M estimated value) is suggested. Significant cost savings may be achieved on four-lane projects with structures ($4-10 M/km) compared to 2+1 lanes ($0.9-2.7 M/km). The ability of 2+1 lanes to transition between two and three lanes means that upgrading of bridge structures, grade-separated intersections and local road overbridges may be deferred.

5. A 2+1 lane road would generally be suitable where there are: i) annualised averaged daily traffic volumes (AADTs) are 10,000-20,000 vpd with one-way projected flows less than 1,200-1,400 vph, ii) high crash severity, iii) flows on local roads and access driveways can be easily controlled by a semi-motorway (expressway) standard of access or Limited Access Roads (LARs), iv) existing high-cost structures, such as bridges have a long service life and v) the route has not been identified for tolling.

Policy

6. Key elements of the proposed policy are: i) provide passing facilities at high demand locations, ii) minimise the need for passing facilities by running a concurrent overtaking strategy and iii) apply supporting treatments and measures, either in conjunction with or as an alternative, to passing and overtaking treatments.

7. Transit's role is: i) supply management i.e. passing, overtaking, intersection, sign and marking treatments, ii) demand management i.e. resource planning & TDM and iii) collaboration with external agencies i.e. education, enforcement, resource planning and research.

8. An initial set of policy principles was also developed, namely: performance-based, staged development, integrated approach and appropriate for conditions. Other principles may be added at a later date.

Literature Review

9. A literature review was undertaken of international and NZ research and best practice. Key research areas are shown in italics together with general outcomes.

10. *Passing Sight Distance (PSD)* – requirements have increased and hence overtaking opportunities have reduced. Overseas research observed about 780-850 m 85th percentile PSD for a car passing a heavy commercial vehicle (HCV) with trailer from an accelerating manoeuvre with opposing traffic. AUSTROADS theoretical PSD requirements are best suited to actual traffic conditions. *Markings* -While NZ does not mark for horizontal restrictions, at this stage only marking for isolated horizontal curves is suggested.

11. *Passing Demand (PD)* – NZ's Project Evaluation Manual (PEM, to be renamed Economic Evaluation Manual in 2006) procedures assess PD by the proportion of road section with PSD 450 m or greater. This method does not reflect all traffic conditions. Some overseas agencies have developed different methods for assessing PD i.e. Morrall's Unified Model and South African National Roading Agency Ltd (SANRAL) model. *Computer Modelling* - TRARR is still adequate but it will not be upgraded. Alternatives are either PARAMICS or TWOPAS for operational efficiency in conjunction with IHSM for safety analysis.

12. *Low-Volume Treatments* – there is little overseas research on low–volume analysis methods. NZ research has identified the Borel-Tanner Distribution as suitable for driver behaviour associated with slow vehicle bays (SVBs). Further research into its application to overtaking treatments is suggested. *Moderate-Volume Treatments* – overseas 2+1 lanes provided the best operational and safety benefits but because NZ does not have an extensive network of 13-14 m sealed carriageways, analysis and selection procedures have to be established for 2+1 lanes.

13. *Safety* - there has been considerable NZ research into passing lanes (PLs), SVBs and their associated driver behaviour. This research should be utilised in developing a safety review and extending the lewngth of state highway requiring a safety audit, including exit tapers, up to 2 km upstream and 4 km downstream. *Guidelines and Warrants* - are not necessarily applicable to NZ conditions but some reflect experience with a wide range of issues, which should be considered within any NZ guidelines.

14. *Implementation* - of overseas PL strategies has been over road sections rather than entire networks. There is little material on the staged application of PLs or supporting treatments and measures. *Performance indicators* - need to be traffic flow and driver sensitive plus easily linked to benefit analysis. Worst versus average conditions should be considered.

Policies & Procedures

15. Internal policies and procedures are shown in italics together with general outcomes. The *Beca Carter Hollings and Ferner* (*Beca) Report & PEM procedures* have been thoroughly reviewed. However, possible areas to consider for improvement are: i) not suited to windy alignments on flat road gradients and straight horizontal alignments on hilly/mountainous road gradients but these terrains are less common and ii) a fixed 450 m PSD for overtaking opportunities is not suited to all conditions, iii) observed passing demand may be a more appropriate input variable and iv) Beca implementation plans have difficulty achieving stated Benefit Cost Ratios (BCRs).

16. *PEM* shortcomings are: i) three different methods, ii) no simplified procedure for SVBs and short PLs, iii) BCR graphs need to be factored to reflect changing costs, iv) for network strategies, existing facilities cannot be taken into account unless they are the same size and spacing and v) BCR graphs only cover AADTs up to 10,000 vpd and 800 m PL length. Further research is suggested to improve the PEM procedures.

17. *Limited Access Roads* (LARs) – a working group has proposed a revised LAR classification, Access Management Plans and changes to conditions for crossing approvals. The revised LAR classification would allow for a semi-motorway (expressway) classification. *Cost Estimation Review* – a centralised database of costs and benefits for passing, overtaking and supporting treatments/measures is suggested to avoid the need to rework any suggested Weighted Average BCR work packages.

18. *PL Policy* – title and wording should be changed to reflect other treatments and measures besides PLs and SVBs. The priority of SH sections by AADT should be reviewed to reflect Passing Demand. *Prioritisation* – for the 2006/07 SH Forecast, BCR and crash severity have been added to the current policy priorities of AADT and completing the strategic network.

19. *Implementation* - interim and long-term strategies for each road section should be developed using Weighted Average BCR work packages. PROMAN and LTNZ on-line would need to be changed so that projects were linked rather than combined and project characteristics can be easily identified.

20. *Construction costs* – for 14 PL projects in Northland and Auckland showed that about 20% of averaged construction costs were due to other Transit work, such as safety and pavement maintenance works that was undertaken at the same time. The remaining cost variations (23% of averaged construction costs) were mainly due to one-off costly items, such as retaining walls, cattle underpasses, planting trials and bridge widening, that could possibly be avoided, depending on PL length.

21. *Funding* – the current PL policy would take about 30 years to complete at about $310 M. A review of SH Forecast projects is suggested. There would be cost savings by i) using 2+1 lanes instead of four lanes, particularly with structures, ii) co-ordinating other Transit works at the same site and iii) using other scheduled Transit works along the SH section to provide passing and/or overtaking opportunities. Also under projected traffic flows, some projects currently scheduled for PLs may require four-lanes or 2+1 lanes.

22. *SH Forecast*- analysis showed that the prioritisation of PL and SVB projects allows more projects into the 1st 40 ranked projects that were located on *Strategic Networks* with high *Traffic Volumes* and high *Crash Severity*.

23. *Regional* differences were due to a variety of factors. A review of the Strategic Network factor is suggested so that other high-volume SHs with high crash severity are not disadvantaged. Also, for some Regions, PLs are less viable and alternative treatments and measures should be considered.

24. *Length* - Generally, SVBs and short PLs are over-represented and longer PLs (i.e. 1.6 km or more) are under-represented because of: i) terrain (at lower flows), ii) benefit assessment over averaged rather than peak flow periods, iii) mainly safety benefits (at lower flows) and iv) the PEM's 450 m PSD criteria which could disadvantage some locations that require longer PLs.

Other contributing factors for NZ may be the less restrictive markings policy, relatively lower traffic volumes and the effect of earlier staged development.

Options

25. The following options were assessed:

i) Overtaking treatments - PSD improvements (i.e. vegetation control, batter relocation, pavement rehabilitation, realignment) and overtaking enhancements (i.e. isolated seal-widening, overtaking at passing facilities and configuration of PLs).
ii) Passing treatments for < 4,000 vpd - isolated shoulder-widening, turnouts/SVBs and short PLs.
iii) Passing treatments for > 4,000-25,000 vpd - wide shouldered two-lane roads, climbing/crawling lanes, PLs in series, extra wide lanes, 2+1 lanes and four-lanes.
iv) Centreline treatments - yellow lines, gap separation of opposing flows, central cables/guardrail.
v) Roadside & edgeline treatments - clear zoning & shoulder run-off, increased signs & markings, wide profile markings, increased shoulder widening and/or chip sealing and side restraints – cable or guardrails.
vi) Intersection treatments - location of passing facilities and overtaking zones with respect to intersections and driveways, provision for through traffic, rationalisation of intersections.
vii) Resource Planning measures - limited access roads, alternative roading networks, new designations (all three are supported with submissions on District Plans and Regional Land Transport Strategies).
viii) Education measures – for the general public and a targeted programme for heavy transport operators and activities generating high numbers of HCVs.
ix) Enforcement measures – for the general public, for selected problem locations and in-vehicle HCV speed controls.
x) Travel Demand Management (TDM) measures - alternative modes, routes and hours.
xi) Intelligent Transport Systems (ITS) measures - variable messaging (preferably linked to ATMS), video monitoring (preferably linked to ATMS) and speed camera (preferably for long vehicles.

Overtaking Treatments

26. PSD improvements can be incorporated into current Transit works including: vegetation control, batter relocation on curves, pavement rehabilitations, and realignments. For overtaking enhancements, isolated seal widening at locations with adequate PSD is preferred because it can be applied throughout the network and is not reliant on the existence of PLs.

27. As PLs are established, provision for opposing traffic to overtake at passing facilities and favourable configurations of isolated passing facilities will assist overtaking opportunities, such as for opposing traffic both upstream and downstream of these facilities.

Passing Treatments

28. In some isolated cases, where SHs have steep grades and poor alignment, some sections of state highway may require passing facilities at less than 4,000 vpd. At these low flows, safety issues would take precedence over operational efficiency and passing initiatives are best done in conjunction with resolving safety issues.

29. For passing treatments less than 4,000-5,000 vpd, SVBs that could be lengthened at a later date or short PLs are preferred on low-volume SHs i.e. less than 4,000-5,000 vpd projected flow. The short PL can redistribute slow following vehicles once they have passed the platoon leader. This ability provides greater operational efficiencies and continues to be effective as flows increased. Also, safety benefits are higher for short PLs compared to both SVBs and shoulder widening.

30. Passing facilities start to be required by 4,000-5,000 vpd, as overtaking opportunities reduce due to the increased likelihood of both on-coming traffic and traffic being in platoons. Typically by 10,000-12,000 vpd, both operational efficiency and safety issues start to become significant and passing facilities tend to be the only means of passing slower vehicles. Passing lanes in series with selective conversion of road sections to 2+1 lanes is preferred for staged implementation.

31. PLs in series are preferred on mountainous road gradients so that costly locations can be avoided and because larger differential speeds require shorter PL lengths. The 2+1 lanes are favoured on flat and rolling road gradients where costs would be less for extra carriageway width and 2+1 lanes would provide higher operational and safety benefits as traffic flows increased.

Supporting Treatments and Measures

32. A key supporting measure for the overtaking strategy will be centreline treatments that allow overtaking on SH sections with up to 7,000 vpd but yellow lines or possibly other treatments may be required in some crash prone locations.

33. Generally, above 7,000 vpd, centre line markings would start to be double yellow lines with progression to 0.5-1.0 m (possibly up to 1.2 m) wide gap separation of opposing flows followed by median cables, depending on traffic volumes and crash history. Improvements to signs and markings at passing facilities would improve efficiencies at these facilities.

34. A revised limited access road (LAR) classification system would support long-term planning measures and would complement the 2+1 lane treatment. Other resource planning measures, such as new designations and encouraging alternative local roading networks would suit specific locations and could be used to complement localised LAR requirements.

35. In conjunction with passing treatments, for SHs with 4,000-25,000 vpd, intersection improvements would have to be progressively applied, as well as some rationalisation of intersections. The location of existing and proposed passing facilities and overtaking zones should consider the downstream and upstream effects of high-volume driveways and intersections.

36. Transit's direct influence using education and enforcement measures is limited and Transit would have to liaise with other agencies, such as Land Transport NZ, Ministry of Transport and NZ Police to implement these measures. However, there is scope for some Transit influence mainly in suggested conditions as part of submissions on resource consent applications for new and upgraded facilities that generate high numbers of HCV trips.

37. Education measures targeted at HCV operators and facilities that generate high HCV movements are considered to be the most effective. However, the influence of in-vehicle speed

controls for HCVs in NZ should be assessed. Until then, the speed limit should be enforced for HCVs at specific problem locations and for all road users at selected crash prone locations. Crashes of particular interest would be overtaking-related crashes, such as rear-end, overtaking and head-on type crashes.

38. Travel Demand Management (TDM) measures, such as routes with current or projected high volumes of combined heavy commercial, light towing and recreational vehicles, high recreational use, commuter routes and projected AADTs over 10,000-12,000 vpd. Critical road sections will include a combination of these traffic flow characteristics as well as having traffic flows requiring changes in the level of infrastructure (i.e. about projected 4,000-5,000, 10,000-12,0000, and 20,000-25,000 vpd),

39. Intelligent transport systems (ITS) measures, such as variable messaging, and web cameras would achieve best results if linked to a larger automated traffic monitoring system (ATMS). However, ATMS is currently only available within Auckland and Wellington. Another ITS application is speed enforcement for heavy commercial vehicles and long towing vehicles, using a special induction loop to detect longer vehicles.

Guidelines

40. A pre-selection section would help to choose the most appropriate choice of treatments on SH sections with or without adequate proportions of PSD and for projected ranges of AADTs.

41. Other main sections are: i) planning and funding, ii) design and construction, iii) operations and maintenance, iv) communications and v) monitoring. These sections relate approximately to Transit's divisions of Transportation Planning, Corporate Services, Capital Projects, Network Operations and Corporate Strategy.

42. Planning and funding issues can be categorised into funding (i.e. work packages and funding), resource planning (i.e. limited access controls, environment, and resource management) and engineering planning (i.e. location, terrain, configuration, safety and crash history). Design and construction issues relate to design (i.e. PSD, passing demand, design hour, length, spacing and flows), and detailing for specific locations (i.e. crown and super-elevation, access and intersections, lane width and tolerances, diverge, merge and transition zones, roadside treatment, centreline treatment and special users).

43. Main operations and maintenance issues include operations (i.e. signs & markings, emergency services, lane closure, upgrades and ITS) and maintenance (testing, scheduling for maintenance, maintenance standards). Communications issues centre on liaison (i.e. Transit staff and consultants and media issues) and information (i.e. protocols, education material and enforcement locations).

44. Monitoring issues could be divided into formal (i.e. Divisional responsibilities, performance indicators, safety audit and data collection) and informal monitoring processes (i.e. feedback).

Strategic & Policy Implications

45. Key external areas of research and internal Transit activities were analysed for strengths, weaknesses, opportunities and threats (SWOT). Changes to policy and procedures were identified. Where external issues could not be addressed by internal policy and procedures,

further research has been suggested. The suggested actions and further research are outlined under Section 27 Conclusions.

46. Any new Policy should meet Transit's goals and NZLTS principles and objectives. Policy principles include: performance-based, integrated approach, staged development and appropriate for conditions. Other Policy principles may be added later.

Conclusions

47. Suggested actions are:

- Amendments to current PL policy and name to include Passing and Overtaking plus supporting treatments and measures.
- Development of guidelines for passing and overtaking strategy.
- Review of SH Forecast projects.
- Development of interim and long-term strategies for SH sections.
- PROMAN changes to cover work packages and identification of project characteristics.
- Revision of LAR classification system with a standardised database for LAR approvals.
- In conjunction with Cost Estimation Review, establish a centralised costs and benefits database.
- In conjunction with assessing network models for passing demand and identifying appropriate performance indicators, investigate suitability of Transit's traffic monitoring system for monitoring traffic performance.
- Increased length of project site for safety auditing up to 2 km upstream and 4 km downstream also safety review procedure for existing passing facilities and overtaking zones.
- Feedback systems to include:
  - i) Divisional responsibilities and contact personnel for key activities.
  - ii) Information to/from Regions/Consultants.
  - iii) Consult/liaise with Transit staff and external agencies of Land Transport NZ, NZ Police, Ministry of Transport and appropriate overseas agencies with primary Transit contacts.
- Further research into:
  - i) Improving PEM procedures for estimated costs, BCR graphs to include 600-800 m PL length and AADTs above 10,000 vpd with one-way flows less than 1,200-1,400 vph, assessment of overtaking opportunities, simplified procedures for low-volume and moderate-volume overtaking, passing and if appropriate supporting treatments/measures.
  - ii) Improved taper design and merge behaviour.
  - iii) Modelling of combined operational and safety effects.
  - iv) Passing demand assessment for the SH network with appropriate performance indicators.
  - v) Influence of in-vehicle speed controls for HCVs and comparison against education and enforcement measures.

Recommendations

48. It is recommended that the following items be adopted:

Current Passing Lane Policy

i) Current title of Passing Lane policy to be changed to Passing and Overtaking Policy to reflect the use of passing, overtaking and supporting treatments and measures.

ii) Within Transit's current Passing Lane Policy, review wording, SH sections and their priorities to allow for a wider range of treatments/measures and if appropriate report to Transit Board with any suggested policy changes.

Guidelines

iii) Transit guidelines to be developed for passing, overtaking and supporting treatments and measures.

iv) For preparation of Transit guidelines, an inter-Divisional working group with terms of reference and sunset clause to be established.

SH Forecast Review

v) Review of projects in current SH forecast to identify i) more appropriate treatments for some projects and ii) other Transit activities that would help passing, overtaking and other supporting treatments and measures.

Interim & Long Term Strategies

vi) Develop interim and long-term strategies for individual State Highway sections together with Weighted Average Benefit Cost Ratio packages of projects and if appropriate, suggest a revised Funding Level for the Transit Board to consider.

vii) If appropriate, consider inclusion of interim and long-term strategies within existing Transit's Corridor Management Plans for SH sections and if appropriate referenced within any Regional Land Transport Strategy and/or District Plan.

PROMAN

viii) In consultation with Land Transport NZ, both Transit's and Land Transport NZ's financial and project management systems are to be altered to allow for Weighted Average Benefit Cost Ratio packages and easier identification of some project features.

LAR Classifications

ix) Work on a revised Limited Access Road classification system including a possible semi-motorway (expressway) standard and additional conditions for crossing approvals to be continued and if there are any policy changes report separately to the Transit Board.

x) In conjunction with any revised Limited Access Road classification, the Limited Access Road database is in the process of being standardised and new items and/or fields of information may have to be added.

xi) In conjunction with any revised Limited Access Road classification, consider the use of other resource planning measures, such as alternative roading networks, designations and changes to District Plans and Regional Land Transport Strategies.

Cost Estimation Review

xii) In conjunction with Transit's Cost Estimate Review, a costs and benefits database of passing and overtaking treatments is to be established and maintained.

Traffic Monitoring System

xiii) In conjunction with assessing passing demand models and determining appropriate performance indicators, investigate the suitability of Transit's traffic monitoring system as a traffic performance monitoring system and adapt the system, if appropriate.

Safety Audit/Review

xiv) For safety audit purposes, the project length should be extended to include up to 2 km upstream and 4 km downstream of the treatment. Safety review procedures for existing passing and overtaking treatments and any relevant supporting treatments

Feedback Systems

xv) Consultation and liaison with appropriate staff from Transit National Office, Transit Regions, Land Transport NZ, NZ Police and Ministry of Transport with primary contacts within Transit for external agencies.

xvi) If appropriate, liaison and collaboration with overseas state highway agencies with similar network issues, particularly carriageway width issues.

xvii) Delegated responsibilities for:

- Monitoring and reporting of performance indicators.
- Establishment and maintenance of costs and benefits database for passing, overtaking and supporting individual options.
- Monitoring and review of NZ and overseas research and developments.
- Collection and dissemination of information on passing, overtaking and supporting individual options from/to Transit Regions and Network Consultants
- Any other key responsibility that is identified.

Further Research

xviii) Improvements to current Economic Evaluation Manual procedures, including:

- Clear description of items covered by estimated construction costs.
- Alteration of BCR graphs to allow for 600-800 m PL lengths and to cover AADTs above 10,000 vpd without constraining one–way flows.
- Reassessment of current PSD criteria for overtaking opportunities.
- Expand simplified procedures for low-volume passing and overtaking treatments.
- Develop simplified procedures for intermediate treatments on SH sections with a projected AADT of 10,000-25,000 vpd.

xix) Improved taper design and merge behaviour.

xx) Modelling of combined operational and safety effects.

xxi) Assessment of simple passing demand models for the SH network.

xxii) Influence of in-vehicle speed controls for HCVs on passing opportunities, operational efficiency and safety with a comparison against education and enforcement measures.

1. INTRODUCTION

1.1 The purpose of this report is to assist with developing a draft policy and guidelines for the Transit Board to consider. The key tasks are:

- International and NZ literature review.
- Review previous work undertaken by Transit and Transit's current Passing Lane (PL) policy.
- Identify and analyse opportunities for improving the efficiency of NZ's two-lane State highway (SH) network.
- Identify issues for developing a set of guidelines.
- Provide recommendations for Transit Board.

1.2 The report will review Transit's current PL policy with a view providing more passing and overtaking opportunities on the SH's two-lane network. Passing relates to vehicles using specific passing facilities and overtaking relates to vehicles crossing into the opposing traffic lane to pass slower vehicles.

1.3 A passing strategy provides passing facilities as demand increases. An overtaking strategy reduces the need for new passing facilities and should run in conjunction with any passing strategy. Supporting treatments and measures will be complementary or an alternative to passing and overtaking treatments.

1.4 This report is structured so that the reader can obtain a brief overview by reading the Key Findings sections together with the Strategic Implications and Conclusions. More detail is provided within Parts I-IV. A blank page has been added after some Parts so that dividers can be inserted between Parts.

2. BACKGROUND

2.1 In 2000, Transit commissioned Beca Carter Hollings and Ferner (Beca) to undertake a study on passing lanes, commonly known as the Beca report. The brief consisted of two tasks:

- to develop an evaluation procedure for assessing passing lanes as a series and to improve on evaluation procedures for individual passing lane projects.
- to incorporate this procedure within Land Transport NZ's Project Evaluation Manual (PEM, to be renamed Economic Evaluation Manual in 2006).

2.2 This procedure was reviewed by Transit and Land Transport NZ staff and included within Land Transport NZ's PEM.

2.3 In 2002, Action Paper CS/02/03/4244 was prepared and approved by Transit's Board as Transit's Passing Lane Policy. This paper prioritised all SHs with greater than 4,000 vpd from Priority 1 to 4. The priority level was generally based on a road section's current AADT values. This process is discussed more fully in Section 7.1 Policy.

2.4 In a few cases, projects were given a higher priority due to their favourable BRC values. SH 1 was given higher priority than other networks due to its inter-regional function and higher likelihood of carrying large numbers of HCVs.

2.5 Attachment B of Action Paper CS/02/03/4244 also identified road sections where four-laning was to be applied. The proposed four-lane road sections were excluded from the list of SH sections requiring PLs.

2.6 In 2003, Action Paper CS/03/11/4770 was approved by the Transit Board and PL projects on SH 3 (Awakino Gorge-Te Kuiti) and SH 1 (Blenheim-Kaikoura) were assigned Priority 1. These sections of SH had traffic volumes below 4,000 vpd but were considered to have high strategic value.

2.7 For 2003/04 and 2004/05, Transit's 10 year State Highway Forecast went out to key stakeholders. For 2005/06 and 2006/07, the State Highway Forecast went out for general public consultation including key stakeholders.

2.8 In 2006, as part of discussions on Transit's proposed State Highway strategy, the Transit Board members suggested that the focus on passing facilities might be too narrow. The Board would like other treatments, such as Swedish 2+1 lanes, to be considered within any revised Passing Lane Strategy.

PART 1. LITERATURE REVIEW

3. INTERNATIONAL LITERATURE

3.1 Australia

3.1.1 VicRoads evaluated central median cables and proposed installation in only some locations, due to carriageway width issues (Larsson et al, 2003). Also consultation with motorcyclists was suggested, although there had been little evidence of motorcyclist crashes in Sweden, with a similar composition of road users.

3.1.2 A comparison between Australian and Canadian PL guidelines is provided (Morrall & Hoban, 1985). Refer to international comparisons.

3.1.3 Australian passing sight distances (PSDs) and markings are compared with other countries (Harwood et al., 1995).

3.2. Canada

i) Passing Sight Distance

3.2.1 A revised PSD model was proposed for inclusion within the Manual of Uniform Traffic Control Devices (MUTCD) (Hassan et al., 1995). The current marking policy was not adequate for cars passing cars above 70 kph or for manoeuvres involving trucks at lower speeds. Ontario markings were slightly better as the determination of passing zones was speed related.

3.2.2 PSD requirements were not constant throughout the passing manoeuvre and increase markedly at the beginning of the manoeuvre during acceleration then reduce markedly at the end of the manoeuvre, during deceleration. These differing requirements should be considered when determining the length of passing zone.

3.2.3 In Ontario, a 1.05 m driver eye height to 0.3 m object height was used at the beginning of the manoeuvre and ended with a 1.05 m to 1.05 m eye height for PSD. The research suggested a reversal with 1.05 m to 1.05 m at the beginning and 1.05 m to 0.3 m at the end. This configuration would help to initiate passing and provided a higher standard of PSD at the end of the manoeuvre where potential conflict with opposing traffic was more likely.

3.2.4 From the NZ perspective, PSD is taken at 1.05 m driver eye height to 1.15 m height opposing vehicle height (Transit NZ, 2002). Therefore, if comparing overseas PSD and markings, the height that the PSD is taken from/to has to be considered.

ii) Signs & Markings

3.2.5 PLs with no-overtaking markings on both sides in a previously 100% overtaking area were evaluated (Morrall et al., 1986). Despite the no-overtaking lines, there was an increased number of overtakings at the location. For this section of SH with greater than 4,000 vpd, opposing traffic crossed the double yellow line or passed shoulder traffic when there was no on-coming traffic in the passing lanes. For Transit’s perspective, 4,000 vpd is too low for double yellow lines.

3.2.6 Education initiatives, such as questions within Alberta driver's licence tests were suggested as part of evaluating of test PL sections in Banff National Park (Morrall & Blight, 1985). Legislation relating to signs and markings has to be in place before embarking on any education and/or enforcement programme.

iii) Passing Demand

3.2.7 The mathematical model "Unified Traffic Flow Model" assessed the effect of opposing flow on both two-way capacity and passing demand (Werner & Morrall, 1984). Further calibration of the theory to actual conditions was required. However, the Unified Model was later applied to development of PLs in Alberta (Morrall et al., 1986). Further refinement work was being carried out under a separate research project sponsored by Alberta Transportation.

3.2.8 For assessing passing demand, PLs were not required until there was less than 50% passing opportunities along a road section. The nett passing opportunities were based on available sight distance and likelihood of an opposing vehicle at the same location (Harwood & Hoban, 1987).

iv) Safety

3.2.9 Hauer reviewed safety research by other researchers on four-lanes between 1981-1999 (Hauer, 2000). Shortcomings in various accident prediction equations were identified. Hauer considered work by Council & Stewart showing that there was more driveway access on two-lane roads compared to four-lane roads. Also four-laning usually changed shoulder width from 1.83 m to 3.05 m.

3.2.10 Therefore, the crash prediction models by Council & Stewart did not take into account access controls and extra shoulder width, which would also contribute to crash reduction rates rather than just extra lanes.

v) Guidelines & Warrants

3.2.11 Alberta provides a comprehensive set of PL guidelines and should be considered as one of a number of source documents for development of NZ guidelines (Alberta Infrastructure, 1999). Rather than using a 30^{th} hour design volume, Alberta uses a 100^{th} hour with a set of Design Hour Volume/AADT ratios for recreational (0.20), rural (0.12), commuter (0.10) and urban (0.08) SHs.

3.2.12 Environmental considerations within Alberta Guidelines include: topsoil removal, aggregate sources, waterways, navigable culverts and bridges, highway drainage, dug out and landscaped borrow sites within and outside of SH road reserve boundaries.

3.2.13 British Columbia guidelines appear more suited to NZ terrain conditions, having slightly shorter PL lengths than Alberta guidelines (Ministry of Transportation and Highways, British Columbia, 1986).

vi) Performance Indicators

3.2.14 Overtaking (also known as Passing) Rate is outlined as an alternative measure for assessing passing demand and level of service (Morrall & Werner, 1990). The Overtaking Rate could also be used to help measure the effect of PLs. Overtaking Rate is used as a supplement rather than a replacement of other measures of performance, such as percentage time spent following (PTSF) and average travel speed (ATS).

vii) International

3.2.15 Canadian and German researchers compare German 2+1 lanes and extra wide lane roads with Canadian wide–shoulder roads and PLs (Frost & Morrall, 1995). Refer to international comparisons.

3.2.16 Ontario, Alberta, British Columbia and Banff National Park PL guidelines are compared with Australian PL guidelines (Morrall & Hoban, 1985). Refer to international comparisons.

3.2.17 Canadian PSDs and markings are compared with other countries (Harwood et al., 1995).

3.3 Finland

3.3.1 Finnish researchers reviewed Highway Capacity Manual 2000 LOS indicators showing that speed-volume curves do not represent actual traffic behaviour (Luttinen, 2000). The speed decrease of Finnish highways was smaller than HCM predicted. Capacity was reached at lower densities and higher speeds than HCM predicted. However, observed conditions were good but not ideal so HCM capacities seemed plausible.

3.3.2 Two-way capacity was affected by opposing flows. The directional capacity was linearly proportional to the opposing flow rate. Directional distribution of flows should be considered when estimating speeds. Two-way capacity could be estimated from the proportion of major flow.

3.3.3 Swedish, Finnish and German 2+1 lane and extra-wide lanes have been reviewed with the intention of applying them to US networks (Potts & Harwood, 2003). Refer to international comparisons.

3.4 Germany

3.4.1 New cross-sectional guidelines for all German SHs were reviewed (Brilon & Weiser, 1995). For newly constructed 2+1 lanes and narrow four lane urban treatments, new cross-sections are provided. These treatments were for SHs with projected operating AADTs of 10,000-20,000 vpd.

3.4.2 For 2+ 1 lanes, a 11.5 m revised shoulder-to-shoulder cross-section was used compared to 11 m for existing carriageways. A four-lane carriageway of 4 x 3.3 m wide lanes with 0.5 m gap separation of opposing flows was proposed for some urban road environments.

3.4.3 Charts were provided for pre-selection of options with projected AADT.

3.4.4 A modular approach was used to provide road widths with intervals of extra width. Generally, motorway widths had been reduced to reduce costs but still provide an acceptable LOS, based on empirical judgement from a panel of experts.

3.4.5 Cross-sectional guidelines reflected a balanced approach to both safety and operating efficiencies and resulted in 2+1 lanes being used in preference to extra-wide lanes. Extra-wide lane roads were not proposed for the future.

3.4.6 For cyclists, pedestrians and combined use from both users, criteria for extra seal width and separate facilities were provided.

3.4.7 For monitoring of operational efficiency, the decisive parameter was traditionally the mean travel speed of the passenger car.

3.4.8 Swedish, Finnish and German 2+1 lane and extra-wide lanes were reviewed with the intention of applying them to US networks (Potts & Harwood, 2003). Refer to international comparisons.

3.4.9 German 2+1 lanes and extra wide lane roads were compared with Canadian wide–shoulder roads and PLs (Frost & Morrall, 1995). Refer to international comparisons.

3.5 Great Britain

3.5.1 British passing sight distances and markings are compared with other countries (Harwood et al., 1995).

3.6 Serbia-Montenegro

3.6.1 Research into assessing passing demand indicates a passing sight distance (PSD) of about 780 m for cars overtaking truck and trailers with opposing traffic (Mijuskoovic, 1995). The 780 m PSD was comparable with separate studies of Swedish (850 m) and Baystate Roads Program (815 m) PSD requirements.

3.6.2 Differences in PSD were thought to be due to traffic composition. Less developed countries, such as Serbia-Montenegro, with a lower percentage of HCVs and higher proportion of old vehicles were expected to have a slightly shorter passing sight distance requirement.

3.6.3 Some data was not used due to inexperienced surveyors. Transit should ensure that competent surveyors are used to minimise data error.

3.6.4 From Transits's perspective, the research shows the effect that traffic composition can have on PSD and that every country will have different requirements. NZ research on three South Island sites indicated that a large proportion of all vehicles including HCVs are travelling at similar speeds (Roozenburg & Nicholson, 2004). Therefore, the distribution of operating speeds for NZ's fleet may be different to some overseas situations, particularly as in-vehicle speed controls are not mandatory for HCVs in NZ.

3.7 South Africa

3.7.1 For assessing passing demand on South African SHs, the peak weekly flow was proposed instead of the traditional 30th highest design hour. The level of service (LOS) D was proposed for most peak periods with LOS C during weekly peak periods on Class 1 roads (South African National Roads Agency, 2004).

3.7.2 This draft report also considered performance issues. The worst case rather than average values were preferred. The performance indicator should cover all users rather than separate user classes. Therefore, traffic density was proposed. Both PTSF and ATS performance indicators had shortcomings. Follower density was preferred as an indicator of driver perception of service as was being investigated.

3.2.15 Follower density is made up of percentage vehicles following/speed then multiplied by AADT. While percentage following may be high and speeds could be low on some low-volume roads, this measure is multiplied by AADT to determine relative effects within the network.

3.7.3 Follower density could also be used on multi-lane and four-lane roads. Therefore, comparisons could be made over a range of lane configurations. A four second headway was proposed to separate following from free flow traffic, whereas some American research used five second headway.

3.7.4 As part of email discussions with Christo van As of South African National Roads Agency Ltd during April 2006, an Excel based program was being developed to evaluate LOS on South African roads at a network level. Weekly AADT and 30th highest design hour flows were used. The program was expected to be available commercially later this year.

3.7.5 Transit should monitor development of this program given Transit's need to develop interim and long-term strategies for some sections of SH and Transit's development of a National SH Traffic Model. Interim and long-term strategies are discussed within this report under Section 7.23

3.8 Sweden

3.8.1 New National Swedish Road Administration (NSRA) guidelines are reviewed together with Swedish Road and Transport Research Institute (VTI) research findings (Bergh & Carlsson, 1995).

3.8.2 On Class 1 roads, Sweden's proposed 85th percentile PSD of 850 m applies to cars accelerating to pass a truck and trailer with similar high operating speeds with a high incidence of opposing traffic. Different levels of overtaking sight distance and frequency are applied to different classes of road. Therefore, under proposed Swedish design guidelines, a variety of PSDs were proposed along a road section so that timid drivers as well as car overtaking truck and trailer manoeuvres could be accommodated.

3.8.3 From Transit's perspective, the PEM's assessment of overtaking opportunities uses the proportion of 450 m clear sight distance along a road section. Based on Swedish research, this distance is inadequate for car overtaking truck and trailer manoeuvres with or without opposing traffic and for some car overtaking car manoeuvres with opposing traffic.

3.8.4 Whether the Swedish design guidelines translate into a different Swedish markings policy would require further investigation. Also, as discussed earlier, NZ's fleet composition and differential speeds for different types of vehicles would require a separate assessment of overtaking opportunities for NZ conditions.

3.8.5 Design and operational improvements to early 2+1 roads were discussed (Bergh & Carlsson, 2000). Notable improvements were access points at transitions for emergency services, maintenance standards, extra seal widening on single lane, clear zoning and flat slope batters replaced with some cabling on shoulders and minimum widths at constrictions.

3.9 United States

i) Passing Sight Distance

3.9.1 A revised stopping sight distance model was proposed (Fambro et al., 1995). Recommended stopping distances, sag distances sag vertical curve lengths and lateral clearances were between the current US minimum and desirable requirements Suggested crest curve lengths were shorter than current minimum requirements. New parameter values were considered to be more realistic of current road conditions and were validated by field data. The recommended changes were not expected to have an impact on safety.

3.9.2 Baystate Roads Program, Massachusetts indicated that for a passing vehicle travelling at 109 km/hr and passed vehicle travelling at 94 km/hour, a passing sight distance of 815 m is required (Baystate Road Program, 2004). It also suggested that any alteration of markings could be done as part of scheduled overlays. However, the Baystate Roads reference did not discuss how this distance was used to develop a marking policy. As previously mentioned, this PSD was similar to values based on research in Sweden and Serbia-Montenegro.

3.9.3 The FHWA considered human factors, such as the aging driving population (US Dept.of Transportation – Federal Highway Administration, 1998). An initial manoeuvre time of 5 seconds into the opposing lane and a 3 second merge time back into the slow lane was proposed.

3.9.4 From Transit's perspective, NZ's aging driving population may require a slightly conservative approach to determining PSD.

ii) Signs & Markings

3.9.5 Markings policy for Wisconsin guidelines allowed for passing of opposing traffic if PSD is available (Dept of Transportation, State of Wisconsin, 2002).

3.9.6 Human factors showed that overtaking zones less than 370-380 m were generally not used (US Dept. of Transportation – Federal Highway Administration, 1998). Therefore, the US markings policy of a 122 m minimum gap between no-overtaking zones was ineffective.

3.9.7 Two-Way Left Turns (TWLT, right turns in NZ) had a markedly better crash rate (4.96 crashes/10^6 vehicle miles) than four-lane undivided roads (6.75 crashes/10^6 vehicle miles) but started to become less effective after about 17,000 vpd (Centre for Transportation Research and Education, Iowa State University, 2005). This treatment was used in urban and urban fringe area with 50-70 kph.

3.9.8 From Transit's perspective, Swedish 2+1 lanes have a 70 kph zone for some of their at-grade intersections. Therefore, this TWLT treatment (right turns for NZ) may be applicable to some NZ conditions, if multiple side roads are in close proximity and some minor roads cannot be closed.

iii) Passing Demand

3.9.9 The effect of disaggregating road section by time and location shows a marked difference in performance measures, although the LOS may stay unchanged (Navarro & Rouphail, 2000).

3.9.10 Disaggregation provided a better appreciation of problem locations when under-saturated sections by time and space are removed from the analysis. Therefore, this research suggested that peak time intervals, such as 30th hour and discrete road sections should be used for measuring performance.

3.9.11 From Transit's perspective, selecting appropriate lengths of SH is important so that aggregated effects do not mask localised problems.

iv) Low-Volume Treatments

3.9.12 Morrall & Hoban provide a useful summary on low cost treatments (Harwood and Hoban, 1987). These low-cost treatments were best suited for roads with typically less than 4,000 vpd. Passing and climbing lanes treatments on roads up to about 10,000 vpd are also discussed. This document was a major source of information for low-volume treatments within this report.

3.9.13 The Transportation Research Board (TRB) is trying to establish research into analysis methods for low-volume roads but has not been able to secure a budget (Transportation Research Board, 2005). This potential TRB research should be monitored by Transit.

v) Safety

3.9.14 Prediction models for crash rates were proposed for converting undivided two-lane roads to divided four-lane roads (Council & Stewart, 200). As previously discussed research by Hauer showed that these models did not take into account stricter access controls and more shoulder widening on four-lane roads.

3.9.15 Road features were discussed that provide consistency between road sections and so lead to a safer transition along road sections (Woolridge et al., 2003).

3.9.16 Low-cost safety improvements to the adjacent roadside versus the roadway showed that both treatments gave similar BCRs. However, roadside improvements had the advantage of being incrementally applied (Benekohal & Lee, 1991).

3.9.17 From Transit's perspective, there may be some low-volume locations, where roadside safety treatments would improve safety as opposed to using passing facilities to provide safety benefits.

vi) Guidelines & Warrants

3.9.18 Kansas guidelines were relatively new and relate to flat terrain. However, a review of Kansas PL guidelines were very comprehensive with a good discussion on theoretical issues and could act as part of a number of source documents for developing NZ guidelines (Mutabazi et al, 1999).

3.9.19 For Wisconsin guidelines, the definition of rolling terrain is applicable to western and southwest Wisconsin where rolling terrain matched Washington State (Dept of Transportation, State of Wisconsin, 2002).

3.9.20 Therefore, Transit should refer to a mix of PL guidelines but application will have to relate to NZ road conditions.

vii) Performance Indicators

3.9.21 Navarro & Rouphail use the HCM definitions to distinguish between i) service measures or measures of effectiveness (MOE) that can be assigned a grade, such as LOS and ii) performance measures that are experienced by the driver, such as speed travel time and delay (Navarro & Rouphail, 2000).

3.9.22 From Transit's perspective, performance indicators that are experienced by the driver should be used and average effects should be eliminated from any performance indicators by using peak or maximum levels e.g. 30^{th} worst hour, 85^{th} percentile speed. However, as previously discussed research from South Africa suggested that peak weekly flows could be an appropriate measure rather than average weekly flows (South African National Road Agency, 2004).

viii) Implementation

3.9.23 Proposed Californian PLs in series were computer modelled to determine LOS (Morrall et al., 1995). The main cause of the upgrade was due to a stricter markings policy, whereas before Caltrans had not marked any no-passing zones. PL lengths was about 15-23% of total analysis length with spacings about 7-10 km apart. The upgrade avoided sections with projected AADTs that were scheduled for four-laning.

3.9.24 From Transit's perspective, this research shows the value of developing strategies by road section. However, the use of computer simulation is not recommended as NZ already has developed PEM procedures for developing road section strategies, although some improvements to these PEM procedures is discussed later within this report under Section 6.1 Beca Report and Section 6.2 Project Evaluation Manual Procedures.

ix) International

3.9.25 US researchers have reviewed Swedish, Finnish and German 2+1 lane and extra-wide lanes with the intention of applying them to US networks (Potts & Harwood, 2003). Refer to international comparisons.

3.9.26 US PSD and markings are compared with other countries (Harwood et al., 1995).

3.10 International Comparisons

i) International Sight Distance Design Practices

3.10.1 A review of PSD requirements showed that theoretical considerations of PSD were best addressed by Australian design standards (Harwood et al, 1995). The associated markings policy showed that Canadian markings policy were generally the most conservative with British markings the least conservative. Therefore, Transit should remain with AUSTROADS guidelines.

3.10.2 Australia and US markings policies were similar except for the Australian practice of requiring 250 m minimum separation between no-overtaking zones, whereas US practice was a minimum of 122 m. However, a US review of research literature showed that generally drivers only used overtaking lengths of about 300 m (i.e. 268-274 m) (US Dept. of Transportation - Federal Highway Administration, 1998).

3.10.3 Also, for Australia, the termination of the overtaking zone was extended slightly to allow for available sight distance at the end of the overtaking zone that did not met the full PSD requirements.

3.10.4 The taper length for many Canadian locations was 200 m regardless of operational speed. Australian guidelines were speed related with about 165 m for an operating speed of about 100 km/hour. Therefore, Transit should use AUSTROADS guidelines as the taper length can be varied to suit hilly/mountainous terrain where lower operating speeds occurred.

3.10.5 Unlike Australia, Transit's markings policy does not cover horizontal sight distances. However, NZ research into the effect of not allowing for horizontal sight restrictions is discussed later (Koorey & Gu, 2001).

3.10.6 The comparison of overseas countries did not include any detailed commentary for Sweden or Germany. Given the higher operating flows that Sweden and Germany seem to achieve at merge tapers, any possible revision of Transit's markings policy should consider these two countries.

ii) Design Guidelines for Passing Lanes

3.10.7 Australian PL guidelines were compared with Canadian guidelines (Morrall & Hoban, 1985). The Australian method of assessing passing opportunities, which was similar to NZ, gave low values of Actual Passing Demand compared to North American guidelines.

3.10.8 The Australian taper length of 165m was shorter than Canadian situations of typically 200 m.

3.10.9 Three types of bunching were suggested as a measure of LOS, percentage of vehicles with less than say 4 sec headway, percentage time spent following and the distribution of bunch sizes including isolated vehicles

3.10.10 This research suggested that the difference between Canadian PL lengths of typically 1.5-2 km and Australian PL lengths of typically 0.6-1.2 km was because Canadian roads with PLs already had higher flows with extensive platooning and a stricter no-overtaking markings policy. Australian PLs were typically installed at 1,000-5,000 vpd and could be progressively developed in series.

3.10.11 Allowing traffic from the opposing untreated lane to overtake at PLs did not appear to lead to any safety problems for one-way flows up to 400 vph in the treated direction i.e. passing lane direction (Harwood et al., 1985). This study did not suggest that flows above this level were unsafe, rather that there was not enough data for one-way flows above 400 vph to provide any statistical confidence. Also, for the surveyed sites, there was no safety problems at diverge and merge areas. Turning across opposing traffic did not appear to be a safety problem.

3.10.12 From Transit's perspective, given a 400 vph one-way flow, 55/45 directional split, and peak hour flow of 10.5% AADT, the maximum flow equates to about 6,900 vpd. Therefore, Transit should allow traffic from the opposing untreated lane to overtake at PLs at least up to about 7,000 vpd with some localised double yellow lines and more restrictive markings above this AADT, if required.

iii) Application of European 2+1 Lanes & Extra Wide Lanes

3.10.13 Sweden, Finland and Germany have trialled 2+1 lanes and extra wide lanes (Potts & Harwood, 2003). All of these countries have extensive existing 11-13 m wide-shouldered road networks, where intermediate treatments can be applied. Therefore, application in NZ would be to newly constructed or upgraded roads not existing carriageways.

3.10.14 Swedish guidelines provided increased shoulder-to-shoulder width for newly constructed carriageways (14 m) compared to existing carriageways (13 m). Similarly for Finland, an extra 1.35 m width was used on newly constructed roads (14.35 m) compared to existing carriageways (13 m). German carriageway widths were changed from 11 m to 12 m (11.5 m minimum new construction).

3.10.15 For Swedish and German roads, best safety and operational results occurred with good road geometrics, a semi-motorway (expressway) standard of access and central median barriers. Germany constructed about two thirds of 2+1 lanes as newly constructed bypass routes with a semi-motorway (expressway) level of access and 0.5 m gap separation between opposing flows. A 1.0 m gap separation between opposing flows with a rumble strip was under consideration.

3.10.16 Sweden had a mixture of semi-motorway (expressway) and conventional limited access roads. In Sweden, a lower level of access control seemed more common and relied more on central median cables and reduction to 70 km/hour for at-grade intersections.

3.10.17 Central median barriers were not been universally adopted over all countries. Germany had some concerns mainly, due to operational and maintenance issues. While not noted within the research, its existing 11-12 m wide roads would have insufficient width to accommodate central median cables.

3.10.18 Swedish, Finnish and German operating and capacity flows were higher than North American values for similar cross-sections. Better slow lane use and merging at transition areas seemed to be two reasons for this difference. Operating and capacity flows for intermediate treatments were similar to two-lane roads but LOS was higher.

3.10.19 There were typically about 10-20% HCVs on German roads. The Draft Transit Geometric Design Manual indicated about 5-10% HCVs for NZ roads. A review of NZ SVBs showed HCV values of 12-20% AADT (Koorey, 2002). However, SVBs were typically placed on low-volume roads or roads with high differential speeds. Therefore, the absolute number of HCVs on NZ SHs may not be high compared to overseas roads.

iv) Canadian versus German Roads

3.10.20 German 2+1 lanes and extra wide lane roads were compared with Canadian wide–shoulder roads and passing lanes (Frost & Morrall, 1995). The 2+1 lanes had better overall performance than PLs in series. The German extra-wide lanes had the best operational performance but were not proposed for future development in Germany due to safety concerns.

3.10.21 Canadian crash records were collected at about a quarter of the property damage value for German records. Therefore, Canadian non-injury records and hence total crashes appeared markedly higher than German safety results.

3.10.22 Transit needs to consider data collection criteria when comparing overseas crash reduction rates. Therefore, the best practice is to compare fatal and serious crashes only, although the German situation would seem more applicable to NZ.

4. RELEVANT NZ RESEARCH

4.1 Accident Countermeasures: Literature Review

4.1.1 Collective crash reduction rates were identified that could be applied to passing opportunities (Travers Morgan, 1992). However, the crash data was not specific to NZ conditions. General outcomes were:

- Literature from 11 countries was reviewed with the majority from Australia, USA, the United Kingdom and New Zealand.
- Amongst other road features, crash reductions were identified for lanes, namely turning (10-37% rural, 10-25% urban), passing lane (10-37% rural, 10-25% urban), 4-lane (35% rural) and sealed shoulder (20-75% rural).
- Crash reduction by severity and manoeuvre were also provided.

4.2 Typical Accident Rates for Passing Lanes and Unsealed Roads

4.2.1 As an improvement on Travers Morgan's work, NZ crash reduction rates for PLs (three lane and four-lane undivided) were identified under four categories of traffic flow and for three types of terrain (McLarin, 1997). Summary tables were provided, expressing crash rates in terms of exposure i.e. crashes/10^8 v-km.

4.3 Assessing Passing Opportunities Literature Review

4.3.1 Transit carried out research on a Literature Review (Thrush, 1996) and Stage 1 of Assessing Passing Opportunities under its own name. Stages 2 & 3 were undertaken through Transfund (now known as Land Transport NZ). General conclusions of the Literature Review were:

- Criteria need to be driver sensitive, easily measured and easily calculated on site.
- While overseas warrants and guidelines were unlikely to be applied to NZ, various aspects should be considered: i) driver frustration, ii) percentage of road length with passing opportunities, iii) traffic flow, iv) length of PL, v) road gradient and vi) percentage of heavy vehicles.
- Prediction of benefits for economic evaluation would require a computer based model and TRARR was the most appropriate candidate.

4.3.2 The literature review was a key element of NZ research in passing opportunities. The bibliography provided an extensive list of literature on both PSD and PLs.

4.4 Stage 1. Assessing Passing Opportunities

4.4.1 A draft report was provided but a final report not published, mainly due to restructuring of the Transit NZ organisation, which changed the roles of sponsoring Transit staff (Tate, 1997). One of the main purposes of this research was to establish a framework for modelling under NZ conditions. The general outcomes from Stage 1 were:

- TRARR and TWOPASS were similar and choice should be made on convenience issues.
- New Zealand fleet descriptions were altered for use in TRAR.
- While fleet characteristics had a major impact on predicted benefits, the changes were very stable in% terms. For example, using three very different fleet descriptions could result in say travel times of 1,000, 1,500 and 1,800 seconds but for a particular passing lane resulted in a 3% travel time saving in each case.
- As the percentage of travel time savings was robust, it was suggested that all TRARR models have travel time surveys to "calibrate" the models.

4.5 Stage 2. Assessing Passing Opportunities

4.5.1 Stage 2 improved modelling assumptions and reviewed differences in safety benefits between "tack-on" and realigned passing lanes (Koorey et al., 1999). The study used crash data from 1985-1993 inclusive and per-dated formal safety audits by Transit NZ. General outcomes of Stage 2 were:

- Willingness to pay costs were estimated to be 3.5 c/veh/km not travelled behind slow vehicles.
- Safety benefits identified a difference between PLs on new alignments and tack-on PLs, with "tack-on" PLs having less favourable crash reductions.
- Initial development of a sieving model to determine optimal locations before TRARR analysis.
- Improvements in calibrating TRARR modelling with field observations.

4.5.2 Driver frustration involved estimates for willingness to pay (WTP). Research concluded a range of 3.2-3.7 c/veh/km not travelled behind slow vehicles but an average value of 3.5 was applied to all PL projects, as different rates for unsatisfied passing demand (UPD) versus WTP were not considered robust enough.

4.5.3 Variables effecting WTP included i) length of journey but are possibly related more to total costs for a journey rather than cost per kilometre, ii) preferred travel speed, iii) frequency of travel along road section, iv) need to differentiate frustration between ability to pass and ability to be passed.

4.5.4 For just the PL length, there was an average crash reduction rate of 25% for NZ three-lane and four-lane sections of rural state highway. Taking into account the PL length, 0-2 km upstream and 0-4 km downstream, the overall injury crash reduction rate was about 14%. Reductions were higher for realignments (54%) compared to "tack-on" passing lanes (5%). With tack-on passing lanes, there was an increase in loss of control crashes (15%) and rear end/obstruction crashes (15%) and a reduction in overtaking (38%) and head-on crashes (62%).

4.5.5 For tack-on PLs, some crash rates increased immediately downstream of the PL and may be due to the merge. Severity reduced by 15% overall in the same direction but for tack-on PLs the 15% reduction was negated by an increase in crash severity in the opposing direction. This would suggest that crash severity reductions were primarily due to geometric improvements.

4.5.6 For combined tack-on and newly aligned PLs, PLs with 600-800 m (33%) and greater than 1500 m (51%) had the most significant reduction but crash rates for PLs 1,200-1,500 m long increased by 37%. For PLs with AADTs of 4,500-6,000 vpd, there was a slight increase in crash rate but these sites had the lowest crash rates both before and after construction.

4.5.7 Improvements to TRARR calibration included: i) better mass data collection techniques, ii) use of specific values rather than averaged values for input parameters, iii) sensitivity of model to speed differential, traffic volumes, available passing sight distance (APSD) and initial accrued passing demand (APD), iv) using surveyed traffic volumes to determine parameters, such as bunching and proportion of HCVs and v) specifying outputs that can be easily related to traffic volumes.

4.6 Stage 3. Assessing Passing Opportunities

4.6.1 As well as suggesting further modelling improvements, Stage 3 looked at operational effects on modified no-overtaking markings and compared differences between PLs and SVBs (Koorey & Gu, 2001). General outcomes of Stage 3 were:

- There were nett safety benefits for modified markings involving horizontal and vertical sight restrictions markings but further surveys or simulations were required. Also, the operating speed should be considered when assessing no-overtaking areas rather than assuming a 100-110 km/hour operating speed.
- Suggested revisions to PEM simplified procedures for assessing PL benefits included i) investigation of HCM procedures for PLs, ii) relating WTP values to PSTF and iii) re-presentation of accrued passing demand (APD) in terms of percentage bunching.
- Field performance of SVBs showed that motorist behaviour was different to PLs. Changes to current NZ guidelines for length and a separate simplified procedure were suggested.
- Comparison of TRARR and TWOPAS with a view towards identifying a suitable model for more detailed analysis and to assess both safety and operational benefits.

4.6.2 Small amounts of overtaking (up to 2.5%) occurred at sites with sub-standard visibility. Changing no-overtaking lines to accommodate horizontal sight restrictions would at least double the amount of line marking, reduce overtaking rates by 50% and increase PTSF by 20-30%. However, travel times would not increase by more than 9% and less where traffic volumes were greater. A modified approach allowing isolated horizontal curves to be marked was seen as a compromise between current markings and allowing for both vertical and horizontal sight constraints. A nett safety benefit would be expected but driver frustration was likely to offset any reduction in dangerous overtaking manoeuvres.

4.6.3 Field calibration of simplified procedures included: i) the revised HCM procedures for passing lanes should be investigated for NZ conditions, ii) revised WTP procedure relating driver frustration to percentage time spent following (PTSF), iii) suggested changes to Transfund's simplified procedures to better determine APD with possible re-presentation of procedure in terms of percentage bunching.

4.6.4 Field performance of slow vehicle bays showed that SVBs and PLs should be differentiated with markings and with driver education to avoid confusion. SVBs should be located where mean traffic speed is less than 60 km/hour or less if longer queues are likely. Travel time saving should only be considered if passed vehicles do not have undue delays before re-entering traffic stream. Separate simplified procedures for SVBs should be developed rather than using the simplified procedures for PLs.

4.6.5 From Transit's perspective, there are no simplified PEM procedures for SVBs and modelling is required. Earlier research suggested that the Borel-Tanner Distribution would be suitable for traffic conditions with up to 2 following vehicles (Koorey & Gu, 2003). However, the Beca Report, discussed later in Section 6.1, did not develop a simplified procedure for SVBs.

4.6.6 To help determine a more detailed model, a comparison between TRARR and TWOPAS was suggested. Safety assessments as well as operational efficiency should be included within rural simulations, including investigation of the US Interactive Highway Safety Design Model (IHSDM). An improved model should be adopted or developed as a result of these further investigations.

4.7. Rural Road Simulation Models

4.7.1 This research followed on from Stage 3 Assessing Passing Opportunities with a view to developing a more detailed rural simulation model that included both operational and safety benefits (Koorey, 2003). The review of operational models focused mainly on TRARR, TWOPAS and PARAMICS. Review of safety models involved mainly IHSDM, SafeNET and Road Risk Manager. Other operational and safety models were assessed.

4.7.2 Scoping and site selection showed that modelling of horizontal and vertical alignment was important as these features have the greatest influence on driver speed. Undesirable vehicle following and congestion delays were linked to: traffic volumes and composition, available passing sight distance and traffic speed distributions. Roadside development and lower speed limits were difficult to model and site measurements were suggested. Narrow road widths did not adversely affect safety, except in isolated situations such as one-lane bridges. Other features affecting safety were: side roads, one-lane bridges and roadworks with traffic control.

4.7.3 Most analysis was carried out to evaluate efficiency but a combined safety and efficiency model was preferred. TRARR, used in NZ, had some limitations and other tools such as TWOPAS should be investigated. Other models such as PARAMICS should be considered but the driver behaviour model was originally developed for urban situations. Since this research by Koorey, PARAMICS has developed a rural road model.

4.7.4 Any desirable model would be able to consider a wide range of road, environment, vehicle and driver factors and also have additional features to provide a wide range of accurate outputs. Features for easy use of input and output data should also be considered. Incorporation of road modelling into existing road design packages would enable easy assessment of designs and other traditional road user benefits.

4.7.5 Field data collection and simulation showed that NZ was served by modelling tools for PLs but not necessarily for other project types. The three models of TRARR, TWOPAS and PARAMICS all had their relative strengths. TRARR was familiar to NZ practitioners. TWOPAS features were as comprehensive as TRARR but it did not bring in road data automatically in the then current beta version. However, this discrepancy may be addressed in a later version.

4.7.6 PARAMICS provided considerable flexibility but would need to be calibrated and validated for NZ conditions, although there were some reservations about the driver behaviour model. Existing usability problems in TWOPAS and PARAMICS would need to be addressed to make them more practical for rural road simulation. However, since this research, PARAMICS now provides an upgraded rural road version.

4.7.7 Review of IHSDM and related safety models showed that many crash analysis models were static models predicting crash rates from similar site features. Mirco-simulation results could be compared with observed conflicts. Road features of horizontal curvature, absolute gradients and reduced sight distance were significant influences on rural road safety, especially when combined with both higher mean speeds and higher speed variances. Some calibration of overseas models would be required, although an initial estimate of relative change could be provided.

4.7.8 Models made use of road geometric standards and local crash data but little information was available on the safety effects from combined changes to road features. NZ has a relatively good system of highway data and crash data. Both data sets could be combined but on-site data may also be required. As more "easy" fixes are implemented, more sophisticated prediction models will be required. The best safety models should combine both driver behaviour and road features. Since this research by Koorey, Transit's high-speed data capture for road and pavement conditions have improved and therefore more accurate estimates can be used.

4.7.9 While not part of evaluation criteria for this study, Transit should ensure that any further evaluation considers the ease of converting its existing TRARR models for various SHs.

4.8 Estimating Passing Demand

4.8.1 Improvements to the PEM procedures were suggested when assessing the demand for overtaking (Roozenburg & Nicholson, 2004). The 2004 simplified PEM procedures assumed that coefficient of variation (COV) was 13.5%. Under PEM procedures A 10.2.7, benefits were only adjusted when the COV was greater than + or - 13.5%. However, research on three South Island sites indicated that now a large proportion of all vehicles were travelling at similar speeds.

4.8.2 The speed distribution was closer to fitting a Logistic distribution rather than a Normal distribution. The research also showed that the goodness-of-fit was best for combined streams rather than individual streams. Further investigations were suggested to determine the appropriateness of estimating passing demand for a single combined stream using Logistic-distributed speeds as this would help to simplify analysis for low-cost treatments.

4.8.3 The revised PEM procedures for PLs use the Troutbeck method. For this method, when the standard deviation of the faster stream was low e.g. flat terrain, passing demand from the PEM procedures was estimated to be low compared to observed passing demand. For a 10 km/hour difference between truck and car speeds, there was a 12% increase in the Benefit/Cost Ratio (BCR) compared to BCR under PEM procedures.

4.8.4 From Transit's perspective, given the nature of determining BCRs, the 12% difference was not marked enough to request Land Transport NZ to change the PEM procedures. Also, the revised PEM procedures tended to under-estimate BCR rather than over-estimate BCR.

4.9 Overtaking Lane Design

4.9.1 This research considered crash data and driver behaviour in both directions of travel with a full environmental assessment for 21 of the crash sites (Luther et al, 2004). Main issues were: overtaking in the opposite direction, merge design and loss of control crashes. A simulation-based study tested driver behaviour for various merges, using the DS3 driving simulator. Validation of the DS3 simulation data showed that overall simulated results were similar to observed behaviour except that there were some marked differences in lane selection behaviour.

4.9.2 The crash analysis identified that: i) younger males were more likely to be involved in crashes relating to passing lanes, ii) driver frustration and iii) longer vehicles seemed over-represented (47.5% of crashes involved drivers attempting to overtake longer vehicles).

4.9.3 Engineering issues were: i) number of sites lacked escape routes, ii) sealed shoulders were not wide enough for driver to avoid a crash, iii) sloping verges, ditches and banks contributed to the unforgiving nature of the roadside area, iv) at some sites, there was inadequate sight distance, v) current criteria for double yellow lines may not adequately address problems and factors relating to overtaking at passing lanes.

4.9.4 Suggested improvements included: i) all merges to be constructed to AUSTROADS standards, ii) avoiding blind merges if possible, iii) both shoulders to comply with Transit NZ 1.5 m minimum width with 2 m width preferred, iv) reduce driver frustration by providing more passing opportunities, v) consider wider lane in oppose direction to provide overtaking for opposing traffic, vi) double yellow line with wide profile markings in high risk areas, vii) solid median barrier in high risk areas, viii) better signs if confusion about sight distance and lane use, ix) better education about safe overtaking, x) warning signs if adverse conditions occur e.g. ice and xi) either remove pseudo lanes i.e. hatched shoulders or treat merge of these zones same as for passing lanes.

4.9.5 From Transit's perspective, about 50% of long vehicles were involved in crashes. Therefore HCV drivers and drivers of towing vehicles may require education measures

4.10 Other NZ Research

4.10.1 Research into PSD used a randomly generated simulation on various parameters to show that on average 707 m PSD is required with an 85th percentile PSD of 903 m (Roozenburg & Nicholson, 2003). These values need verification by NZ field trials. The main parameter that influenced PSD was the time between oncoming and passing vehicle at the end of the manoeuvre rather than the acceleration of the passing vehicle.

4.10.2 Beca Carter Hollings & Ferner (Beca) (Roozenburg, Turner) and Montgomery Watson Hazra (MWH) (Tate) are currently undertaking work for Land Transport NZ on Rural Crash Prediction Models. Currently, GHD is undertaking a Land Transport NZ research project into lane merging "Merge Like A Zip".

4.10.3 Beca carried out research on developing procedures for economic evaluation of PLs. This research is discussed later under Section 6.1 Beca Report.

5. KEY FINDINGS OF PART I

5.1 Passing Sight Distance

5.1.1 There has been a significant amount of research into the theoretical aspects of Passing Sight Distance (PSD). Overseas research showed that about 780-850 m is required for car overtaking truck and trailer manoeuvres with accelerated passing, where both vehicles have high operating speeds and there is opposing traffic. Comparison of overseas PSD guidelines shows that Australia's PSD was the best at relating theoretical considerations to actual traffic conditions. NZ follows AUSTROADS guidelines but the adoption of these guidelines is a relatively recent event.

5.1.2 NZ research into assessing passing opportunities was suggested by McLarin (McLarin, 1997). NZ research into PSD had looked at a variety of variables and showed that distance between opposing traffic and the passing vehicle at the end of the manoeuvre was the most important factor (Roozenburg & Nicholson, 2003). The simulated PSD was 707 m (85th percentile) but would have to be calibrated by field surveys.

5.2 Signs & Markings

5.2.1 Comparison of international marking standards showed that Canada had the most conservative approach, whereas Australia and USA were mid-range compared to Britain, which had the least conservative theoretical PSD (Harwood et al., 1995). Australian marking standards are more closely aligned with theoretical considerations and are also speed-related.

5.2.2 Recent NZ research showed that a significant number of PL merges did not comply with AUSTROADS standards (Luther et al., 2004). Therefore, any direct comparisons between AUSTROADS and other standards may not relate fully to NZ conditions.

5.2.3 Unlike most other overseas countries, NZ does not mark locations with horizontal sight restrictions. NZ research by showed that horizontal markings would provide a nett safety benefit but could lead to added driver frustration and increase travel time delays. More investigation was required. Rather than changing all NZ's markings, some isolated horizontal curves may be suitable for horizontal restrictions (Koorey & Gu, 2001).

5.2.4 From Transit's perspective, at this stage, no national application of horizontal restriction is suggested but horizontal restrictions could be provided on isolated curves with a high crash severity, particularly to reduce head-on crashes, which are sometimes used to justify passing facilities.

5.2.5 NZ research showed that in some cases, i) merge tapers did not comply with AUSTROADS standards, ii) criteria for double yellow lines was not adequate, iii) PSD were inadequate, iv) better signs are required for lane use, PSD and warning for weather conditions, v) double yellow with wide profile markings or solid medians should be considered in high risk areas, vi) blind merges should be avoided and vii) shoulders did not comply with Transit's 1.5 m minimum width (Luther et al., 2004). Transit should also consider lengthening the project length for safety audits of new passing facilities and provide a safety review process for existing PLs.

5.2.6 After consulting with various industry practitioners, Luther and others did not undertake an assessment on European merge markings because of perceived public resistance. However, European merge markings may partly contribute to higher operating volumes on 2+1 lanes and could help operating flows at PL merges. Improved merging could extend the range of locations where 2+1 lanes could be applied instead of four lanes. Other research is currently being done into merge behaviour by GHD NZ Ltd. Transit should investigate European markings, particularly at the merge area but should build on preceding and current research.

5.2.7 Transit has currently adopted the European dominant slow lane approach for the diverge area and this has worked well in ensuring that slow vehicles use the left lane.

5.3 Passing Demand

5.3.1 NZ PEM procedures for assessing passing demand involve determining the proportion of road length with at least 450 m PSD (Land Transport NZ, 2005). As highlighted by international research, this length may not be suitable for timid car drivers or for cars passing trucks travelling above 80 km/hour (Bergh & Carlsson, 2000).

5.3.2 Canadian theoretical research using the Unified Traffic Flow theory allowed for the effects of passing demand on capacity (Werner & Morrall, 1984). This research has been applied to Canadian PL strategies. Research by the South African National Road Agency Ltd (SARNAL) provided another approach for assessing the level of passing demand and applying the model over a network (South African National Road Agency Ltd, 2004).

5.3.3 NZ research proposed a framework for an initial assessment of passing demand, which utilised the Unified Model but would require further field calibration (Koorey et al., 1999). Transit could use the conceptual model to undertake further evaluation on both the Canadian and SANRAL models. When the conceptual framework was developed, the researcher was aware of the Unified model.

5.5.1 NZ field studies on passing demand showed that the Logistic distribution was the most appropriate and suited a single traffic stream rather than two separate streams for cars and HCVs (Roozenburg & Nicholson, 2004). This single stream behaviour suggested that car and HCV operating speeds were similar.

5.4 Computer Modelling

5.4.1 NZ modelling is currently served by TRARR. For calibration of TRARR to NZ conditions, the values for many parameters were improved but willingness to pay, which related to driver frustration, used an averaged value (Koorey et al., 1999).

5.4.2 There are no planned upgrades from the developers. Research has been undertaken into a more detailed model that determines both safety and operational benefits, using readily available road and crash data. TWOPAS and PARAMICS had some limitations that needed to be addressed. IHSDM was identified as a suitable compatible safety model (Koorey, 2003).

5.4.3 However, since Koorey's 2003 research, a PARAMICS rural road model has been developed. Separate from any of the above research, Transit's high-speed data capture of road geometrics has become more sophisticated, thereby reducing modelling error.

5.4.4 While not mentioned in Koorey's 2003 research, any new rural road simulation model should consider the ease of conversion for existing TRARR models. Transit has many TRARR models for various parts of the SH network.

5.4.5 The lack of upgrading of TRARR has implications for NZ's PEM passing lane procedures as i) SVBs and crawling lanes at scheme assessment stage, ii) road sections with high numbers of slow vehicle, such as HCVs and recreational vehicles and iii) PLs with significant construction costs or significant construction or pre-construction periods, are all situations that are not covered by simplified procedures and require rural simulated models (Land Transport NZ, 2005). Therefore simplified procedures for low-volume treatments should be developed.

5.4.6 Luther and others used the DS3 computer programme, calibrated for NZ conditions, to simulate driver behaviour. Transit should consider using this model in any further evaluation of merge taper design.

5.5 Low-Volume Treatments

5.5.2 Apart from some early US research by Harwood and Hoban, there have been few developments in low cost treatments (Harwood & Hoban, 1987). The US Transportation Research Board is currently trying, albeit unsuccessfully so far, to develop a research project on analysis methods for low cost treatments (Transportation Research Board, 2005).

5.5.3 NZ research showed that SVB driver behaviour was different to PL driver behaviour and identified the Borel-Tanner Distribution, as being suitable for assessing passing and frustration benefits at low volumes. Also, NZ use of low-volume SVB treatments was markedly higher than overseas use (Koorey & Gu, 2001). Therefore, Transit should undertake its own research into assessing low-volume treatments, so that simplified PEM procedures could be developed.

5.5.4 To assist overtaking by opposing flows at PLs, NZ research showed that in some cases the width of shoulder in the opposing lane was less that Transit minimum standard of 1.5 m and should be widened to 1.5 m minimum or preferably 2.0 m. Also wider lanes could be provided in the opposing lane. (Luther et al, 2004). The Manual of Traffic Signs and Markings (MOTSAM) Part II shows that sealed shoulder width should be the same as the standard link sealed shoulder width for that section of SH (Transit NZ Land Transport NZ, 2004).

5.6 Moderate-Volume Treatments

5.6.1 US research into European intermediate treatments with typical AADTs of 10,000-20,000 vpd showed that although 2+1 lanes had a lower operating capacity than extra-wide lanes, they had a better safety record (Potts & Harwood, 2003). There were differences between applications to existing (11-13 m) carriageways compared to newly constructed (11.5-14 m) facilities.

5.6.2 However, North American, European and Scandinavian SH agencies had extensive networks of 11-14 m wide carriageway that could be easily converted to intermediate treatments. NZ, like Australia has mainly 8.5-9 m wide carriageways. Therefore, while using overseas experience, Transit should consider developing its own set of guidelines and selection criteria.

5.6.3 NZ has not undertaken any significant research into intermediate facilities for 10,000-20,000 vpd. Transit has recently built a tack-on 2+1 lane and is proposing to build another 2+1 lane road, as a green-fields realignment. Therefore, monitoring of costs and performance is suggested for both types of construction and if appropriate a before-and-after study for the realigned section.

5.7 Safety

5.7.1 Generally, Sweden used LAR controls and central median cables in conjunction with speed controls for at-grade intersections to improve safety on 2+1 lane roads. The majority of Germany's new intermediate treatments were provided as bypass routes on new alignments and use a semi-motorway (expressway) access standard and 0.5-1.0 m gap separation of opposing flows. Best safety results for 2+1 lanes were achieved with upgraded road geometrics, semi-motorway (expressway) access controls, central median cables and clear zoning.

5.7.2 Some low-cost safety measures could be applied incrementally independent of carriageway upgrading and would provide similar Benefit Cost Ratios to carriageway improvements (Benekolah & Lee, 1991). Transit should consider increased use of roadside safety treatments/measures for low-volume SHs, as an initial treatment, rather than using SVBs and short PLs. Also some incremental roadside treatments may be useful for loss of control crashes downstream of passing and overtaking facilities.

5.7.3 NZ research showed that tack-on PLs (5%) had a low crash reduction rate compared to newly aligned PLs (54%) (Koorey et al., 1999). For tack-on lanes, there was a overall 15% increase in lost control crashes, mainly 0-2 km downstream. As there were a large number of lost control crashes, this type of crash tends to dominate the safety reduction figures.

5.7.4 While NZ research showed high HCV use for SVBs compared to overseas (Koorey & Gu, 2001) crash reduction rates were less than US results. (Harwood & Hoban, 1985). Entry and exit visibility varied for SVBs that were safety audited in the Kaimai Ranges (Nicholson et al., 2000). Transit should consider entry and exit visibility, as part of any proposed location guidelines for PLs and SVBs and as part of any Safety Auditing.

5.7.5 Transit currently undertakes clear zoning at many proposed PLs, as a method of reducing crash severity for lost control crashes. Where, possible Transit should consider co-ordinating more Transit works that would have an effect on safety, such as better signage and delineation of curves.

5.7.6 Research by Luther and others showed that long vehicles (47.5%) and young drivers were over–represented in PL crashes (Luther et al., 2004). Transit should consider education and possibly enforcement measures for HCV drivers and drivers of towing vehicles. Possibly, a question on overtaking for driver's licence and heavy vehicle licence tests would be appropriate.

5.7.7 Beca and Montgomery Watson Hazra (MWH) through Land Transport NZ are currently undertaking research into mathematical crash prediction models. For four-laning, Hauer showed that mathematical models have to take into account other work that is undertaken at the same time as the principal activity, as this can affect results (Hauer, 2000). However, the same principle applies to all prediction models. Transit should monitor the NZ research.

5.8 Guidelines and Warrants

5.8.1 Significant influences on NZ passing opportunities will be NZ's relatively lower AADTs, varying terrain, percentage of HCVs and PL length. Overseas guidelines would not be suitable for NZ conditions (McLarin, 1997). Transit should develop its own set of guidelines but consider overseas experience and issues within the context of NZ conditions.

5.8.2 Kansas guidelines provided an extensive commentary on the theoretical aspects of passing facilities (Mutabazi et al., 1999). Alberta guidelines reflected a wider experience of issues, including environmental aspects (Alberta Infrastructure, 1999).

5.8.3 PL guidelines from British Columbia and Wisconsin were influenced by terrain and had shorter PL lengths, although not as short as typical PLs in Australia (Morrall & Hoban, 1985). For 2+1 lanes, recent research showed changes to design and operational standards as experience with these types of treatments increased (Bergh & Carlsson, 2000).

5.9 Performance Indicators

5.9.1 Indicators that are sensitive to driver perception, such as delays and travel speed are preferred to graded measures, such as level of service or degree of saturation (Navarro & Rouphail, 2000).

5.9.2 NZ research suggested that Willingness to Pay should be related to percentage time spent following (PTSF) and Accrued Passing Demand should be related to percentage bunching effects (Koorey & Gu, 2001).

5.9.3 Canadian research proposed an overtaking (passing) ratio (Morrall & Werner, 1990). South African research proposed parameters, such as follower density (South African National Roads Agency, 2004). Both parameters should be considered in conjunction with any assessment of passing demand models.

5.9.4 From Transit's perspective, Transit's current traffic data collection system has the ability to record travel speed and headway but is not currently being fully utilised. However, there may be limitations in the current location of the count stations and the timing of the survey, which are based on recording average rather than peak period conditions.

5.9.5 Therefore, performance indicators other than travel speed and headway plus recording at specific sites may be required, particularly for before-and-after studies. As part of any proposed Transit TDM strategy, there may also be potential for ITS applications regarding monitoring of sites.

5.10 Implementation

5.10.1 The implementation of PL strategies for sections of Canadian (Morrall & Blight, 1985) and US (Morrall et al., 1995) highway was partly necessitated by changes to marking policy requiring more passing facilities, as well as increased traffic volumes.

5.10.2 The approach showed the benefits of treating whole lengths of SH rather than individual locations. Transit should consider both an interim and long-term strategy. The earlier interim strategy would target problem locations within road sections. The long-term strategy would use projected AADTs to consider the whole road section.

5.10.3 Koorey and others identified the need for an initial assessment of passing demand (Koorey et al., 1999). In conjunction with passing demand, Canadian and SANRAL models should be evaluated, as a coarse sieving tool for network demand or to identify problem locations within road sections.

PART II. REVIEW OF TRANSIT POLICIES & PROCEDURES

6. SUPPORTING TRANSIT WORK

6.1 Beca Report

6.1.1 The objective of Transit Project No. PR-5-0028 was to develop a simplified method for assessing PL benefits, for both PLs in series and as individual PLs (Beca Carter Hollings & Ferner Ltd, 2000). The Beca report detailed the process for assessing a series of passing lanes as an overall strategy and also improvements for assessing individual PLs based on the same methodology. Main tasks were:

i) Stage 1: Simplified Procedure

- Determine benefit and cost streams.
- Develop BCR graphs relative to PL spacings.
- Sensitivity analysis to determine level of accuracy.
- Develop PEM procedures in consultation with Transfund (now Land Transport NZ),
- Stage 1 Report.

ii) Stage 2: Regional Implementation Plans (for two regions)

- Data collection.
- Classify State Highway sections by terrain.
- Develop Regional PL Strategy.
- Desk top assessment and site visit of proposed locations.
- PL Implementation Report for each region with priority list and plots of existing and proposed locations plus required spacings at appropriate future dates.

6.1.2 Generally, the report was a good start at generating a simplified procedure for PLs in series. However, the process could be improved in terms of construction cost estimates, determination of passing opportunities, BCR graphs and level of accuracy for some terrains.

6.1.3 Costs were based on PL costs for Beca Carter Hollings & Ferner's North Island projects and Transit's Canterbury Region 11. Comparison with projects undertaken in Regions 1 (Northland) & 2 (Auckland) showed that average Beca Report construction costs were markedly lower. This comparison is discussed later within this report under Section 7.4 Construction Costs. A centralised database for itemised project costs is suggested.

6.1.4 Construction costs will increase, as remaining sites become more difficult. Therefore, graphs of BCRs need to be factored for variations in construction costs. There are no tables for I&R and Design costs. Therefore, the PEM procedures does not allow for full project costs in the BCR analysis but can be incorporated manually.

6.1.5 The Beca report indicated that the 450 m sight distance criteria gave capacities less than observed. To overcome these problems, a varying critical gap was used with 5 sec for overtaken vehicle at rest to 15 sec for overtaken vehicle at 75 km/hour and progressively increasing to larger values for overtaking vehicles over 100 km/hour.

6.1.6 Calibration to NZ conditions used a smaller overtaking gap acceptance than AUSTROADS guidelines. The report suggested that NZ drivers were taking shorter gap acceptance intervals to overtake slow vehicles and that this was a riskier manoeuvre. However, AUSTROADS guidelines values for gap acceptance may be conservatively high. Therefore, comparison with overseas calibrated values derived from field data should be required before forming any conclusions on NZ driver behaviour.

6.1.7 Sets of graphs are provided, that cover four different terrain categories of flat, rolling, hilly and mountainous at 5, 10 and 20 km spacings. Transit's current markings policy only allows for clear PSD in the vertical direction only. However, under PEM procedures, revised terrain definitions are used to allow for the likelihood of PSD restrictions in the horizontal direction.

6.1.8 Sensitivity analysis showed that for some terrain locations the accuracy would not be sufficient to determine accurate BCRs. There was insufficient data for robust analysis of some terrain conditions. The methodology did not cater for winding alignments on flat terrain and straight alignments on mountainous terrain. Therefore, TRARR modelling would be required for some terrain locations.

6.1.9 Canterbury Region has run into difficulties with low BCRs compared to other Regions. Transit has not progressed its implementation plan for Manawatu-Wanganui. In view of some differences in BCR estimation, the both implementation plans should be checked.

6.2 Project Evaluation Manual Procedures

6.2.1 As part of the work associated with the Beca Report, revised procedures were drafted by Transit in consultation with Transfund (now known as Land Transport NZ). Version 1 of the revised procedures was included in the PEM as Amendment 6 September 2002 and the current version is Amendment 9 October 2005 (Land Transport NZ, 2005). The revised procedures provided for:

- Simplified method for assessing passing lane strategies.
- Simplified methods for assessing individual passing lanes.
- Rural simulation for assessing passing lanes.

6.2.2 While the PEM procedures are a good initial start at developing strategies for facilities at individual sites and in series, there are some shortcomings that require further research. The revised PEM procedures now have three analysis methods, which could potentially provide three different answers, some above and some below funding criteria.

6.2.3 For PL strategies and individual sites, the simplified procedures does not allow for existing facilities on the road section. Therefore, modelling is still required to consider the effects on existing facilities, unless the proposed PLs in series includes existing PLs at the same spacing and length.

6.2.4 Currently, rural simulated modelling is required for i) SVBs and crawling lanes at scheme assessment stage, ii) road sections where high numbers of slow HCVs and recreational vehicles and iii) PLs with significant construction costs or significant construction or pre-construction periods.

6.2.5 Simplified procedures need to be developed for low-volume treatments at individual sites and in series. Modelling is too costly for minor work, such a SVBs. Adjustment factors are provided for length of passing lane down to 750 m without tapers. However, there is no provision for short PLs at 600 - 800 m.

6.2.6 For analysing individual sites using simplified procedures, output measures of passing demand that relate to site observations, such as bunching and average travelling speed would be useful. Input road data currently relates to vertical and horizontal alignment and to AADTs. Output benefits currently relate to travel time savings, vehicle operating costs, frustration cost savings and crash cost savings.

6.3 Limited Access Road Working Group

6.3.1 Transit project HO 02-59 addressed some opportunities for improving the way Transit manages access to the SH network for both driveways and local roads. However, the working group is no longer active and the draft report has not been presented to Transit's General Management Team (GMT) or the Transit Board. If the Working Party is re-activated, the composition of the Working Party could be reviewed to reflect restructured Divisional functions. A revised LAR classification system for access control is suggested.

6.3.2 Based on a draft report (Douglass, 2003), the three main suggested recommendations from the project are:

- An Access Management Category classification system to be established for the SH network that provides criteria for access according to the access management needed, the purpose, importance and functional characteristics of the various links within the network.
- A more strategic focus be given to highway planning by providing a better definition of both the Access Management Plan (AMP) and Access Management Structure Plan components of Corridor Management Plans (CMPs).
- A better process is established for negotiating access management issues with owners, developers and local authorities for highway sections subject to high volumes and development demands.

6.3.3 From Transit's perspective, the National State Highway Strategy (NSHS) is also considering a classification system but not just for access control. Also the NSHS is looking to include a wider range of functions for SHs. Therefore, any revised classification system may have to consider the two different functions of access control and SH strategy.

6.3.4 Additional conditions were also suggested for crossing approvals, namely purpose, frequency of use and review mechanism. While not part of the additional conditions, period of peak demand could also be considered, as the peak period for adjacent land use activities may not conflict with SH peak periods.

6.3.5 Anecdotal evidence suggests that the proposed LAR system will be difficult to achieve on some SHs with intensive land development. Therefore, any revised LAR system will have to balance existing and future requirements with both Access Management Plans and Access Management Structure Plans. Possibly other mechanisms such as Structure Plans for local roading networks will be needed to complement shortfalls in access provision or reduce existing over-provision of access driveways.

6.4 Cost Estimation Review

6.4.1 This Transit project is currently in progress. The main objectives of this work are:

- To enhance the reliability of Transit's Cost Estimation performance and provide a more robust platform for financial planning.
- To build on previously successful review and developments.
- To widen scope to include Cost Control.
- To instil a habitual focus on Cost Estimation into the Project Teams.

6.4.2 For any revised Passing and Overtaking Strategy, better itemisation of cost estimates is required so that total costs can be easily disaggregated. The relative frequency of construction works should enable a sizeable database to be established, provided Transit Regions and their Network Consultants regularly provide costs details. Also, some provision for cost monitoring of new types of treatment will enable better decision-making on option selection.

7. PASSING LANE POLICY AND PROCEDURES

7.1 Policy

7.1.1 From Action Paper CS/02/03/4244, "The current policy on passing opportunities described under the Efficiency and Safety Improvements section (4.2) of the National State Highway Strategy sets out the objectives as follows:

- To maximise passing opportunities by trimming back vegetation, embankments, and crests that restrict sight distance.
- To provide passing lanes of an appropriate length to enable passing manoeuvres to be safely undertaken at nominal spacing of 5 km on routes with traffic volumes in excess of 4,000 vehicles per day, and otherwise where necessary to provide regular passing opportunities, particularly in rolling and mountainous terrain where such opportunities may be limited.
- To provide slow vehicle bays on steep grades and where appropriate on lower volume heavy vehicle and tourist routes."

7.1.2 The policy allows a "Weighted Average" BCR to be used to provide PLs as a corridor treatment.

7.1.3 Attachment A of the original policy identified 41 sections of SH with annualised average daily traffic volumes (AADTs) of more than 4,000 vpd and allocated a priority of 1-4:

- Priority 1 = 10,000 or more vpd.
- Priority 2 = 7,000-9,999 vpd.
- Priority 3 = 5,000-6,999 vpd.
- Priority 4 = 4,000-4,999 vpd.

7.1.4 Exceptions are:

- SH 1 has either Priority 1 (AADT of 7,000 vpd or more) or 2 (AADT of 4,000-6,999 vpd) due to high HCV use,
- SH 1 Whangarei-Warkworth, SH 1 Mosgiel-Milton and SH 2 Masteron-Featherston have Priority 1 as these projects had high BCRs.
- An updated policy in 2003 included both SH 3 Awakino Gorge-Te-Kuiti and SH 1 Kaikoura-Blenheim as Priority 1 for strategic reasons.

7.1.5 Attachment B of the original policy identified a total of 634 PLs (352 proposed sites, 207 existing sites and 75 sites to be investigated) within the 41 road sections with more than 4,000 vpd. The total of 634 PLs assumes a passing lane every 5 km for SHs with more than 4,000 vpd.

7.2 Prioritisation

7.2.1 Previous to 2006/07 SH Forecast, the PL strategy was prioritised using individual regional priorities. Funding was distributed over each Transit Region's higher priority projects. Relativity between projects was reached through consensus between all Regions.

7.2.2 For the 2006/07 SH Forecast, PL were prioritised using a Ranking Number that applied factors between 0-1 for traffic volumes, number of fatal and serious injuries and the SH's strategic function. Factors were summed and the total multiplied by the project's BCR. The project with the largest number is ranked first and similarly for the next highest number.

7.2.3 Factors are:

- Network Factor: 1.0 = SH 1, SH 2 Featherston-Masterton, SH 3 Awakino Gorge-Te Kuiti, 0.5 = others.
- AADT Factor: 0.05 = less than 4,000 vpd, 1.0 = 4,000-5,000, 0.2 = 5,000-6,999, 0.5=7,000-9,999, 1.0 = more than 10,000. (For SH 1 Milton-Mosgiel, SH 1 Kaikoura-Blenheim, SH 2 Featherston-Masterton, SH 3 Awakino-Te Kuiti and SH 1 Warkworth-Whangarei 0.5 = 0-9,999 vpd, 1.0 = 10,000 vpd or more).
- Safety Factor: 0.0 = 0 fatal and serious injuries, 0.1 = 1, 0.2 = 2, 0.5 = 3-5, 1.0 = 6 or more (no. of injuries not no. of injury crashes).

7.2.4 This system is more objective than previous systems. However, some road sections are based mainly on strategic grounds and should be reassessed as part of any future policy review.

7.2.5 The ranking system tends to favour SH 1 projects with larger traffic flows and high crash severity. However, some of these projects may be more suited to a different treatment i.e. 2+1 lanes or four-laning. Generally, low trafficked sites not on SH 1 without high numbers of fatal and serious injuries do not have a low priority.

7.3 Policy Implementation

7.3.1 Transit's current policy allows for a final layout of one passing facility every 5 km on SHs with more than 4,000 vpd. However, there is no interim strategy that progressively applies this layout. Also PLs and SVBs are generally built on an individual basis. It would be better to consider a 10-80 km road section depending on terrain and passing demand.

7.3.2 PROMAN does not cater for Weighted Average BCRs to help develop packages of work over two or more sites. Land Transport NZ staff has been consulted on this issue and are amenable to Weighted BCR packages. There is now provision within PROMAN for projects to be recorded as packages. It is suggested that each package is given a unique package number.

7.3.3 Where possible, Transit projects should also be linked in terms of timing. Therefore, financial and project management systems for both Transit and Land Transport NZ should be altered to link other Transit work proposed at the same time, using a unique link number.

7.4 Construction Costs

7.4.1 Table 1 compares construction costs for completed PLs (including one-off items, safety and pavement maintenance) in Transit's Northland and Auckland Regions (Regions 1 & 2 respectively) with PEM construction costs. The Region 1 & 2 sample involved 3 hilly sites (1.5 km average), 8 rolling sites (1.4 km average) and 3 flat sites (1.3 km average). To determine construction costs from total costs, Investigation and Reporting plus Design costs were assumed to be about $70,000/ facility for all terrains.

7.4.2 Excluding other Transit work, such as clear zoning, guardrails and pavement remedial works, area wide treatments, pavement rehabilitation plus one-off costs, such as bridge widening, planting trial, cattle underpasses, intersection improvements, average 2004 PL construction costs for Region 1 & 2 were about $350,000/km compared with October 2005 PEM average rates of about $360,000/km.

Table 1. Passing Lane Construction Costs

Combined Terrain	**Average Construction Costs $1,000/km**			
	PEM	**2004 Region 1 & 2 Sample**		
	Base Costs Oct 2005	**Base Costs**	**Incl One-Off**	**Incl One-Off, Safety & Mtce**
Flat	250	200 [1]	370	400
Rolling	320	340	420 [2]	680
Hilly	500	520	730	830
Mountainous	800	-	-	-
Average	**360** [3]	**350**	**510**	**640**

Note: [1] Sample of 2 sites, excludes 1 site with costs not fully broken down. [2] Sample of 5 sites excludes 3 sites with area wide pavement treatments & excessive guardrails. [3] Excludes mountainous value.

7.4.2 High variations in construction costs were partly due to one off items, including bridge widening, planting trial, retaining walls and cattle underpasses intersection improvements. Also Transit safety and pavement maintenance work was undertaken at some of the sites, namely clear zoning with guardrails, pavement rehabilitation, full width pavement treatments. Therefore, in some cases, location guidelines may help to avoid costly items. Also, PEM procedures should clearly describe, which items make up the base costs.

7.4.3 While not applied to all 13 PL projects, one-off items accounted for about 23% of averaged PL construction costs and Transit safety and pavement maintenance work accounted for about 20%. Due to Region 1 & 2's typically higher AADTs, longer PL lengths were required and possibly costly items were less likely to be avoided. Also, for some general areas, geotechnical problems were commonly encountered.

7.4.4 While it was more cost effective to undertake other Transit work at the same time, all costs were included under the PL budget. Within PROMAN there is no facility to identify separate Transit Divisional costs. Therefore, as mentioned earlier, provision is suggested within PROMAN to link both timing and packages of Transit works.

7.4.5 On the other hand, there were various realignment works that included PLs and these costs were borne by the realignment project cost. Therefore, within PROMAN, all passing lane facilities, both on the SH Forecast PL programme and as part of other works, should be identified.

7.5 Funding Level

7.5.1 Transit may wish to review its funding level, once interim and long-term strategies have been developed. While some PL spacings could be increased to 10 km or 15 km to match demand, the original policy estimate of $146 M for 427 (352 proposed + 75 to be investigated) facilities is conservatively low. Based on current expenditure of about $10 M/year with about 13 new PLs/SVBs per year, it would take about 30 years to complete 427 new facilities at a total of about $330 M. With $12 M/year, it will take about 25 years to complete 427 new facilities.

7.5.2 However, the revised $330 M estimated cost does not allow for: i) traffic increases on SHs with currently less than 4,000 vpd and ii) alternative treatments for sites that will increase to more than 10,000 vpd over the next 30 years.

7.5.3 An alternative strategy, such as an overtaking strategy would help to reduce the demand for passing facilities, particularly at low traffic volumes. However, cost savings or more funding will be needed to offset SHs with projected 10,000 vpd or more.

7.5.4 Table 2 shows the distribution of funding over 1st ranked 40 projects and remaining 99 projects in the 2006/07 SH Forecast. Later analysis shows that about 68% of 1st 40 ranked projects are about 0.8-1.2 km long i.e. 1 km long. Therefore, total costs for 1st 40 ranked projects would be about $620,000/km, which is less than Region 1 & 2's estimated total costs of $710,000/km ($640,000 construction +$70,000 investigation and design).

Table 2. Level of Funding

Phase	First 40 Projects		Remaining Projects	
	Average $1,000/project	Total $ M	Average $1,000/project	Total $ M
Investigation	38	1.5	35	3.5
Design	33	1.3	35	3.4
Construction	550	22.0	644	63.8
Total	**621**	**24.8**	**714**	**70.7**

7.5.5 It is unclear whether one-off items or other Transit works have been included in the total costs for all 1st 40 ranked projects. Possibly, the higher construction costs for remaining projects could reflect that these projects are located at more difficult sites.

7.5.6 Assuming 40 projects/3years from the 1st 40 ranked projects, the total $24.8 M equates to $8.3 M/year. Given that the current budget is about $10 M/year, the difference is $1.7 M/year. As previously discussed, the difference may be partly due to extra Transit works or one-off items. Also contributing to the difference, some projects may have more than one site or PLs on both sides of the SH.

7.5.7 As previously mentioned, location guidelines should provide some cost savings if high cost items can be avoided and would help overall investigation and design costs by avoiding work on costly or operationally inefficient sites. Better systems for assessing passing demand would ensure that funding is directed at high demand locations. To help with monitoring and analysis of projects, within PROMAN, the number of PLs and SVBs for each project and the number of projects within any Weighted Average BCR package should be identified.

8. STATE HIGHWAY FORECAST ANALYSIS

8.1 Region

8.1.1 Table 3 shows the distribution of current 2005/06 projects by region. Generally, the 1st 40 ranked projects will get built within the next 3 years. The current PL Strategy within the 2006/07 SH Forecast contains 139 proposed PL and SVB projects at various stages of investigation, design and construction. Some projects contain more than one site and some projects have PLs on both sides of the road but there are generally few of these types of projects.

Table 3. Distribution by Region

Region	First 40 Projects		Total Projects	
	Number	Percentage	Number	Percentage
Northland	8	20	13	9
Auckland	6	15	13	9
Waikato	5	13	34	25
Bay of Plenty	2	5	11	8
Napier-Gisborne	9	22	16	12
Manawatu-Wanganui-Taranaki	3	8	17	12
Wellington	5	13	6	4
Marlborough-Nelson	1	1	8	6
Canterbury	2	5	10	7
Otago-Southland	0	0	11	8
Total	**40**	**100**	**139**	**100**

8.1.2 Napier-Gisborne has a high number of 1st 40 ranked projects. The high number is mainly due to high BCRs with six projects having BCRs greater than seven in conjunction with high flows (three projects with 7,000-9,999 vpd) and high crash severity (three projects with three or more serious or fatal injuries over the last five years). For Northland, the high number of 1st 40 ranked projects is mainly due to high crash severity with seven out of eight projects having more than three serious or fatal injuries in the last five years.

8.1.3 Wellington appears to be over-represented in the 1st 40 ranked projects mainly due to four Wairarapa projects having special priority. The low number of Canterbury 1st 40 ranked projects reflects the low number of total Canterbury projects plus generally low BCRs (Average 2.3) and moderately low AADTs with only one project having 7,000-10,000 vpd. Also, Canterbury's current low proportion of 1st 40 ranked projects may reflect early implementation of more favourable projects due to having an implementation plan prepared as part of the Beca Report.

8.1.4 Waikato appears to be under-represented in the 1st 40 ranked projects compared to total projects but its proportion of 1st ranked 40 projects is similar to Auckland and Wellington. However, some Waikato projects within Total Projects are to be considered in Weighted Average BCR packages that have yet to be developed.

8.1.5 Waikato's low number of 1st 40 ranked projects is due to a variety of factors, namely about 50% (17) of its total projects are not on SH 1, only one project has 3 or more fatal or serious injuries and about 25% have 7,000 or more vpd. None of Bay of Plenty's projects are on SH 1 and it had no projects with 3 or more fatal or serious crashes over the last 5 years.

8.1.6 Marlborough-Nelson and Otago-Southland are under-represented mainly due to both low traffic volumes and crash severity. None of these Regional projects have crash severity of three or more serious/fatal injuries over the last five years. Only one project in Marlborough-Nelson has 7,000 or more vpd. Manawatu-Wanganui-Taranaki has similar proportions of projects in both the 1st ranked 40 projects (8%) and total projects (12%). However, all three of these projects are on SH 1.

8.2 Traffic Volumes

8.2.1 Table 4 summarises projects by current AADT. Two sites from the 2006/07 SH Forecast did not have AADT figures so 137 total projects were used. The proportion of 1st 40 ranked projects with 7,000 vpd or more (50%) is favourably high compared to total projects (30%). Similarly, for the 1st 40 ranked projects, the AADT range of less than 4,999 vpd is under-represented (18%) compared to total projects (34%), which is to be expected under prioritisation.

Table 4. Distribution by Current AADT

AADT (vpd)	**First 40 Projects**		**Total Projects**	
	Number	Percentage	Number	Percentage
10,000 or more	6	15	11	8
7,000-9,999	14	35	30	22
5,000-6,990	13	32	49	36
4,000-4,999	2	5	14	10
Less than 4,000	5	13	33	24
Total	**40**	**100**	**137**	**100**

8.2.2 As overtaking using the opposite lane is not expected to effect safety up to at least 7,000 vpd, an overtaking strategy may be effective for a large portion of total (70%) and 1st 40 ranked (50%) projects. However, there may be some locations where passing facilities are still required, as alignment is poor and PSD is not available.

8.3 Crash Severity

8.3.1 Table 5 shows the distribution of projects by crash severity. For total projects, 133 projects had crash severity records and 1st 40 ranked projects had 38 projects.

Table 5. Distribution by Crash Severity

No. of Serious & Fatal Injuries	**First 40 Projects**		**Total Projects**	
	Number	**Percentage**	**Number**	**Percentage**
6 or more	4	10	6	5
3-5	11	29	15	11
2	4	10	17	13
1	7	19	32	24
0	12	32	63	47
Total	**38**	**100**	**133**	**100**

8.3.2 Generally, a higher percentage of projects with three or more serious or fatal injuries are represented in the first 40 projects (29+10=39%) than for total projects (11+5=16%). For 1st 40 projects with 4,999 vpd or less, 6 out of 7 projects have crash histories of three or more people with serious or fatal injuries over the last 5 years. Therefore, crash severity was one of the main reasons for selecting projects with 4,999 vpd or less.

8.4 Network

8.4.1 Table 6 shows the distribution of projects by network. For total projects, SH 1 and special priority projects make up about half of all projects (53%) but are favourably over-represented in the 1st 40 projects (63%).

Table 6. Distribution by Network

Network	First 40 Projects		Total Projects	
	Number	Percentage	Number	Percentage
SH 1	20	50	62	45
Special Priority	5	13	11	8
Others	15	37	66	47
Total	**40**	**100**	**139**	**100**

8.4.2 However, this does not take into account that for some Regions, such as Napier-Gisborne, Waikato, Bay of Plenty, Manawatu-Wanganui and Nelson-Marlborough, a substantial amount of their network is not part of SH 1.

8.4.3 A review of special priority projects is suggested, as this will allow an increase in non-SH 1 projects without reducing priority for SH 1. Alternatively, after reviewing interim and long-term strategies for all SHs, removal of the network factor for all SHs may be more appropriate.

8.4.4 As a compromise, only the PL sites specifically mentioned within the original policy or update should have special priority. Any future proposed PLs within the special priority SH sections would not have preference over other road sections.

8.5 Length

8.5.1 Table 7 shows the distribution of 2006/07 SH Forecast projects by project length. Seven projects did not have a specified length so a sample of 132 projects is used. Similarly, three 1st 40 ranked projects did not provide a length within PROMAN. Lengths have been rounded to the nearest 100 metres. Within PROMAN, length is based on the extent of the project and therefore, generally includes tapers. It is suggested that a field for length excluding tapers is provided within PROMAN.

8.5.2 The typical length of NZ passing facilities is low compared to North American typical lengths (approx 1.5-2 km) but is similar to Australian typical lengths (0.6-1.2 km) (Morrall & Hoban, 1985). The shorter length is probably due to variety of factors: averaged flow conditions, effect of safety benefits, terrain and effect of HCV speeds on passing opportunities.

8.5.3 Regarding traffic volumes, a comparison was made using AADT data from section Traffic Volumes. For 1st 40 ranked projects, 28% were either SVBs or short PLs i.e. 800 m or less compared with 18% of 1st 40 ranked projects having 4,999 vpd or less. Similarly, 24% of 1st 40 ranked projects are 1.3 km or more compared to 50% of 1st 40 ranked projects with currently 7,000 vpd or more. Overall, there are a high proportion of 1st 40 projects with 1 km or less (52%). Generally, the lengths of PLs are short compared to traffic volumes.

Table 7: Distribution by Length				
Length (km)	**First 40 Projects**		**Total Projects**	
	Number	Percentage	Number	Percentage
1.9 or more	2	5	6	5
1.7-1.8	1	3	5	4
1.5-1.6	0	0	8	6
1.3-1.4	6	16	18	14
1.1-1.2	9	24	29	22
0.9-1.0	9	24	32	24
0.6-0.8	7	20	19	14
0.5	0	0	1	1
0.4 or less	3	8	14	10
Total	**37**	**100**	**132**	**100**

8.5.4 Regarding averaged flows and safety benefits, Land Transport NZ PEM procedures assess SVBs and PLs on a nett benefits basis rather than a reduction in platooning basis. Also, operational benefits are derived from time periods over of the week, which encourage a shorter PL length rather than from peak flow conditions.

8.5.5 About 39% of 1st 40 ranked projects have 3 or more fatal or serious crashes. Therefore, as well as SVBs and short PLs, a large proportion of PLs with 7,000 vpd or more probably have short optimum lengths but high crash benefits and are able to achieve reasonably high BCRs compared to facilities with only operational benefits.

8.5.6 Regarding terrain, as discussed previously, a sample of 14 recently constructed projects in Region 1 & 2 showed that the average project length in flat terrain was 1.3 km (3 projects), in rolling terrain was 1.4 km (8 projects) and in hilly terrain was 1.5 km (3 projects). While no AADT data was supplied with the sample, Region 1 & 2 (Northland & Auckland) typically has higher AADTs compared to most other Regions.

8.5.7 For this sample, terrain was not a factor in reduced length. However, within the sample, the high proportion of PLs in rolling and hilly terrain (79%) would suggest that a similar high proportion of facilities are being constructed within the 1st 40 ranked projects. It is believed that at higher AADTs (10,000 vpd or more), operational benefits would start to dominate but at flows of 5,000-10,000 vpd, a shorter length in rolling/hilly terrain may still provide reasonable operational benefits. Therefore, the influence of rolling/hilly terrain is probably more marked at lower flows.

8.5.8 Regarding passing opportunities, current PEM procedures for assessing overtaking opportunities require a PSD of at least 450 m. This distance would not be adequate for passing trucks or timid drivers passing other vehicles. Current procedures may be underestimating actual passing demand on flat terrain, where longer PLs are usually required due to smaller differential speeds. Some of these flat locations also have low crash severity, such as parts of the South Island. Therefore, the likelihood of longer PLs is less under current PEM procedures

8.5.9 The advantage of an early implementation plan for Canterbury Region could mean that many higher volume sites on relatively flat terrain in the Canterbury area have already been developed.

8.5.10 Compared to Canada, other contributing factors for Australia (similar to NZ) were relatively lower traffic volumes and the effect of earlier staged development before traffic volumes become larger (Morrall & Hoban, 1985). Also Australia's markings policy was less restrictive than parts of Canada (Harwood et al., 1999). By implication, NZ's markings policy is less restrictive than parts of Canada.

9. KEY FINDINGS OF PART II

9.1 Supporting Transit Work

9.1.1 The review process behind acceptance of the Beca Report and subsequent PEM procedures has been thorough. However, there were some shortcomings. A sample of 14 Northland and Auckland PL projects showed that total construction costs were markedly different from PEM construction costs mainly due to one-off items (23%) and other Transit work undertaken at the same time, such as safety works and pavement maintenance (20%). BCR graphs should be adjustable for different construction costs and PEM construction costs should clearly describe items that are included within the PEM construction cost.

9.1.2 The Beca Report provided implementation strategies for Canterbury and Manawatu-Wanganui. Canterbury Region has run into difficulties with low BCRs when using this implementation plan. Transit itself has made little progress on Regional Implementation Plans for the other Regions.

9.1.3 Lack of accuracy for all terrains meant that projects with straight horizontal alignments in hilly terrain or windy horizontal alignments on flat terrain cannot use the BCR graphs. The method of assessing overtaking opportunities relies on a fixed distance of 450 m PSD. Factors such as differential speeds, the size of passed vehicle and the likelihood of opposing traffic are not taken into account when determining overtaking opportunities along a SH section.

9.1.4 Regarding PEM procedures, there are now three different methods for evaluating PLs with the potential for three different results, resulting in some justifying and others that don't justify funding. Simplified PEM procedures are needed for low-volume treatments, such as for SVBs and short PLs at individual sites and in series. BCR graphs could possibly be extended to include 600-800 m PL lengths and AADTs over 10,000 vpd with one-way flows less than 1,200-1,400 vpd.

9.1.5 The effect of existing facilities cannot be taken into account unless the existing facilities are the same length, type and spacing as proposed facilities. Performance indicators for passing demand that are driver sensitive and relate to site observations, such as bunching and average travelling speed would be useful to monitor before-and-after performance.

9.1.6 It is suggested that the LAR Working Group be reactivated. Main findings of the Group were:

- Proposed revision of LAR classification system, including a semi-motorway (expressway) standard of access.
- Proposed that Access Management Plans (AMPs) and Access Management Structure Plans (AMSPs) be used in conjunction with Transit's Corridor Management Plans (CMPs). (Note: As part of a preliminary investigation, the suggested crossing densities from the LAR Working Group's draft report were considered too onerous to provide on some parts of the state highway network).
- Additional conditions on crossing applications needed.

9.1.7 Transit's Cost Estimation Review could be an opportunity for a centralised database for costs and benefits that include block projects, such as PLs and SVBs. However, costs should be disaggregated so that cost variations can be identified.

9.2 Policy & Procedures

9.2.1 Transit's current PL Policy has a long-term goal of a PL or passing opportunity every 5 km on SHs with more than 4,000 vpd. This policy is outlined in Action Paper CS/02/03/4244 and CS 03/11/4770. SHs with more than 400 vpd have been identified at a total of 634 sites (352 proposed, 207 existing and 75 under investigation) and allocated a Priority between 1-4, based on AADTs. Preference is given to road sections with high AADTs that are on SH 1 and some strategic networks.

9.2.2 For the 2006/07 SH Forecast, a prioritisation method has been developed that uses BCR and crash severity (number of people injuries not number of crashes) in addition to AADT and where the project is on a strategic network to generate a ranking number.

9.2.3 It is suggested that the Strategic Network factor be reviewed. SHs not on SH 1 or special-priority networks but with high AADTs and high crash severity are disadvantaged under the current PL policy. As a compromise, favourable weighting could remain for PLs on special-priority networks that are already noted within the current policy. Any further proposed PLs on special-priority networks would not receive favourable priority.

9.2.4 The current policy has a goal of a PL or passing opportunity every 5 km. However, for practical implementation, it is suggested that interim and long-term strategies for SH sections be developed. Weighted Averaged BCR packages of projects, which are allowed under the current Policy, would have to be identified. Weighted BCR packages should be developed as interim strategies for the next 10 year interval with long-term strategies over the next 25-30 years.

9.2.5 However, changes will have to be made to Transit's and possibly Land Transport NZ's computerised systems to allow packages of projects to be financially controlled and project managed. While there is currently no formal mechanism for these packages within PROMAN and LTNZ on-line, both Transit and Land Transport staff accept this practice of weighted packages for block-funded projects.

9.2.6 Some changes are suggested so that project characteristics can be easily identified and monitored. Extra fields in PROMAN are required for:

- Road section
- Individual project types for both overtaking and passing strategies.
- Terrain
- Project length excluding tapers.
- Individual Weighted Averaged BCR packages
- Linkages to other Transit projects that will occur at the same location and same time
- Individual passing and overtaking treatments within other Transit work e.g. realignments and pavement rehabilitations, not included within packages for the SH section.
- Number of sites within each project.

9.2.7 As part of interim and long-term strategies, funding levels should be reviewed. Based on current typical expenditure of about $10-13 M/year for about 14 new PLs/SVBs per year, it will take about 30 years to complete 427 sites at a total cost of about $310 M. This expenditure excludes SHs that will carry more than 4,000 vpd during the next 30 years or may require more costly treatment if they will carry more than projected 10,000 vpd.

9.2.8 Construction costs are markedly higher than estimates within PEM procedures. However, a review of 14 PL projects in the Auckland and Northland Regions showed that about 23% of averaged construction costs were due to costly one-off items, such as bridge widening, planting trials, retaining walls and cattle underpasses.

9.2.9 Other Transit work carried out on these 14 PL projects, such as clear zoning, guardrails and pavement maintenance accounted for about 20% of averaged construction costs. Location guidelines for PLs are suggested to avoid costly items. On the other hand, separate investigations showed that costs for some realignment projects included PLs and were not included in the SH Forecast programme.

9.2.10 Under current project costs, about $8.7 M would be spent on 14 projects/year. The difference of $1.3 M is mainly due to i) some projects with lower ranking being included in Weighted Averaged BCR packages, ii) some projects have more than one site or may be on both sides of the SH and iii) some individual projects that are close to the top 40 ranked projects may be advanced depending on progress with other higher ranked projects.

9.2.11 In conjunction with developing interim and long-term strategies, SH forecast projects should be reviewed. There is the potential to make cost savings on current four-lane projects with structures, particularly in peri-urban areas. Typically, for a $200 M project with structures, cost savings of about $140 M could be achieved if a 2+1 lane was used instead of a four-lane SH. Also extra Transit work that is currently scheduled to occur at the same time and location should be co-ordinated to reduce costs. Other Transit work that defers the need for extra facilities i.e. PSD improvements, safety works and seal widening should be identified.

9.3 State Highway Forecast

9.3.1 An analysis of project distribution shows that prioritisation tended to favour PLs and SVBs on SH 1 and special-priority strategic networks, with high AADTs and high crash severity. As mentioned earlier, a review of the Strategic Network factor is suggested.

9.3.2 The distribution of 1st 40 ranked projects by Region was due to a variety of factors. Napier – Gisborne (23% of 1st 40 ranked PL projects) had six out of nine projects with high BCRs greater than 7 and moderately high flows and moderate crash severity. For Northland projects (20%), seven out of eight projects had 3 or more fatal/serious injuries.

9.3.3 Auckland (15%) had moderately high flows but Wellington (13%) relied on special priority for 4 of 5 projects. Waikato (13%) had 50% of total projects not on SH 1 and Bay of Plenty (5%) had no total or top ranked projects on SH 1. Both Waikato and Bay of Plenty regions had low crash severity. Wanganui- Manawatu-Taranaki projects (8%) were all on SH 1.

9.3.4 Canterbury (5%) generally had low BCRs for its total projects, which may reflect previous implementation of more favourable projects due to a Beca implementation plan. Nelson-Marlborough (0%) and Otago-Southland (0%) generally had low volumes and low crash severity.

9.3.5 Generally, SVBs and short PLs (i.e. 800m or less) are over-represented compared to AADTs. Similarly, longer PLs (i.e. 1.6 km or more) are under-represented. The shorter length is probably due to a variety of factors: terrain, benefit assessment over whole of week period rather than solely peak periods, high proportion of safety benefits at lower flows and the effect of high HCV speeds on PEM procedures for estimating passing opportunities.

9.3.6 Compared to Canada, other contributing factors for Australia were relatively lower traffic volumes and the effect of earlier staged development (Morrall & Hoban, 1985). Also NZ's markings policy is less restrictive than Canada (Harwood et al., 1999).

PART III. OPTION IDENTIFICATION & ASSESSMENT

10. OPTIONS

10.1 Overtaking Treatments

10.1.1 Improvements are limited to 1-2 passing vehicles depending on terrain, low AADTs and low likelihood of opposing traffic. These improvements could only be suitable for traffic volumes up to about projected 7,000 vpd, as safety issues may start to increase above these traffic volumes. The projected AADT relates to traffic volumes at the end of the project's 25-30 year life.

10.1.2 The following PSD improvements are suited to road sections where PSD is not adequate and needs to be improved. Ideally, these options are most beneficial if linking two separate sections of sight distance together.

i) Vegetation control

- Applies mainly to horizontal sight distances.
- Suitable for all terrains.
- Possibly applied in conjunction with clear zoning.

ii) Batter Relocation

- Applies to cutting back batters to improve horizontal sight distance.
- To improve driver to vehicle line of sight.
- No change to road pavement.
- Applicable to windy alignments.

iii) Pavement Rehabilitation

- Improvements to road's vertical alignment.
- Suitable for passing opportunities mainly in flat and rolling terrain but more treatment length required with low speed differential conditions.
- More costly in hilly and mountainous sections.

iv) Realignment

- Improvements to a road's horizontal alignment.
- Suitable for passing opportunities mainly in flat and rolling terrain but more treatment length required with low speed differential conditions.
- Possible inclusion of passing facilities in conjunction with realignment.

10.1.3 The following overtaking enhancement options are suited to SH sections with existing adequate passing sight distance. Best suited to road sections with platooned flows.

v) Isolated Seal-Widening

- In NZ, typically 0.75-1.0 m wide extra shoulder. Ideally 1.5-2 m.
- Length varies.
- Overtaking vehicle may encroach into opposing lane.

- Suited to narrow width sealed carriageways carrying increased traffic volumes including HCVs and recreational vehicles (RVs).

vi) Overtaking at Passing Facilities

- 1.5-2.0 m extra seal on shoulder of opposing lane.
- In Germany not generally permitted. In Canada permitted up to 4,000 vpd
- Relies on overtaken vehicle moving to the left and relatively low opposing flows.
- Centreline markings to favour opposing flows.

vii) Configuration of Passing Facilities

- Suited to road sections with long spacings between PLs/SVBs.
- Favourable overtaking areas for opposing flows are upstream of passing facilities where traffic is bunched before reaching PL/SVB and between alternating PLs with merges facing away from each other.
- Unfavourable overtaking areas for opposing flows are short four-laning, overlapping PLs, overlapping downstream effective lengths and between closely spaced alternating PLs with merges facing towards each other.

10.2 Passing Treatments (Low-Volume < 4,000 vpd)

10.2.1 The following treatments would generally be applied to SH sections with less than projected 4,000 vpd and platoon lengths of 1-2 following vehicles. In some cases, Short PLs may also be used for larger traffic volumes.

i) Isolated Shoulder-Widening

- In Canada, 2.4 m wide sealed shoulder.
- Length varies. In US, 0.3-5 km.
- Overtaking vehicle may partly encroach onto opposing lane, depending on size of slow and passing vehicles.
- Relies on slow vehicles moving to the left. Some signage to direct traffic to the left would be useful.
- Possible difficulties with slow vehicle merging as traffic volumes increase.
- May suit some areas with significant volumes of pedestrians, cyclists or agricultural vehicles.
- In NZ, marked so that slow traffic does not have priority over passing traffic at merge.

ii) Turnouts

- Sealed shoulder or auxiliary lane on flat or uphill grades.
- Typically AUSTROADS length of 60-160 m long for 30-90 km/hour respectively. 200 m minimum recommended in HCM.
- More efficient on hilly and mountainous terrain with small queues.
- Possible difficulties with slow vehicle merging as traffic volume increase.

iii) Slow Vehicle Bays

- Auxiliary lane to be used by all vehicles.
- Located on uphill, flat and downhill grades, if large speed differential.
- In NZ, maximum 300 m long.
- Recommended at least 20 km/hour speed differential (AUSTROADS, 2003).
- Not as efficient on flat level terrain, especially if passing trucks.
- In NZ, marked so that slow traffic does not have priority over passing traffic at merge.
- Good visibility required at exit and entry.

iv) Extendable Slow Vehicle Bay

- Initially, built as a 300 m long SVB but with provision to be extended to short PL and standard PL length as demand increases.
- Also applies to extension of existing SVBs.
- Generally suited to hilly and mountainous terrain where speed differential is high.
- Located on uphill, flat and downhill grades, if large speed differential.
- Same long- term benefits as Short PL or PL but slightly higher cost due to construction being carried out in two stages.
- Generally discouraged if PLs are already established along a route but maybe appropriate if the rest of the road section is SVBs.
- Good visibility required at exit and entry.

v) Short Passing Lanes

- 3.5 m wide auxiliary traffic lane to be used by all vehicles.
- Generally suited to hilly and mountainous terrain where speed differential is high.
- Located on both uphill and downhill grades.
- About 600-760 m long.
- Same merge priorities as standard PL i.e. no priority to either vehicle.

10.3 Passing Treatments (Moderate-Volume 4,000-25,000 vpd)

10.3.1 Typically, the following treatments would be considered for SH sections with projected 4,000-10,000 vpd and may be expected to operate at higher traffic volumes.

i) Short Four-Lanes

- Two opposite 3.5 wide auxiliary traffic lanes to be used by all vehicles.
- From North American literature, length varies between 3-5 km. In NZ, common in Canterbury area on flat, slightly rolling terrain about 1 km long.
- Similar benefits as PLs.
- Sometimes requires more land purchase due to extra carriageway width.
- Best to avoid situations with access driveways, intersections and bridge structures due to extra width.

ii) Climbing Lanes/Crawler Lanes

- Auxiliary lane primarily for HCVs and RVs on uphill grades.
- In NZ, typically longer than 1.5 km, say 3-4 km long depending on terrain.
- Recommended where at least 10 km/hour speed differential.
- Sometimes difficulty with HCVs entering traffic stream so end of climbing lane is best situated on flat section or possibly crest to avoid damage to seal.
- Good visibility required at exit and entry.

iii) Passing Lanes in Series

- 3.5 wide auxiliary traffic lane to be used by all vehicles.
- Located in all terrains on both uphill and downhill grades.
- Typically 760-1500 m long. Efficiency of length depends on terrain and frequency of passing lanes.

iv) Wide-Shouldered Two-Lane Roads

- 3.5-4 m wide traffic lanes with 2.5 m wide sealed shoulder.
- In Germany, 11-12 m width, In Sweden 13-14 m width.
- Overtaking vehicle may partly encroach onto opposing lane depending on vehicle size and queue length.
- Relies on slow vehicles keeping to the left.
- Possible difficulties with slow vehicles merging as traffic volume increase.
- May suit some areas with significant volumes of pedestrians, cyclists or agricultural vehicles.
- More costly in hilly and mountainous terrain than NZ standard 8.5 m wide two-lane roads due to wider cross section.

v) Extra-Wide Lanes

- 5.5-6 m wide lanes, both sides of road. Total 12-13 m seal width.
- All terrains but less costly on flat and rolling terrain.
- Typically 5 km long.
- Overtaking vehicle encroaches partly into opposing lane. Relies on overtaking vehicle keeping to the left and any opposing vehicle also keeping to its left.
- In NZ, does not currently exist and would need a newly constructed or upgraded carriageway.

vi) 2+1 Lanes

- Three continuous 3.2-3.6 m wide lanes, including auxiliary lane.
- Total 12-13 m seal width. In mountainous areas, total 13 m seal width (Germany) and total 15 m seal width (Canada).
- In Sweden and Finland located generally in flat and rolling terrain. In Germany, in mountainous terrain as well.
- Separating cable median barrier or minimum 0.5-1.0 m flush separation is desirable. No–overtaking lines in both directions for non-divided facilities.

- Typically, 2.4 km initial passing lane then alternating 1.6 km passing lanes. Presumably for flat terrain.
- Overseas usually applied as a retrofit over 10-30 km of existing 12-13 m wide sealed carriageway.
- In NZ, only one example exists on SH 1 Long Swamp-Rangiriri and other locations would need a newly constructed or upgraded carriageway.

vii) Four-Lanes

- Four continuous 3.5-3.75 m wide lanes. Generally, divided but sometimes undivided. Ideally, central median with barrier preferred but this affects access.
- In Germany, newly developed 11.5 m wide cross-section without median barrier for urban environment.
- Requires more controls than two-lane highways, for driveways and local roads.
- In NZ, AADT usually greater than 20,000 vpd.
- All terrains but very high costs on hilly or mountainous terrain.

10.4 Centreline Treatments

10.4.1 These centreline treatments are best suited for application in conjunction with overtaking treatments and can be applied over the whole network. The aim is to retain overtaking zones up to projected 7,000 vpd, with selective use of double yellow lines on crash prone locations. Above 7,000 vpd, generally more double yellow lines would be used with possible use of wide profile markings. Over projected 10,000-12,000 vpd, there would be more use of 0.5-1.0 m separation of opposing flows with selective use of central median cables at crash prone locations.

i) Yellow Lines

- Yellow marking policy and practice within Manual of Traffic Signs and Markings (MOTSAM). Mandatory for NZ SHs.
- Horizontal restrictions are not applied in NZ markings policy.
- Includes use of alternating yellow and double yellow lines, depending on available sight distance and opposing traffic volumes.
- Possible use of wide profile markings.

ii) Gap Separation of Opposing Flows

- Typically 0.5 m but up to 1.0 m in Germany.
- US recommends 1.2 m
- Not commonly used in NZ conditions, would require tack-on width for some roadways.
- Possible potential for overtaking in three car situations if slow vehicle has sufficient sealed shoulder width but less safety in these situations. Further investigation required.
- In Germany about two thirds of gap separated 2+1 lanes arte provided as bypass routes on new alignments with semi-motorway (expressway) standard of access and a high standard of road geometrics.

iii) Central Median Cables/Guardrails

- Cables commonly used in Sweden.
- Highest crash reductions in conjunction with semi-motorway (expressway) standard of access and new road geometrics.
- Would require tack-on width for many NZ roadways.
- High maintenance requirements and regular programmed lane closure required for cables.
- More appropriate for SH sections without intensive adjacent land use.

10.5 Roadside & Edgeline Treatments

10.5.1 A list of roadside/edgeline options are provided below. While chip sealing on some curves treats the carriageway rather than the roadside/edgeline, the effect of this treatment would tend to reduce loss of control crashes, cornering and off road type crashes.

i) Clear Zoning & Shoulder Run-Off

- As per AUSTROADS Rural Road Design, 9 m clear zone with reduction in clear zone width on curves.
- Hazard removal in clear zone.
- Consider both sides of passing facility if significant overtaking in the opposite direction.

ii) Increased Signs and Markings

- Chevrons and speed advisory curves.
- Yellow line markings on crash prone locations caused by horizontal sight restrictions.
- Edgeline markings and edgeline marker posts.
- Reflective raised pavement markers (centreline and/or edge lines).

iii) Wide Profile Markings

- Raised ridges run perpendicular to direction of travel as opposed to rumble strips that run parallel to direction of travel.
- Higher level of treatment than reflective raised markings.
- Lesser level of treatment so possibly suits locations distance from passing facility.

iv) Increased Shoulder Widening and/or Chip Sealing

- Possibly suits curves with existing/potential adverse safety but with radius close to or flatter than out of context curves, which are typically 300-500 m radius curves.
- Consider both marco-texture and micro-texture of chip seal but needs to be regularly programmed for maintenance.
- In some cases, could reduce crashes in both directions of travel.

v) Side Restraints - Cables or Guardrails

- Used where clear zoning and shoulder run-off may not be viable.

- Cables have higher maintenance requirements but less visual intrusion.
- Need to ensure sufficient side anchorage.
- Preferably, located approx 1.3 m minimum beyond edgeline.

10.6 Intersection Treatments

i) Two-Way Right Turns

- Similar to central flush median with turning bays.
- Located in urban areas with reduced speed zone.
- Suitable if multiple road intersections in close proximity.
- American literature suggests that it starts to become less effective after AADT 17,000 vpd. Also with increased turning movements increased potential for conflict

ii) Shoulder Bypass Lanes

- At-grade intersection control.
- In Sweden, would be located at lane transition zone with 70 kph speed zone.
- Shoulder bypass lane is the same as shown on a Type A intersection in AUSTROADS at grade intersection guidelines (AUSTROADS, 1998).
- Usually 2.5 m wide seal widening.
- Length varies depending on traffic volumes.
- High speed through traffic uses this facility.
- Likely to be few occasions when turning traffic affects through traffic.
- Generally installed at lower traffic volumes than turning bays.

iii) Turning Bays

- At grade intersection control.
- In Sweden, would be located at lane transition zone with 70 kph speed zone.
- Central right turn bays, left turn deceleration lanes, seagull turning islands.
- Length and warrant for use depends on traffic volumes.
- Minimum 3.5 m wide in State Highway environment
- Generally installed at lower traffic volumes than roundabouts.

iv) Rural Roundabouts

- At-grade intersection control.
- Typically minimum radius 25-30 m.
- In Sweden, would be located at lane transition zone with 70 kph speed zone.
- Efficiency subject to variations between flows on each approach leg.
- Less land requirement than grade-separated intersections.
- Less capacity than grade-separated intersections.

v) Grade-Separated Intersections

- Interchange or similar.
- Very expensive.
- Highest capacity intersection.

- Usually large land requirement for built up approaches and intersections either side to manage on-ramp and off-ramp traffic.

10.7 Resource Planning Measures

i) Access Control

- Applied to motorways, semi-motorways (expressways in NZ), some conventional higher volume SHs.
- Also state highways that are designated Limited Access Roads (LARs) under District Plan.
- Applications for access as part of land use development lodged with and processed by Transit.
- Best done in conjunction with Corridor Management Plans (CMPs) or similar state highway plans.
- Standardisation of Regional LAR database systems is required.
- Currently private access conditions include number, location and geometric standard. LAR Working Group proposes that conditions be expanded to include purpose of use (land use activity), frequency of use (movements/day) and duration (period of high demand).
- Includes private low-volume access crossings, high-volume driveways and District road intersections.
- For overseas, limited controls for one type of road user i.e. pedestrians, cyclists and farm vehicles.

ii) Encouraging Alternative Roading Networks

- Suited to peri-urban areas with high mix of local traffic.
- Liaison with Local Authorities to develop Structure Plans.
- Best used in conjunction with Regional Growth Strategies, Regional Land Transport Plans and District Plans.
- Structure Plans to reflect land use activities as well as roading layout.
- Selective development of SH/District road intersections with closure of less used intersections.
- Strengthening of urban roading standards in peri-urban areas for District Plans e.g. urban road reserve widths.
- Connectivity of local network through layout of rural subdivision
- Connection of roads to District network in preference to SH network.
- Driveways to connect to lower hierarchy roads.
- Provision for future use of alternative modes of transport e.g. walking/cycling access crossings, turning areas for buses, linked network rather than isolated cul-de-sacs.
- Relatively low cost to Transit if costs borne by developers.

iii) Designations on New Alignments

- Suited to realignments, upgrades of SH carriageway width and intersection upgrades.
- Long time frame for implementation.
- Requires regular justification through District Plan/Environment Court process.

- Initially, easier to apply LAR measures after realignment but with increased land development, effectiveness may reduce if LAR provisions are ineffective.
- Avoids existing intensive land use development, if realigned.
- Sometimes provision for special user requirements and facilities also has to be considered within SH designation to allow access across/to SH e.g. cyclists, pedestrians, farm equipment, livestock and adjacent properties by SH intersections.

10.8 Education Measures (through Land Transport & Ministry of Transport)

i) General Public Education

- Public information on use of passing facilities and overtaking measures.
- Review of overtaking and passing manoeuvres within Road Code for cars, towing vehicles and recreational vehicles.
- Question within driving tests.
- Part of defensive driving courses.
- Required driver behaviour for towing boats, caravans or heavy trailers
- Transit feedback to Land Transport NZ over any education issues relating to SH Forecast public consultation.

ii) Targeted Programme

- NZ research showed that about 50% of surveyed crashes at passing facilities involved long vehicles, such as HCVs and towing vehicles (Luther et al., 2004).
- Education programme as part of voluntary speed controls on HCVs instead of mandatory controls.
- Education programmes and work practices, as part of Resource Consent conditions for new or upgraded facilities that generate high volumes of HCV traffic.
- Start with 90 km/hour speed limit for HCVs and towing vehicles to be observed at passing facilities and overtaking locations.
- Education programme for drivers connected to existing facilities that generate high volumes of HCV traffic, such as processing facilities, tourist facilities and transport hubs e.g. separation distances between following HCVs, use of passing facilities on delivery and pick-up routes.
- Work practices at existing facilities that generate high volumes of HCV traffic e.g. discharge of HCVs from Inter-island ferries, minimisation of HCVs in convoy.
- Question within heavy vehicle licence test.
- Liaison with Heavy Freight and Tourist Coach industry groups.
- Independent or company telephone hot-line with vehicle number on vehicle to report driver behaviour.

10.9 Enforcement Measures (through Land Transport NZ & NZ Police)

i) General Public Enforcement

- Enforcement of speed limit for all road users at crash prone locations with overtaking, rear end and head-on crashes, which are associated with requiring a PL..

- Liaise with Land Transport NZ about research into legislation on platooning effects (In some US states, it is illegal to cause queuing of more than five following vehicles).
- Transit feedback to Land Transport NZ and NZ Police over any enforcement issues relating to SH Forecast public consultation.
- Transit feedback as part of regular Land Transport NZ regional safety meetings on which both Transit and NZ police have area representatives.

ii) Problem Locations

- Enforcement of speed limit on HCVs and other towing vehicles at problem passing lanes and/or overtaking locations.
- Enforcement of speed limit on general public at crash prone locations.
- Transit feedback to NZ Police required.

iii) In-Vehicle HCV Speed Controls

- Commonly used overseas.
- Used in NZ by some fleets, such as fuel transporters but able to be over-ridden for safety reasons.
- Fuel economies of HCV can be preset for certain speeds.
- Record of speeds reviewable, if stopped by Police.
- Liaison required with Land Transport NZ about research into effects of mandatory in-vehicle HCV speed controls.

10.10 Travel Demand Management (TDM) Measures

10.10.1 Rather than the TDM philosophy of encouraging active modes and only providing infrastructure for sustainable modes, the TDM techniques, as mentioned below, should be applied to road sections with the following flow characteristics, namely:

- Routes with regularly high traffic volumes (i.e. 10,000-25,000 vpd).
- Routes with high volumes of slow moving vehicles i.e. HCVs, light towing vehicles, recreational vehicles.
- High volumes during weekends and public holidays, especially recreational traffic.
- Commuter routes through peri-urban areas.
- Road sections close to requiring infrastructure upgrades.

i) Alternative Hours

- Staggered shift times for activities/processing plants that generate a high number of HCV trips.
- Non-conflicting times on ferry arrival and departure times with congested sections of road network.
- Encouragement of night-time HCV use through better infrastructure.
- Peak spreading of weekend and public holiday recreational traffic.
- Peak spreading of weekly .

ii) Alternative Routes

- Temporary or permanent use of other less important State highways/District roads to avoid congested sections of the network.
- Separation of local and through traffic activity.
- Establishment of rural freight routes, preferably flat road gradients.
- To be undertaken in conjunction with encouraging alternative roading networks.

iii) Alternative Modes

- Encouragement of public transport along rural commuter routes.
- Alternative transport modes to reduce HCV trips.
- Web-based ride sharing.
- Encouragement/infrastructure for walking and cycling along rural commuter routes or on any nearby District road network.
- Travel plans for high HCV activities/processing plants to cover alternative staff transport to the site.

10.11 Intelligent Transport Systems (ITS) Measures

i) Variable Messaging (preferably with video monitoring)

- Suited to locations and periods with high demand. Also poor weather conditions.
- Best used in conjunction with video monitoring and means to alter sign messages.
- Altered to suit variety of conditions.
- Mobile or fixed applications.
- Possibly defers carriageway upgrades on SHs close to maximum operating flows e.g. assists with merging, variable speed controls.

vi) Video Monitoring (preferably linked to ATMS)

- Suited to high demand sites for incident management and monitoring of traffic conditions.
- Suited to performance monitoring of any sites. Best used in conjunction with other performance monitoring being done at the same location/time.
- Mobile or fixed applications.
- Real time information.
- Possible applications for demand management in conjunction with website, especially if linked to other existing video sites on adjacent four-lane networks.
- Better if linked to automated traffic monitoring system (ATMS) but ATMS currently limited to parts of Auckland and Wellington.

iii) Speed Cameras (preferably for long vehicles)

- Induction loops to recognise long vehicles with 90 km/hour speed restriction.
- Consider locating at problem passing lanes and overtaking zones, where vehicles sensitive to gradient changes will not slow down.
- More effective if applied to long-vehicles only and the public is aware of this specific application.

10.12 Rationalisation of Options

10.12.1 SVB extensions will result in short PLs or PLs depending on length. Given that SVB extensions have been classified under low-volume treatments, any further evaluation will be under short PLs. It is assumed that SVBs tend to be located in difficult terrain and that any extensions will be relatively short. Also the length of extension will enable the facility to be upgraded from SVB to PL in terms of operational efficiency and safety.

10.12.2 In NZ, SVBs have a maximum length of 300 m. In USA, turnouts tend to be about 200 m long with a defined width and markings. From AUSTROADS guidelines for rural roads, turnouts would tend to resemble shoulder widening. However, as much of the research material is North American based, any further evaluation of turnouts will be under SVBs.

10.12.3 Under current NZ conditions, SVBs and PLs currently address the majority of demand caused by heavy vehicles. In the future, this situation may change if concentrations of HCVs increase at some locations, such as routes to major processing plants and rail/marine ports.

10.12.4 Generally, climbing/crawling lanes are more suited to locations with high proportions of HCVs and RVs and sustained gradients. Therefore, climbing/crawler lanes will not be considered further as this treatment is more appropriate for specific terrain and traffic conditions.

10.12.5 Overseas sections of short-laning are about 3-5 km long. While there may be some situations where short four-laning is appropriate, it would be difficult to apply this type of treatment over large parts of the NZ network. In NZ, terrain conditions can vary markedly over a 3-5 km length and traffic volumes may not warrant such a high level of infrastructure. Therefore, short four-laning will not be considered further.

11. PRELIMINARY ASSESSMENT

11.1 Overtaking

11.1.1 Table 8 compares the relative differences for passing sight distance treatments. All of these treatments would be applicable to roads with less than 4,000 vpd. Savings due to crash reductions for local curve realignments and pavement rehabilitations may also depend on crash severity.

Table 8. Performance of Passing Sight Distance Treatments

Option	Relative Cost	Travel Time	Traffic Platooning	Crash Reduction
Realignment	High	Varied	Varied	Reduced
Pavement rehabilitation	Med	No-Small	No-Small	Small
Batter Relocation	Low	No	No-Small	No-Small
Vegetation Control	Low	No	No-Small	No-Small

11.1.2 In general, these treatments would be used if other problems need to be rectified at the same time rather than being undertaken solely as a passing improvement. While PSD treatments may contribute to the overall performance of the road section, these improvements are generally localised. Therefore, passing sight distance treatments will not be evaluated further.

11.1.3 Table 9 compares the relative differences between enhanced overtaking treatments. All overtaking enhancements rely on the existing carriageway having enough sight visibility. Seal widening has more potential for reducing travel time and platooning, compared to other treatments, as seal-widening can be applied to problem areas rather than just at passing facilities.

11.1.4 Not all passing facilities would have adequate passing sight distance, particularly if low-volume passing facilities were located in rolling terrain. Configuration of passing facilities will depend on the availability of overtaking sight distance between passing facilities. Overtaking enhancements will not be evaluated any further.

Table 9. Performance of Overtaking Enhancements

Option	Relative Cost	Travel Time	Traffic Platooning	Crash Reduction
Seal Widening	Low-Medium	Varied	Varied	Small
Overtaking at PLs/SVBs	Low	No-Small	No-Small	Small
Configuration of PLs/SVBs	Low	No-Small	No-Small	No-Small

11.2 Passing (Low-Volume)

11.2.1 Table 10 compares the relative differences between low-volume passing treatments, namely short PL, SVB and isolated shoulder widening. Short PLs have the highest cost but also has the potential to provide the greatest benefits. SVBs have less cost but also less benefits. As relative effects are similar, further evaluation would be required.

Table 10. Performance of Low-Volume Passing Treatments

Option	Relative Cost	Travel Time	Traffic Platooning	Crash Reduction
Short PL (single)	Low-Med [1]	Reduced	Reduced	Reduced
SVB	Low	Small	Small	Small
Shoulder-Widening	Low	Small	Small	No-small

Note [1] Depending on terrain, longer length can increase costs.

11.3 Passing (Moderate-Volume)

11.3.1 Table 11 shows the relative differences between moderate-volume treatments. Most treatments have high costs, except for PLs in series. Wide-shouldered roads are less favoured at reducing platooning as its effect will reduce with increased traffic flows.

Table 11. Performance of Moderate-Volume Passing Treatments

Option	Relative Cost	Travel Time	Traffic Platooning	Crash Reduction
Four Lanes (divided)	High	Reduced	Reduced	Reduced
2+1 Lanes	High [1]	Reduced	Reduced	Highly Reduced
Extra Wide Lanes	High	Highly Reduced	Reduced	Poss Increase
Wide-Shoulder Road	High	Reduced	Varied [2]	Reduced
Realignment	High	Reduced	Reduced	Reduced
Passing Lanes in Series	Med	Reduced	Reduced	Reduced

Note: [1] Assumes new construction. [2] Larger platoons with volume increase. [2] Highly reduced with cables, access controls & new geometrics.

Safety effects are less favourable for extra wide lanes, which may form two traffic lanes each way at high volumes. As relative effects are similar, further evaluation would be required.

11.4 Centreline

11.4.1 Table 12 compares the relative effects for centreline treatments. The safety performance of yellow lines on overtaking will reduce as traffic volumes increase. However, yellow markings are favoured over other centreline treatments as a widespread treatment, due to their very low cost and its general applicability to operational efficiency and safety.

11.4.2 For crash prone situations, gap separation would have a slight advantage over central median cables, as overtaking manoeuvres can still occur but relies on good road geometrics for better results. While crash reduction would be low to medium with gap separation, central median cables and guardrails are expected to provide a higher crash reduction. No further analysis will be undertaken.

Table 12. Performance of Centreline Treatments

Option	Relative Cost	Travel Time	Traffic Platooning	Crash Reduction
Yellow Lines	Very Low	Varied	Varied	Small [1]
Gap Separation	Low	Varied	Varied	Low-Medium
Central Median Cables	Medium [2]	No	No	High
Central Guardrails	Medium-High [2]	No	No	High

Note: [1] Less effect with increased flows. [2] Depends on existing seal width.

11.5 Roadside & Edgeline

11.5.1 Table 13 compares the relative effects for roadside and edgeline treatments. None of the treatments contribute to travel time savings or traffic platooning. For lower cost treatments, wide profile markings appears to give better value with crash reductions but may be less suited to snow prone areas. Clear zoning should give better value over longer sections of road than chip sealing and side restraints, if the cost of hazard removal and shoulder run-off formation remains low. Therefore, no further analysis will be undertaken.

Table 13. Performance of Roadside & Edgeline Treatments

Option	Relative Cost	Travel Time	Traffic Platooning	Crash Reduction
Incr Signs & Markings	Low	No	No	Low
Wide Profile Markings	Low	No	No	Low-Med
Chip Seal	Low-Med	No	No	Low-Med [1]
Clear Zoning & Run-off	Low-Med	No	No	Med
Side Cables	Med	No	No	Med-High
Side Guardrails	Med [2]	No	No	Med-High
Incr Seal Shoulder Width	Med-High	No	No	Med-High [1]

Note: [1]. Depends on maintenance and/or if crashes in both directions. [2.] Higher initial cost than cables

11.6 Intersection

11.6.1 Table 14 compares the relative differences for turning measures. Access control, roundabout and grade separation costs are high if there is intensive land use and these measures have to be applied once adjacent land has been developed. Costs can be reduced if these measures and adjacent land use can be planned over a long period.

11.6.2 Grade separation and roundabout will only have marked operational effects if traffic flows are high. At low volumes, treatments for at-grade intersections, such as turning lanes, shoulder bypass lane and two-way right turn lanes will have little effect on platooning and small effect on travel time as flows along the SH will have priority. Two-way right turn lanes may cause platooning at higher traffic volumes due to vehicles slowing down to turn causing following vehicles to bunch up.

Table 14. Performance of Intersection Treatments

Option	Relative Cost	Travel Time	Traffic Platooning	Crash Reduction
Grade Separation	Very high	Reduced	No effect	Reduced
Roundabout	High	Reduced	No effect	Reduced
Turning Lanes	Low	Small	No effect	Reduced
Shoulder Bypass Lane	Low	Small	No effect	Reduced
Two-way Rt Turn Lanes	Low	Small	Poss increase	Reduced

11.6.3 While intersection treatments will contribute to the overall performance of a road section, these improvements are best used in conjunction with other treatments and therefore will not be evaluated further.

11.7 Resource Planning

11.7.1 Table 15 shows the relative differences between resource planning measures. Limited access roads would have the most effect over the whole network. However for specific locations, such as peri-urban areas, greater benefits may be achieved by collaborating with local authorities in developing alternative networks to separate local and through traffic activities.

Table 15. Performance of Resource Planning Measures

Option	Relative Cost [1]	Travel Time	Traffic Platooning	Crash Reduction
Limited Access Roads	Medium-High	Varied [2]	No effect	Reduced
Alternative Road Networks	Low-High	Varied	Varied	Reduced
Designations	Medium	Reduced [3]	Varied [3]	Reduced [3]

Note: [1] Cost to Transit. [2] Depends on number of intersections and high-volume driveways. [3] Eroded, if LAR protection is ineffective on newly constructed road.

11.7.2 While benefits from designated realignments, lane increases and intersection upgrades may be initially high, these benefits would be eroded if LAR measures were ineffective. Also for any toll-funded roads, designation measures would be more important than other resource planning options. No further analysis will be undertaken.

11.8 Education

11.8.1 Table 16 shows the effects of education options. The effectiveness of education measures will vary depending on staff and funding levels from other organisations. Recent NZ research showed about 50% of all crashes at surveyed passing facilities involved long vehicles, which included HCVs and towing vehicles. Therefore, targeting HCV drivers and facilities that generate a high number of HCV movements should provide reasonable safety benefits.

Table 16. Performance of Education Measures

Option	Relative Cost [1]	Travel Time	Traffic Platooning	Crash Reduction
General Public	Low	Varied [2]	Varied [2]	Varied [2]
Targeted Programme	Low	Small	Varied	Reduced [3]

Note: [1] Cost to Transit.[2] Greater effect with increased funding. [3] Depends on road conditions as well as speed limit.

11.8.2 The effectiveness of on-going education measures as part of resource consent conditions depends on the amount of emphasis that Council Hearings and Environment Courts wish to place on any suggested conditions. Therefore, targeted but voluntary education measures through other agencies may be a better option. No further analysis has been undertaken on the effectiveness of education measures.

11.9 Enforcement

11.9.1 Table 17 shows the relative differences between enforcement measures. Enforcement of locations with overtaking, passing and safety problems is considered the best option. Safety benefits are expected to be higher for problem locations.

Table 17. Performance of Enforcement Measures

Option	Relative Cost [1]	Travel Time	Traffic Platooning	Crash Reduction
General Public	Low	Increase	Increase	Varied
Problem Locations	Low	Small	Reduced	Reduced
In-HCV Speed Controls	Low	Increase	Reduced	Varied

Note: [1] Low cost to Transit.

11.9.2 The effectiveness of enforcement measures will vary depending on staff and funding levels from other organisations. Therefore, an enforcement programme focussing on problem locations would minimise staffing and funding requirements. Transit could provide feedback to NZ Police on SH Forecast consultation on enforcement issues. Transit could liaise with Land Transport NZ to initiate research into the effect of enforcement measures, such mandatory in-vehicle speed controls for HCVs.

11.9.3 Safety benefits from general public enforcement could be varied by increased frustration leading to more risky behaviour. Similarly, in-vehicle speed controls for HCVs can also lead to more risky behaviour. Also general public enforcement at crash prone locations may vary depending on road conditions. Also, crashes may be occurring at operating speeds that lie within the speed limit. No further analysis will be undertaken.

11.10 Travel Demand Management

11.10.1 Table 18 compares the relative differences for TDM measures. All options have similar advantages. The most critical road sections will have AADT flows that are close to requiring changes in the level of infrastructure. These critical locations will be site specific and therefore the most effective option will have to be determined on a case-by-case basis. Therefore, no further analysis will be undertaken.

Table 18. Performance of Travel Demand Management Measures

Option	Relative Cost [1]	Travel Time	Traffic Platooning	Crash Reduction
Alternative Hours	Low	Reduced	Reduced	Varied
Alternative Routes [2]	Low	Poss increase	Reduced	Varied
Alternative Modes [2]	Low	Reduced	Reduced	Medium [3]

Note: [1] Low cost to Transit. [2] Subject to availability. [3] If not increased vulnerable users.

11.11 Intelligent Transport Systems

11.11.1 Table 19 compares the relative differences for ITS measures. Variable messaging can influence both operational and safety effects due to the variety of messages, whereas video monitoring is most effective if used in conjunction with web–based information systems. Speed cameras specifically for long vehicles would provide favourable results across all categories, if applied to problem locations where heavy commercial vehicles or similar are likely to have a large speed differential downstream of the passing facility or overtaking zone.

Table 19. Performance of Intelligent Transport System Measures

Option	Relative Cost	Travel Time	Traffic Platooning	Crash Reduction
Variable Messaging/Video	Low	Varied [1]	Varied [1]	Varied [1]
Video Monitoring with ATMS	Med	Varied [2]	No	Small
Speed Camera	Low	Varied [3]	Varied [3]	Varied [3]

Note: [1] Greater effect with increased flows. [2] Best used in website connection. [3] More favourable if applied to long-vehicles only.

11.11.2 The advantages of variable messaging can be optimised, if messaging can be varied from an off-site centralised location or linked to a larger ATMS using video monitoring. ITS measures are best suited to specific high demand locations and periods. No further analysis will be undertaken.

11.12 Comparisons

11.12.1 Compared with overtaking treatments, low-volume passing treatments provide the best scope for providing both operational and safety benefits at low-volumes. A detailed quantitative assessment will be undertaken on low-volume passing treatments.

11.12.2 From the qualitative analysis, moderate-volume passing treatments offer the most scope to provide both operational efficiency and safety improvements at moderate-volumes. While PLs in series have less cost, their benefits are not as high as other treatments. Due to the similar relativity of moderate-volume passing treatments, a detailed quantitative assessment will be undertaken.

11.12.3 As an operational tool, yellow lines are applicable to the whole network due to their very low cost and low labour requirements. Gap separation of opposing flows and central median cables provide higher safety benefits for higher costs. Signs and markings at passing facilities are only applicable at the passing facility but can have upstream and downstream effects.

11.12.4 Roadside and edgeline treatments are generally dictated by road geometrics, roadside hazards and their location relative to the passing facility or overtaking zone. For the majority of situations, increased signs and markings, wide profile markings, chip sealing and clear zoning/shoulder run-off should be more cost effective as a road section treatment. However, some crash prone locations may require a more costly treatment, such as side restraints or shoulder widening.

11.12.5 Intersection treatments are restricted to specific locations and would be applied on a case-by-case basis. Intersection treatments are supporting treatments rather than treatments in their own right.

11.12.6 Access controls can be applied over the majority of SH lengths and have the most potential as a general treatment but alternative roading networks and designations could provide the most benefits for specific locations at relatively low cost to Transit.

11.12.7 Most education and enforcement measures lie outside of Transit's direct control. However, Transit could collaborate with government agencies and other industry organisations that have similar objectives. Transit can request conditions on submission on Resource Consent Applications i.e. driver education programmes and work practices.

11.12.8 Enforcement of speed limits at problem locations and targeted education measures for problem driver behaviour are considered the best strategies given Transit's current supply of PLs and SVBs.

11.12.9 TDM and ITS measures are better suited to specific locations and time periods and would work better if part of a co-ordinated regional or district approach.

12. EVALUATION OF PASSING TREATMENTS (<4,000 vpd)

12.1 Low-Volume Flows

12.1.1 Except for short PLs (600-800 m long), other low-volume treatments are would generally be undertaken on SHs with less than 4,000 vpd. SHs with higher AADTs will have restricted passing opportunities due to the increased likelihood of larger following queues. Therefore, short PLs have the most capacity for increased traffic volumes.

12.2 Low-Volume Operational Efficiency

12.2.1 Table 20 shows efficiency by number of passes compared to a 1.6 km PL on level terrain and by platoon leader use. Short PLs are assumed to have higher operational efficiency than SVBs. Short PLs have sufficient length to allow faster following vehicles to pass other slow following vehicles within the PL length, once they have both passed the platoon leader.

12.2.2 Use of SVBs and shoulder widening relates to the likelihood of the platoon leader being able to re-enter the traffic stream. Also the use of shoulder widening can vary depending on the length and width provided. Therefore, use by platoon leader is not the best parameter for comparing between short PL and SVBs.

Table 20. Operational Efficiency of Low-Volume Passing Treatments			
Option	**Use by Platoon Leader (%)**		**No. of Passes Compared to 1.6 km PL (%)**
	US [1]	**NZ**	**US**
Short PL	-	-	75-100 [1]
Turnout/SVB	10-30	30-60 [2]	20-50 [3]
Isolated shoulder-widening	21-43	-	20-50 [3]

Note: [1] assumed to be higher than Turnout/SVB. Similar to 1.6 km PL at low flows. [2] Koorey, Farrelly, et al., 1999. [3] Harwood & Hoban, 1987, if well designed.

12.2.3 In NZ, HCVs are a high proportion of SVB users. Possibly, the size and mass of HCVs allows them to re-enter the traffic stream, as following cars are more likely to slow down for them.

12.2.4 NZ platoon leaders use SVBs more than US leaders. The Highway Capacity Manual 2000 recommends 200 m minimum length for turnouts. When the US data was collected around 1985, the maximum length for US turnouts was about 190 m on high-speed roads (Harwood & Hoban, 1987). The shorter length may partly explain of the difference in platoon leader use.

12.2.5 Generally, downstream operational efficiency will vary depending on the site. Benefits reduce rapidly in steep or windy downstream alignments. For steep or windy alignments, operating speeds are constrained by the alignment rather than by slow moving vehicles.

12.2.6 As volumes increase, the operating efficiency for SVBs and shoulder widening will reduce as queues become greater than 2 following vehicles. Therefore, the spacing of SVBs and shoulder widening has to be more frequent to reduce queue length i.e. 2-5 km.

12.3 Low-Volume Safety

12.3.1 Table 21 compares the reduction in total crashes for USA and NZ. For NZ, reduction rates are for all short PLs on both tack-on and new alignments.

Table 21. Crash Reduction Rates of Low-Volume Passing Treatments		
Option	**Reduction in Total Crashes (%)**	
	US	**NZ**
Short PL	-	33 [2]
Turnout/SVB	30 [1]	17 [2]
Isolated shoulder widening	0	0-20 [3]
Passing Lane	**25 [1]**	**13-25 [4]**

Note: [1] Harwood & Hoban, 1987, unclear if upstream and downstream effects are included. [2] Koorey et al., 1999, figure in table for combined tack-on and newly realigned PLs, 50% for tack-on short PLs ,19% for tack-on SVBs. [3] Land Transport NZ, 2005, loss of control & overtaking crashes only. [4] Koorey et al., 1999, 13% for PL length, include 2 km upstream and 10 km downstream, 25% for PL length only.

12.3.2 For NZ, newly aligned short PLs (50%) have a better crash reduction rate than tack-on short PLs (33%). Newly aligned SVBs (19%) and on-tack SVBs (17%) have similar crash reduction rates. The high reduction rate of NZ Short PL compared to other NZ passing facilities is probably due to short PLs have a greater downstream effect than SVBs and shoulder widening. Also, the more voluntary use of SVBs and shoulder widening may have some influence.

12.3.3 The higher crash reduction rate for US SVBs compared to NZ SVBs could be due to the NZ practice of typically locating SVBs in hilly/mountainous terrain, where visibility at entry/exit points may be more restricted. Also downstream alignments in difficult terrain would be poorer and this may affect downstream crash reduction rates.

12.3.4 In NZ, the high HCV use of SVBs suggests that a higher proportion of slow vehicles would be reluctant to stop at uphill merges, possibly resulting in more potential for crashes. US literature suggests that there is a high amount of merge conflict but it does not translate into crashes for US conditions.

12.3.5 Shoulder widening values are varied, probably due to the voluntary nature of its use. Also for up to about 3,000 vpd, safety effects of shoulder-widening are mainly for single vehicles crashes and between 3,000-7,000 vpd, both single and two vehicle crashes are reduced. Therefore, as the evaluation is on SHs with less than 4,000 vpd, safety effects will tend to be low and not relate to overtaking.

12.4 Low-Volume Costs

12.4.1 Table 22 compares typical $NZ costs for each treatment. Averaged total costs were compared for cost per km, per facility and in series over 10 km. As a facility, short PLs are more expensive than SVBs. However, in series short PLs are less costly. Localised shoulder- widening is the least costly but location requires available passing sight distance.

Table 22. Typical Total Costs of Low-Volume Passing Treatments

Option	Average Total Costs		
	$/m (Range)	$1,000/Per Facility	$1,000/10 km in series
Short PL	900 (400-1,630)	720	720
Turnout/SVB	890 (480-1,620)	360	720-1,080
Isolated shoulder-widening	600 (270-1090)	240	480-720

12.4.2 From 2006/07 SH Forecast, costs for 9 short PLs sites and 13 SVB sites were considered. A 2.5 m wide shoulder is assumed and costs were based on two thirds of total short PL costs. For the sample, SVBs lengths were about 400 m with tapers and short PLs were about 600-800 m with tapers. Shoulder widening is assumed to be about 400 m long.

12.4.3 The high total costs in Table 21 ($890-900/m) compared to average total cost for passing facilities in Table 2 ($620/m) reflects that short PLs and SVBs are usually located in hilly/mountainous sites.

12.4.4 Both short PLs and SVBs have similar average unit costs with a wide range of unit costs. The lower values are probably due to existing partial formation or less groundworks. The higher costs values probably reflect other Transit work at individual sites.

12.4.5 At low flows, a PL would have an effect on PTSF for up to 20 km downstream and about 3 km downstream for ATS (Harwood et al., 1999). Therefore, a 10 km effective length is conservatively short. As flows increase, SVBs in series usually have 3-5 km spacings (Harwood & Hoban, 1987). For shoulder widening, 3-5 km spacings were assumed.

13. EVALUATION OF PASSING TREATMENTS (4,000-25,000 vpd)

13.1 Moderate-Volume Flows

13.1.1 Table 23 shows the theoretical flows for some section treatments and compares Canadian and German values. All flows relate to level terrain and are two-way except for Design Volume Hour (DVH). The theoretical flow values are compared later with observed flows in Table 24.

13.1.2 In general, European flow values are higher than Canadian values, except for 2+1 lanes. Canada has a wider cross section (13.4 m flat, 15.6 m mountainous) compared with Germany (11-12 m) for 2+ 1 lanes. The wider cross section may account for the higher Canadian capacity value for 2+1 lanes.

Table 23. Theoretical Flows of Moderate-Volume Passing Treatments

Option (Country)	Design Volumes		Capacity Flows	
	1 way DVH (vph)	AADT (vpd)	1 way DVH (vph)	AADT (vpd)
Motorway				
Canada	1,640/lane	10,000	2,200/lane	>10,000
Germany	2,200/lane	>18,000	2,600/lane	>35,000
2+1 Lanes				
Canada	1,200	8,000	2,800	18,600
Germany	1,800	12,000	2,500	15,000
Extra-Wide Lanes				
Canada	1,010	6,730	1,200	8,000
Germany	1,900	12,000	3,300	18,000
Wide-Shoulder				
Canada	670	4,500	900	6,000
Germany	1,600	8,000	2,400	12,000

13.1.3 German researchers were undertaking work to confirm the theoretical basis for the German capacity values shown in Table 22 (Potts & Harwood, 2003). Recent email discussions with these researchers indicate that flow-speed curves have been developed for 2+1 lanes. The research is in German and would need translating.

13.1.4 The capacity of 2+1 and extra-wide lane roads are constrained by the merge area, where one-way operational flows are critical. Therefore, 2+1 lane and extra wide lane roads would have similar operating flows to PLs in series and less than two lane roads near capacity. However, with 2+1 lanes while merge flows constrain capacity, at operating flows opposing flows should not affect lanes divided by a central median cable.

13.1.5 The directional split can vary, particularly on the weekend. If the directional split is fairly even, higher operating and capacity AADTs can be achieved for 2+1 lanes. Therefore, one-way flows are a better indicator of flow constraints than AADT.

13.1.6 The German speed limits for various cross sections are generally about 10 km/hour higher than comparable Canadian roads. This may partly explain the higher capacities for Germans roads.

13.1.7 Table 24 is a comparison of observed European operating flows. For German 2+1 and two lane roads, the observed two-way capacity flows are higher than the values given in Table 23. However, for one-way flows, Table 24 observed flows are lower than Table 23 theoretical flows. Therefore, rather than relying on theoretical values, it is better to use observed flows.

13.1.8 Operational one-way flows would suggest that about 1200-1400 vph is close to the capacity for the merge. A US review of European 2+1 lanes suggested that 1,200 vph would be appropriate. In Finland, at 1,400 vph one-way flow, the reviewers observed a break down in traffic merging, as queuing vehicles changed lanes to improve their position.

Table 24. Observed Flows of Moderate-Volume Passing Treatments

Option	Typical Operating Flows		Maximum Flows	
	1 way DVH (vph)	AADT (vpd)	1 way DHV [1] (vph)	AADT (vpd)
2+1 Lanes				
Germany	-	15,000-25,000	-	30,000
Finland	1,200-1,400	14,000	1,600-1,900	20,000-25,000
Sweden	1,300-1,400	4,000-20,000	1,600-1,700	-
Wide-Shouldered Two Lane				
Sweden	-	-	1,900-2,000	-

Note: [1] Design hour volumes.

13.1.9 Another possible factor in the difference between Canadian and European one-way flow values may be due to differences between signs and markings for the merge. The European practice is for passing lane traffic to give way to slow lane traffic at the merge. Therefore, as the merge is more efficient, higher one-way operating and capacity flows can be achieved.

13.1.10 Unlike NZ, European markings have directional arrows by the merge area, directing passing vehicles to merge into the slow lane after passing and diagonal hatching on the fast lane it merges into the slow lane. In NZ, priority is not defined at the merge with each driver supposed to experience caution.

13.1.11 At the diverge area, the slow lane is marked as the dominant lane with passing vehicles having to cross lane marking to enter the passing lane. NZ passing lanes have similar diverge markings to the Europeans.

13.2 Moderate-Volume Operational Efficiency

13.2.1 Table 25 is based on results of a computer simulation over both level and rolling terrain (Potts & Harwood, 2003). Flows are two-way with a 70/30 split in directional flows. Results are combined for both directions.

13.2.2 The results suggest that 2+1 lanes are at least one level of service higher compared with passing lanes at 5 km spacings. Transit's long term policy is to provide a PL or overtaking opportunity every 5 km.

13.2.3 The 2+1 lane treatment had better LOS over all range of flows compared to PLs in series and two-lane roads. PLs with 5 km and 11 km spacings had the same LOS. The simulation data showed greater reductions in both Average Travel Speed (ATS) and Percentage Time Following (PTFS) for 5 km spacings compared to 11 km spacings but ATS and PTSF values fell within the same range of values for each Level of Service (LOS). Therefore, LOS is not sensitive to flows.

Table 25. Level of Service for Moderate-Volume Passing Treatments

Option	**LOS (PTSF%, ATS km/h)**		
	Two–way 400 vph	1,200 vph	2,000 vph
2+1 Lanes	A (26, 96)	B (45, 93)	C (55, 90)
Passing Lanes @ 5 km	A (32, 95)	C (57, 91)	D (69, 89)
Passing Lanes @ 11 km	A (32, 95)	C (61, 91)	D (75, 88)
Wide-Shoulder Two-Lane[1]	B (37, 95)	D (66, 91)	E (82, 88)

Note: [1] Assumed wide-shoulder

13.2.4 For continuous four–lane sections, ATS and PTSF are slightly lower than 2+1 lanes, if 2+1 lane roads are not close to capacity flows. On four-lane roads, some slow drivers are more likely to travel two-abreast rather than complete a passing manoeuvre and re-enter the slow lane.

13.2.5 Table 26 shows the results of field surveys in Germany (Frost & Morrall, 1995). Headways were less than 5 seconds but a directional split was not provided. Over the range 1,000-1,800 vph, 2+1 lanes and extra–wide lanes had about 10-15% less PTSF than wide-shoulder two lane roads. Extra-wide lanes have similar PTSF performance compared to 2+1 lanes.

Table 26. Percentage Following for Moderate-Volume Passing Treatments

Option	**% Following**		
	Two-way 1,000 vph	1,200 vph	1,800 vph
2+1 Lanes	-	63	75
Extra Wide Lanes	55	63	-
Wide-Shoulder Two Lane	70	75	85

13.2.6 Empirical studies in Germany have shown that extra-wide lanes have an average increase of about 25 km/hour compared to two-lane highways for passenger cars (Frost & Morrall, 1995). However, this resulted in the majority of passenger vehicles travelling over the posted speed limit. The German speed limit can vary from 100-120 km/hour but is assumed to be 100 km/hour as this assumption is more compatible with other research results (Bergh & Carlsson, 1995).

13.2.7 For 2+1 lane roads with central median cables and one-way flows of 200-300 vph, Swedish studies have shown that average spot passenger car speeds on two-lane sections were about 107 km/hour (110 km/hour speed limit), which was about 4 km/hour higher than previous extra-wide lanes (Bergh & Carlsson, 2,000). For one-lane sections, average spot passenger car speeds were more or less unchanged. Based on PTSF and spot speeds, extra-wide lanes would have a similar LOS compared to 2+1 lanes.

13.2.8 However, at high operating flows, it is expected that flows would break down at 2+1 lane merge zones, thereby reducing ATS. Therefore, extra-wide lanes would have a higher LOS than 2+1 lanes at near-capacity flows for 2+1 lane roads. The LOS for PLs in series is lower than extra-wide lanes and 2+1 lanes but higher than two-lane roads.

13.3 Moderate-Volume Safety

13.3.1 Table 27 shows the typical crash rates for German highways (Frost & Morrall, 1995). Two-lane values are provided for comparison. Except for extra-wide lanes, all other treatments have lower crash rates than two-lane highways. The 2+1 lanes roads have a markedly lower crash rate in both categories of crashes compared to extra-wide lanes. For both crash categories, extra-wide lanes have a higher crash rate than conventional two-lane roads.

Table 27. German Crash Rates for Moderate-Volume Passing Treatments

Option	Crash Rate (Crashes/10^6 vkt)	
	Fatal & Injury	Fatal, Injury & Serious Non-Injury
4 lane divided with wide shoulder	0.15	0.37
4 lane divided	0.19	0.39
4 lane undivided	0.21	0.39
2+1 lanes	0.16	0.28
Extra-wide lane	0.28	0.49
Wide-shoulder	0.19	0.35
2 lane (conventional)	**0.25**	**0.39**
2 lane (narrow lanes)	**0.22-0.44**	**0.39-0.71**

13.3.2 A comparison using Canadian crash data was not attempted. The typical crash rates for Canada were higher than for Germany. The difference in crash rates is partly due to Canada collecting data on property only crashes that are about a quarter the value of German property only crashes. In NZ, there is no requirement to report non-injury (property only) crashes. Therefore, NZ crash rates would probably follow German crash trends, provided other road conditions were similar.

13.3.3 Table 28 compare crash reduction rates, showing that fatal and injury crash reductions were highest on Swedish roads (Potts & Harwood, 2003). This reduction is due to many factors, namely i) central median cables, ii) higher standard of road geometrics, iii) restriction of access driveways and roads iv) prohibition of pedestrians, cyclists and slow moving farm equipment and v) speed reductions from 100 km/hour to 70 km/hour on approaches to at-grade intersections.

Table 28. Crash Reduction Rates of Moderate-Volume Passing Treatments

Option	Crash Barrier (N/Y)	Crash Reduction Rate: Fatal (%)	Injury (%)	Fatal+Injury (%)
Semi-Motorway 2+1				
Sweden	Y	60-70	–	40-55 [1]
Germany (gap separation)	N	-	-	36
Finland [2] (no gap separation)	N	0	13	11
Conventional 2+1				
Sweden	Y	45-55	-	30-50
Sweden	N	-	-	5-10
Passing Lane				
New Zealand	N			14-23 [3]

Note: [1] Includes fatal and serious injury crashes only. [2] Based on limited data. [3] Koorey et al., 1999, 14% taking into account PL length, 0-2 km upstream and 0-10 km downstream, 23% if only along PL length.

13.3.4 Comparing German semi-motorway (expressway) values (36%) against Swedish semi-motorway (expressway) values (40-55%) could suggest that favourable reductions could still be achieved if the road is built to a semi-motorway (expressway) standard with access controls but no median cables. Similarly, Swedish values suggest that favourable fatal crash reduction rates (30-50%) could be achieved if only a central median cable barrier is used on 2+1 roads with some access controls.

13.3.5 However, up to 2003, about one third of German 2+1 lanes have been retrofitted from 11-12 m wide carriageways. The remaining two thirds were newly constructed bypass routes. Therefore, the majority of German 2+1 lanes were assumed to be semi-motorways (expressways). The lower German crash reduction rates may be partly due to the inclusions of conventional 2+1 lanes within overall results.

13.3.6 Five Finnish 2+1 roads were retrofitted from existing carriageways but for the remaining two roads in service, all access is accommodated at interchanges. It is unclear whether the Finnish crash data relates to only the remaining two roads in service. For crash reduction purposes, Finnish 2+1 lanes were assumed to be semi-motorways (expressways).

13.4 Moderate-Volume Costs

13.4.1 Table 29 compares the approximate costs for various treatments in New Zealand. Two lane roads are provided as a basis of comparison. Four-lane and two-lane costs were taken from Transit's Elemental Cost database. PL construction costs were taken from an analysis by Transit Regional staff of Auckland and Northland PL projects. PL Investigation & Reporting (I&R) and Design costs were taken from the 2006/07 SH Forecast.

Table 29. Typical Total Costs of Moderate-Volume Passing Treatments

Option	Approx Costs ($NZ M/km)
Four Lane	
Urban with structures	5-10
Rural with structures	4-10
Rural without structures	2-4
2+1 Lanes	
New alignment without structures	1.5- 2.7 [1]
Tack-on without structures	0.9 [2]-1.5
Wide-Shoulder (14m) [3]	
New Alignment without structures	1.3-2.5
Tack-on without structures	0.7-1.3
Passing Lanes (single, one side) [4]	
Hilly	0.75
Rolling	0.6
Flat	0.4
Two Lane (8.5 m)	
With structures	**2-3**
Without structures	**1-2**

Note: [1] Based on one 2+1 lane project, design estimate. [2] Based on one 2+1 lane nearly completed, cost may increase with at-grade intersection upgrades. [3] Assumed to be similar to 2+1 lanes. [4] Average total costs include I&R, Design ($70,000/facility), other Transit works (20%) but excludes one-off extra items (23%) i.e. retaining walls, cattle underpasses, etc.

13.4.2 The total costs for 2+1 lanes were similar to rural four-lanes without structures but larger cost differences occur for four-lanes with structures. Both four-lanes and 2+1 lanes will have high costs, particularly in difficult terrain. Passing lanes do not extend along the full length of the road section and spacing can be varied to avoid more costly locations. Therefore, PLs in series should provide a low-cost alternative in difficult terrain.

13.4.3 For the 2+1 lane project Long Swamp to Rangiriri Stage 1, the total cost for Stage 1 was about $0.9 M/km for a tack-on widening without structures. However, there may be additional costs associated with intersection works. For Long Swamp to Rangiriri Stage 2, the 2+1 lane total cost was estimated to be about $2.5 M/km for realignment without structures. This compared favourably with the relativity for Swedish costs of: 9 m two-lane road (1.0), 2+1 lane (1.35), and four-lane roads (2.0) (Bergh & Carlsson, 1995).

13.4.4 2+1 costs would be markedly reduced if the layout can be accommodated within the existing carriageway and structures can be avoided. The greatest potential for cost savings would lie in using 2+1 lane treatments in locations, where four-lane with structures were currently being proposed.

13.4.5 Any review of four lane projects without structures against newly aligned 2+1 lanes would require careful consideration as cost ranges for these two treatments can overlap and cost savings have to be balanced against lower capacity.

13.4.6 These cost comparisons does not take into the account the effect of funding sources. For tolling, it would be more appropriate to use four-lanes rather than 2+1 lanes on new bypass routes. Current tolling legislation would not allow funding of an upgrade on existing routes but would allow new facilities with another alternative route to be fully funded.

13.4.7 Therefore, a review of proposed four lane projects in the peri-urban areas is suggested. The total value of these projects is about $1,800 M. Typically, a $200 M four lane project with structures ($4-10 M/km) could possibly achieve cost savings of about $140 M if a 2+1 lane ($1.5-2.7 M/km) was used along the full length. However, treatment of intersections would also have to be taken into account, particularly in peri-urban areas.

14. KEY FINDINGS OF PART III

14.1 Option Identification

14.1.1 Possible options were loosely grouped into overtaking and passing treatments with supporting treatments and measures, namely:

- i) Overtaking treatments – PSD improvements (i.e. vegetation control, batter relocation, pavement rehabilitation, realignment), overtaking enhancements (i.e. isolated seal-widening, overtaking at passing facilities, configuration of PLs).
- ii) Passing treatments < 4,000 vpd - isolated shoulder-widening, turnouts/slow vehicle bays (SVBs) and short passing lanes (PLs).
- iii) Passing treatments > 4,000-20,000 vpd - wide shouldered two-lane roads, climbing/crawling lanes, passing lanes in series, extra wide lanes, 2+1 lanes and four-laning.
- iv) Centreline treatments - yellow lines, gap separation of opposing flows, central cables.

v) Roadside & edgeline treatments – clear zoning, increased signs & markings, wide profile markings, chip seal, increased sealed shoulder width, side restraint cables/guardrails.

vi) Intersection measures - at grade-intersections (i.e. two-way right turns, shoulder bypass lanes, turning bays, roundabouts), grade separation and access controls.

vii) Resource planning measures – limited access roads, alternative District roading networks, designations.

viii) Education measures - general public, targeted programme for heavy transport operators/high HCV activities.

ix) Enforcement measures - general public, problem locations, in vehicle HCV speed controls.

x) Travel demand management (TDM) measures – alternative hours, routes and modes.

xi) Intelligent Transport Systems (ITS) measures – variable message signs (preferably linked to video monitoring), video monitoring (preferably linked to ATMS), speed cameras (preferably for long-vehicles).

14.2 Initial Assessment

14.2.1 Generally, treatments that can be applied over the whole network are preferred to treatments that are site specific.

14.2.2 Overtaking treatments are usually suitable up to about projected 7,000 vpd with selective use above projected 7,000 vpd. These treatments are grouped into PSD improvements and overtaking enhancements. Isolated seal-widening is considered to be the most effective overtaking treatment as it does not rely on the existence of PL facilities. Other overtaking improvements would be selected on a case-by-case basis. To be effective, adequate passing sight distances must already exist or will be provided as a result of other Transit works.

14.2.3 From an initial assessment of isolated shoulder-widening, SVBs and short PLs, all of these low-volume passing treatments showed ability to provide both operational and safety advantages. Therefore, a more detailed evaluation was undertaken. Similarly, for PLs in series, extra wide lanes, 2+1 lanes and four-lanes, all of these moderate-volume passing treatments underwent a more detailed evaluation due to their relatively similar operational and safety advantages. The analysis of these options is discussed more fully under Section 14.3 Detailed Evaluation.

14.2.4 As flows increase, progressively more costly intersection treatments have to be used in conjunction with passing treatments, particularly if long-term access/intersection controls cannot be applied. In conjunction with intersection treatments, a revised limited access road (LAR) classification system is suggested, incorporating a semi-motorway (expressway) standard for access controls on both private driveways and SH intersections with District roads.

14.2.5 Centreline treatments can be applied over most of the network with yellow lines and gap separation providing both operational and safety benefits. These combined benefits would reduce as opposing flows increase and central median cables or a comparable solid restraint would be provided on safety grounds.

14.2.6 While the TDM measure of variable messaging would have both operational and safety benefits, its benefits would be optimised if used in conjunction with video monitoring. Due to the lower costs and minimal labour input from sign and marking treatments, TDM measures are best suited to high demand locations and periods.

14.2.7 For planning measures, LAR measures can be applied over the whole network. However, some revision of the LAR process is required. Development of alternative District roading networks would provide significant benefits at relatively low cost to Transit but would be more applicable to peri-urban areas. The long-term benefits of designations would be eroded, if LAR protection is not effective. Transit is also able to make submissions on District Plan changes that would improve the development of local roading networks.

14.2.8 The majority of education measures lie outside of Transit's influence. However liaison with other agencies, such as Land Transport NZ, Ministry of Transport and NZ Police and networking with other Transit staff and consultants is suggested.

14.2.9 Also, Transit submissions on Resource Consent applications should include education initiatives for HCV drivers and work practices for operators of high HCV generating activities. Targeting problem driver behaviour and problem driver groups is considered the best option for education measures.

14.2.10 The majority of enforcement measures also lie outside of Transit's influence. Until the effects of in-vehicle speed controls for HCVs can be assessed, enforcement by NZ Police at problem locations would seem more appropriate, namely i) enforcement of 80 km/hour speed limit on HCVs and RVs at specific problem overtaking zones and passing facilities and ii) enforcement of speed limit on all vehicles at problem locations with high crash severity that is associated with overtaking behaviour rather than overtaking/passing locations without an overtaking-related crash history.

14.3 Detailed Evaluation

14.3.1 A more detailed evaluation was undertaken on both low-volume and moderate-volume treatments for flows, operational efficiency, safety and costs.

14.3.2 For passing treatments on SHs with typically less than projected 4,000 vpd, short PLs or SVBs with provision for extension to short PLs were the best options. Short PLs have the ability to redistribute slower vehicles within a platoon, which has better downstream benefits.

14.3.3 Short PLs would be able to cater for increased flows better than SVBs and shoulder-widening, which were only suitable for flows with 1-2 queues of following vehicles and high differential speeds.

14.3.4 Operational efficiency of short PLs compared to a 1.6 km PL (75-100%) was assumed to be better than SVBs (20-50%) and shoulder-widening (20-50%). For short PLs, faster following vehicles were able to pass slower following vehicles once they had both passed the platoon leader. This feature meant that as flows increased short PLs (10-20 km) had a longer effective length than SVBs (3-5 km) and shoulder-widening (3-5 km).

14.3.5 The crash reduction rate for short PLs (33%) was higher than for SVBs (17%) and shoulder widening (0-20%). The higher crash reduction rate was probably due to short PL's longer effective length, which affected downstream traffic over a longer length. Also the use of short PLs was more clearly defined and relied less on voluntary use.

14.3.6 The longer effective length meant that although short PLs had a higher cost per facility ($0.7 M/facility) they has a similar or slightly lower cost per 10 km of SH ($0.7 M/10 km) compared to SVBs ($0.7-1.1 M/10 km).

14.3.7 Shoulder widening ($0.5-0.7/10 km) had the least cost but also the lowest crash reduction rates (0-20%), mainly because safety benefits for two vehicle crashes started to accrue mainly above 3,000 vpd.

14.3.8 For passing treatments on SHs with typically projected 4,000-20,000 vpd, staged implementation is preferred. Therefore, PLs in series followed by infilling to provide 2+1 lanes on flat/rolling terrain is preferred. PLs in series are preferred on hilly mountainous terrain.

14.3.9 For projected 10,000-20,000 vpd, extra wide lanes had the largest operating and capacity flows. The 2+1 lane and PLs in series had similar flows as they were both constrained by merging flows at transitions from two to one lane.

14.3.10 Extra-wide lanes and 2+1 lanes had similar operational efficiencies and were better than PLs in series provided that capacity constraints for 2+ 1 lane treatments were not exceeded. Four-lanes had a slightly lower efficiency than extra-wide lanes and 2+1 lanes due to a higher likelihood of two vehicles travelling two abreast but four-lanes had a higher capacity.

14.3.11 However, German safety reduction rates for extra-wide lane roads (0.25 fatal & injury crashes/10^6 vkt) were slightly less than conventional two-lane roads (0.28 fatal & injury crashes/10^6 vkt) but markedly less than 2+1 lane roads (0.16 fatal & injury crashes/10^6 vkt) and four lane divided roads (0.16 fatal & injury crashes/10^6 vkt). Therefore, extra-wide lanes had a low crash reduction rate and were not considered further.

14.3.12 For Sweden, best crash reduction rates occurred when 2+1 lanes were used in conjunction with central median cables, good road geometrics and semi-motorway (expressway) access controls on users, intersections and driveways, particularly for fatal (60-70%) and combined fatal and injury crashes (40-55%). However, Germany used gap separation of opposing flows with semi-motorway (expressway) access controls to achieve similar but slightly lower crash reduction rates for fatal and injury crashes (36%).

14.3.13 Although the estimated cost range for tack-on 2 + 1 lanes is about $0.9-1.5 M/km, The cost range for realigned 2+1 lanes ($1.5-2.7 M/km) and four-lane SHs without structures ($2-3 M/km) are similar. Therefore, selection between 2+ 1 lanes and four-lanes without structures would have to be done on a case-by-case basis. However, for four-lane SHs with structures ($4-10 M /km), the ability of 2+1 lanes to transition between 2 and 3 lanes means that more costly items, such as bridge widenings, grade-separated intersections and lengthening of District road overbridges, can be deferred.

14.3.14 Similarly, PLs in series would be more suited to hilly/mountainous terrain where extra passing length is not required over the whole of the road section’s length and therefore more costly locations can be avoided

PART IV. GUIDELINE ISSUES

15. OPTION PRE-SELECTION

15.1 Projected less than 4,000 vpd

15.1.1 Projected flows relate to flows over the next 25-30 years at the end of the project life. The 4,000 vpd limit may vary depending on site conditions e.g. 5,000 vpd.

15.1.2 Road section with less than 35% overtaking opportunities:

- Review adequacy of signs and markings.
- Check or audit existing treatments plus 2 km upstream and 4 km downstream of any facilities. If required, minor upgrade or extension to existing treatments.
- Check Transit work programmes to see if sight visibility measures are scheduled e.g. vegetation control, batter relocation, pavement rehabilitation, realignment.
- For pavement rehabilitation and realignment, consider inclusion of low-volume passing facilities.
- If no scheduled Transit works that would help PSD, consider shoulder widening, extendable SVB or short PL depending on road conditions.
- If passing facilities are to be provided, allow for overtaking of opposing traffic at these facilities.

15.1.3 Road section with 35% or more overtaking opportunities:

- Enhance overtaking opportunities at areas of sufficient PSD e.g. seal widening, pavement rehabilitation.
- Check if clear zoning is on the schedule
- Check if yellow line treatments are adequate.

15.2 Projected 4,000-7,000 vpd

15.2.1 The 4,000 and 7,000 vpd limits may vary depending on site conditions e.g. 5,000 vpd or 8,000 vpd.

15.2.2 Road section with less than 35% overtaking opportunities:

- Check if all measures for projected < 4,000 vpd with less than 35% passing opportunities have been applied.
- Check that existing treatments don't require an extension or minor upgrade.
- If PSD improvements have already been applied, consider 2.5 m wide shoulder widening, extendable short PL or PL, preferably at a location with large speed differential.
- Retain existing overtaking opportunities in areas with sufficient PSD, including configuration of passing facilities, preferably locate passing facilities first in areas without good PSD.
- If passing facility has to be located where there is clear PSD, consider overtaking for opposing traffic.
- Consider LAR controls and other resource planning measures.
- Check performance of remaining turning/intersection facilities.

15.2.3 Road section with 35% or more overtaking opportunities:

- Check if all measures for projected < 4,000 vpd with greater than 35% passing opportunities have been applied .
- Check that existing treatments don't require an extension or minor upgrade.
- If all sight distance measures have been applied, consider extendable short PL or PL, preferably at a location with a large speed differential and without good sight distance.
- If there are locations with adequate PSD, configure passing facilities so that the effective lengths of any nearby SVBs and PLs do not overlap.
- Consider LAR controls and other resource planning measures.
- Check performance of remaining turning/intersection facilities.

15.3 Projected 7,000-10,000 vpd

15.3.1 The 7,000 and 10,000 vpd limits are flexible and may vary depending on site conditions e.g. 8,000 vpd and 12,000 vpd.

15.3.2 Road section with less than 35% overtaking opportunities:

- Check if all measures for projected 4,000-7,000 vpd with less than 35% passing opportunities have already been applied.
- Check that existing treatments don't require an extension or minor upgrade.
- Consider PL or PL in series, preferably at a location with a large differential speed. By now passing facilities from 4,000-7,000 vpd roads would have used all sites with poor sight visibility and only overtaking areas with overtaking enhancement remain.
- Increased use of double yellow markings in crash prone areas, possibly gap separation of opposing flows or central median cables.
- If there are locations with adequate PSD, consider configuration of PLs and overtaking at PLs.
- Consider retaining LAR or changing to semi-motorway (expressway) classification, in conjunction with either developing a structure plan for alternative roading to reduce driveways and road intersections or designations.
- Consider upgrade of remaining turning/intersection facilities i.e. shoulder bypass, turning bays and possibly roundabout. Also consider two-way right turns for 50 and 70 kph areas.

15.3.3 Road section with 35% or more overtaking opportunities:

- Check if all measures for projected 4,000-7,000 vpd with greater than 35% passing opportunities have been applied.
- Same as projected 7,000-10,000 vpd, with insufficient sight visibility.

15.4 Projected 10,000 vpd or more

15.4.1 The limit of 10,000 vpd may vary depending on site conditions with transitional traffic flows up to projected 12,000-14,000 vpd and projected 20,000-25,000 to be monitored.

15.4.2 All road sections:

- Check if previous 7,000-10,000 vpd measures have been adopted.
- Check that existing treatments don't require an extension or minor upgrade.

- Consider PL in series, 2+1 lanes or four lanes, depending on terrain, one-way flows and method of funding.
- Increased use of double yellow markings, gap separation of opposing flows or central median cables.
- If there are areas of adequate PSD, consider configuration of PLs and overtaking at PLs.
- Upgrade of turning/intersection facilities i.e. shoulder bypass, turning bays, roundabout, grade separated interchange. Also, consider rationalisation of minor road intersections.
- Preferably semi-motorway (expressway) status in conjunction with designations and a revised structure plan for an alternative roading network.
- Education and enforcement measures to be applied in conjunction with Land Transport NZ and NZ Police.
- Consider TDM and ITS measures during peak periods.

15.5 All flows

15.5.1 All road sections:

- Consider opportunities for overtaking and passing treatments within other Transit works, such as vegetation control, batter relocation, pavement rehabilitation and realignment and safety works.
- Consider special user requirements for pedestrians, cyclists and farm vehicles.
- Conditions on resource consent applications for high HCV generating activities.
- Consider the effect of funding on resource planning measures, namely: i) LARs for upgrades on same alignment that have national funding/possibly developer contributions, ii) alternative road networks using possibly regional funding/developer contributions/local authority funding and iii) designations for toll-funded routes and routes with intensive adjoining land use where access cannot be controlled.
- Targeted education measures for HCV operators and activities that have a high number of HCV movements.
- Enforcement by NZ Police of: i) HCV speed limit at locations with passing or overtaking problems and ii) possibly speed limit of all users for low-volume SHs with high operating speeds and crash prone locations with high number of overtaking, rear end and head-on crashes and iii) possible use of long-vehicle speed cameras.

16. PLANNING & FUNDING

16.1 Work Packages

16.1.1 Generally, BCR values will reduce as facilities are provided along a road section. Therefore, early identification of a Weighted Average BCR for a package of works will assist with funding works along a road section rather than individual funding applications.

16.1.2 Critical to this funding approval is confidence in early assessment of benefits and costs. As these types of projects would happen on a more regular basis than larger say $100 M+ projects, it should be possible to establish and maintain an accurate database of costs.

16.1.3 There may be synergies that allow greater benefits for interim strategies assessed as a whole rather than assessed as individual projects.

16.2 Funding

16.2.1 The implementation window for moderate-volume treatments would be 5-10 years, which is less than the time for larger projects but more than for current PL and SVB projects. A mix of 2+1 lane treatments, PL in series and individual PLs and SVBs would enable projects to be adjusted to smooth out funding streams.

16.2.2 As cost savings could be achieved by co-ordination with other Transit works, this linkage has to be recognised within PROMAN and project timing amended to suit as opportunities arise. Therefore, funding for work packages may to accept a high variance in yearly allocations.

16.2.3 Current funding is through block funding with delegated responsibility to Transit staff up to specified cost limits. However, treatments along SH sections of say 15-80 km length may require a change to funding procedures. Possibly, preliminary approval of the overall section strategy by Land Transport NZ with delegated approval for individual projects is acceptable. More consultation with Land Transport NZ is suggested.

16.3 Access Controls

16.3.1 Access controls, particularly for high-volume driveways and local road intersections would contribute to both capacity and safety effects. Therefore, a revised LAR classification system should be developed for SHs with moderate flows.

16.3.2 District and City Councils have the ability to impose LAR conditions if required. If appropriate, in consultation with District/City Councils, access controls should also be considered on local road approaches to proposed larger at-grade intersections, as queuing may affect access to adjacent land use.

16.3.3 Access control is considered to be a long-term strategy. In Germany, about two thirds of their yearly provision of 2+1 roads are newly constructed bypasses, where semi-motorway (expressway) access is easier to apply. In Sweden, local road and access driveway connections are less restricted, with more at-grade intersections but also speed reductions for 100 kph down to 70 kph at these intersections.

16.3.4 As part of intersection access controls, in collaboration with Local Authorities and Regional Councils, Transit should encourage alternative local roading networks, as part of structure plans for Regional Growth Strategies, Regional Land Transport Strategies and District Plans. This measure would provide alternative routes when local road intersections are closed.

16.3.5 LAR database is currently being standardised and should incorporate any additional standard conditions, as suggested under the LAR Working Party report (Douglass, 2003)

16.4 Environment

16.4.1 As previously discussed, within and outside of SH reserve, environmental considerations in Alberta guidelines included:

- topsoil removal.
- aggregate sources.
- waterways.

- navigable culverts and bridges.
- highway drainage.
- dug out and landscaped borrow sites.

16.4.2 Other considerations should include:

- alteration to landform e.g. changes to landscape and neighbouring drainage.
- diversion of watercourses.
- operational effects e.g. noise associated with wide profile markings or rumble strips.
- construction effects e.g. dust particularly for horticultural areas, silt control.
- removal of trees and other substantial vegetation as part of clear zoning.
- possible loss of width for other existing roadside uses and effects of central median barriers, such as pick-up and drop off locations for rural school buses, rural mail delivery.

16.5 District Plan Requirements

16.5.1 Transit submissions on adjacent land use applications should be considered in conjunction with District Plan Structure Plans, Designations and Transit Corridor Management Plans.

16.5.2 Inappropriate land use or activity may generate excessive vehicle use, such as large numbers of HCVs, on SH sections with poor alignments. Within District Plans, Transit should consider submissions on changes to some activities should be considered.

16.5.3 For some SHs, Transit should consider changes to permitted activities within District Plans. Also, for peri-urban areas, a gradual transition to urban rather than rural roading standards is suggested. Rules relating to provision for other modes of transport i.e. walking, cyclist and public transport should be included. The layout of peri-urban subdivisions should connect or provide for connection to other local roads. The roading layout should be amenable to efficient movement and use of public transport vehicles.

16.5.4 Within submissions, Transit should suggest driver education programmes and work practices for new and upgraded facilities that generate high numbers of HCV trips.

16.6 Location

16.6.1 For PLs and 2+1 lanes, features to consider are:

i) Safety

- Crash history of overtaking, rear end and head-on crashes in vicinity, preferably along PL length and up to 10 km downstream. Check that head-on crashes are due to overtaking not poor alignment on curves.
- Consider alignment upstream for 2 km and downstream for 4 km both sides. If appropriate, consider mitigating measures.
- Avoid locations with high turning movements i.e. busy intersections or high-volume driveways. Separation distance for high-volume driveways (> 200 movements/day) and high-volume intersections to be assessed on a case-by-case basis.
- Minimum of 150 m separation from diverge/merge taper ends to closest extent of low-volume driveways (200 movements/day or less) and low-volume District roads, including merge and deceleration lanes.

- Avoid low-volume driveways in and near merge and diverge areas. Preferably, low-volume driveways to be central in PL length with sufficient area for sealed pull-off areas on the same side as the opposing lane.
- Avoid left turning curves for merges and diverge areas.
- Adequate sight distance at beginning and end of PL. Avoid blind merges.

ii) Performance

- Locations where traffic has started to bunch.
- Large speed differentials between vehicles are preferred.
- Preferably downstream of urban areas and speed zones. Avoid 0-5 km upstream of speed zones or urban areas, preferably locate upstream of facility's effective length.
- If possible, locate facility upstream of road sections with good alignments where vehicles are most likely to achieve free-flow speeds.
- Favourable likelihood of access controls, if the road section is not already an LAR.
- Include in new realignments or on roads with good geometrics.
- Where possible, locate facility in terrain with poor PSD or with existing yellow line in the treated direction so that existing overtaking opportunities are retained.

iii) Driver Perception

- From the drivers perceptive, the location should seem a logical place to pass.

iv) Construction Costs

- Avoid bridge widening, culverts, deep ditches, retaining walls, cattle underpasses, locations requiring excessive guardrails, geotechnical problems and excessive earthworks.
- Able to co-ordinate PL work with any other scheduled Transit works, particularly area-wide pavement treatment and safety works.
- If possible PL works to be easily undertaken within SH boundaries.
- If 2+1 lanes are on a proposed toll route, four-lanes are preferred due to funding issues.

16.6.2 For SVBs and shoulder-widening, as well as the features described under PLs, other features to consider are:

i) Safety

- Some researchers recommend approx 300 m sight distance before entering facility.
- Good sight visibility at merge between slow and overtaking traffic (say AUSTROADS taper length for location's operating speed).

ii) Performance

- If high numbers of HCVs and recreational vehicles (RVs) are expected, exit to be on relatively flat location, if possible.
- Both uphill and downhill locations where differential speeds are high.

iii) Driver Perception

- Some researchers suggest at-crest locations for SVBs as it is easier for HCVs to stop if unable to merge but some suggest that at these locations merging traffic is more likely to speed up.

iv) Construction Costs

- Able to extend the facility at a later date into a short PL or PL.

16.7 Terrain

16.7.1 Ideally passing facilities should be installed in terrain with limited overtaking opportunities to conserve existing overtaking opportunities.

16.7.2 Passing facilities should be placed in terrain where traffic is most likely to become bunched and upstream of terrain where vehicles are able to travel at maximum speed.

16.7.3 In terrain with poor alignments, the benefits of passing slow vehicles may not be fully achieved due to free-speeds being constrained by poor alignment rather than slow vehicles.

16.7.4 Flat terrain with good sight distance is considered best for overtaking treatments, subject to differential speed.

16.7.5 At higher AADTs, PLs in series would be best suited to hilly/mountainous terrain and 2+1 lanes would be best suited to flat/rolling terrain.

16.8 Configuration

16.8.1 Opposing PLs with merges facing each other are to be avoided.

16.8.2 At low-volume locations of less than projected 4,000 vpd, PLs are to be alternating to assist passing in the opposing direction at PLs. Therefore, side-by-side PLs are not preferred on roads sections with low traffic volumes.

16.8.3 Spacing of PLs and overtaking opportunities should minimise any overlap of effective lengths.

16.8.4 Consider the effect on downstream or upstream overtaking opportunities. PLs will have the effect of increasing the incidence of opposing traffic downstream of the facility.

16.9 Safety & Crash History

16.9.1 Evaluation of safety features for options has already been discussed within this report under Section 11. Preliminary Assessment, Section 12. Evaluation for Low-Volume Treatments (< 4,000 vpd) and Section 13. Evaluation for Passing Treatments (4,000-25,000 vpd). The most appropriate treatment should take into account the crash history of the site and 2 km upstream and downstream of the site.

17. DESIGN & CONSTRUCTION

17.1 Passing Sight Distance

17.1.1 Transit NZ's Draft State Highway Geometric Design Manual indicates that the overtaking criteria of 420 m clear sight distance (at 110 km/hour operating speed) allows a vehicle to brake when level with a passing vehicle and re-enter the lane behind the vehicle being overtaken.

17.1.2 The 420 m PSD is less that the clear sight distance needed for some situations to complete a full passing manoeuvre. A full passing manoeuvre requires additional sight distance to allow a vehicle to pass and re-enter the lane in front of the overtaken vehicle and to allow for the distance that an on-coming vehicle may travel while the passing manoeuvre is being undertaken.

17.1.3 Swedish research provides information on 50^{th}% percentile and 85^{th}% percentile PSDs for car-car, truck-car and truck & trailer-car overtaking situations. The results consider with and without opposing traffic for both accelerating and flying overtaking manoeuvres. Different PSD criteria are applied to different types of road.

17.1.4 Some North American literature suggests that passing facilities should be provided if there are less than 50% overtaking opportunities along a road section. However, this provision would be too costly for NZ with more varied terrain to provide. Transit should remain with less than 35% overtaking opportunities on all its terrain but altering the passing sight distance to be speed dependent.

17.1.5 Also, provision of adequate sight distance should allow for timid drivers and car overtaking truck and trailers by providing longer lengths at set intervals, depending on the nature of the SH and the composition of road traffic.

17.2 Passing Demand

17.2.1 Both the Canadian Unified Traffic Model and South African SARNA research have developed assessment models for LOS related to passing demand. Some early research has already been done on the Unified Model. Both models should be considered further as part of any research into passing demand.

17.2.2 NZ Research has identified the Borel-Tanner Distribution as suitable for assessing passing demand at low volumes. Further research on application to PEM simplified procedures is suggested.

17.2.3 For NZ conditions, HCV and car speeds appear to be similar. Therefore, similar speeds have to be taken into account when evaluating overseas models.

17.3 Design Hour

17.3.1 Usually a 30^{th} or 100^{th} design hour is used. A lower design hour may be more appropriate for locations with high seasonal flows. For passing lane design, South African research had considered a peak weekly value to determine design flows. However, an average weekly design hour plus a 30^{th} highest design hour would now be used.

17.4 Flows

17.4.1 German guidelines provide pre-selection tables of indicative capacity. Generally, moderate-volume passing treatments, such as 2+1 lanes have a recommended operating flow up to about 20,000 vpd.

17.4.2 Wisconsin literature suggested that about 12,000 vpd or one-way flow of about 1,400 vehicles/design hour is the upper limit for passing lanes before four-laning should be considered.

17.5 Length and Spacing

17.5.1 Comparing both NZ and international literature, PEM procedures are the best example of evaluating PL spacings with regard to length taking into account other factors, particularly terrain. Many SH agencies relate length to AADT or one-way flow but usually flat or rolling terrain is assumed.

17.5.2 Table 30 summarises the most operationally effective PL lengths (Harwood & Hoban, 1985). Similar values are used by many overseas guidelines. The range of PL length values relates to reductions in percent time delay in both flat and rolling terrain. It is reasonable to assume that reduced lengths are used for steeper terrain.

Table 30. Optimal Passing Lane Lengths

One-Way Flow (vph)	Passing Lane Length [1] (km)
100	0.6
200	0.6-1.0
400	1.0-1.4
700	1.4-3.0

Note: [1] 200 m has been deducted from these values to allow for diverge & merge taper costs.

17.5.3 Harwood and Hoban suggest that the optimum length is 0.6-1.4 km. Over 1.4 km, the PL becomes gradually less inefficient, depending on spacing and one-way flow. PL length longer than 1.4 km would require one-way flow rates greater than 700 vph.

17.5.4 US research (Harwood et al., 1985) provided a mathematical equation to determine the effect on reduction in platooning for 50-400 veh/hour of one-way flow in the treated direction (Correlation $R^2 = 0.83$):

$$PR = 0.127\ FLOW - 9.64\ LEN + 1.35\ UPL$$

where PR = Passing rate (passes/mile/hour)
FLOW = Flow in treated direction (veh/hour)
LEN = Length of passing lane excluding tapers (miles)
UPL = Percentage of vehicles platooned upstream

17.5.5 Harwood and others (Harwood et al., 1985) also provided a mathematical equation to determine the effect on reduction in platooning for 50-400 veh/hour of one-way flow in the untreated direction (Correlation $R^2 = 0.71$):

$$\Delta PR = -6.97 + 0.13\ OPFLOW$$

where ΔPR = Change in passing rate (passes/hour/mile)
OPFLOW = Opposing flow in untreated direction (veh/hour).

17.5.6 The variables used were: PL length excluding tapers, flow rate in direction of travel and percentage of following vehicles upstream. Therefore, over a specific value ranges for the parameters, a PL length can be determined for any required reduction in platooning. The equation were derived from PL data and therefore may not be applicable to climbing lanes.

17.5.7 Table 31 shows the effect on PTSF and ATS for an effective length of roadway in flat and rolling terrain that is downstream of a PL (Harwood et al., 1999). Downstream lengths are greatest for platooning effects (PTSF) ranging from 6-21 km. The effect on travel time (ATS) is consistently about 3 km.

Table 31. Effective Length of Downstream Effects

Directional Flow (vph)	Length of Downstream Effect For PTSF (km)	For ATS (km)
200 or less	20.9	2.8
400	13.0	2.8
700	9.1	2.8
1,000 or more	5.8	2.8

17.5.8 On flat terrain, Swedish 2+1 lanes are usually about 2.4 km for the first passing lane then alternating at 1.5 km passing lanes. Other existing Swedish facilities had length varying from 0.8-2 km. These spacings suggest that this facility was in rolling terrain and that lengths were varied to optimise passing lane location on uphill gradients. German experience with 2+1 lanes suggested that shorter lanes at more frequent spacings are better.

17.5.9 NZ research on SVBs shows that facilities less than 0.3 km are not effective at reducing traffic platoons larger than 1-2 following vehicles, at about 60 km/hour operating speed. At higher flows, SVBs in series would typically need to be spaced at 3-5 km.

17.6 Crown & Superelevation

17.6.1 German cross-sections do not have a crowned cross-section. The crossfall is taken constant across the full width of the sealed carriageway. Crossfalls could be flatter if asphaltic concrete is used and therefore differences in level are not as great as if this was applied to the NZ context of chip sealed roads with 2-3% crossfall.

17.6.2 The constant cross-fall enables modular additions of width to be done on either side of the carriageway without affecting the centreline location. It is also easier to accommodate changes in super-elevation due to additional widening.

17.6.3 Retrofitted Swedish and Finnish roads, the crown in the middle of a traffic lane or having the crown crossing over lanes at transitions did not affect the performance of traffic. However, for new cross-sections the crown was placed at the central median cable.

17.6.4 On Finnish roads, if central median cables were installed, an overlay could be provided to relocate the crown by the central median cable. This practice should help snow-plough work, as the carriageway is not curved under the snow-plough blade. However, there have been no

Finnish facilities with central median cables and the overlay is a proposal. In Sweden, where central median cables were used frequently, crowns were not located at the central median and snow-ploughing did not seem to be a problem.

17.7 Access Driveways & Intersections

17.7.1.1 For passing lanes, overseas guidelines suggest that the end of merges are to be located at least 150 m from an intersection or width constraint, such as a bridge.

17.7.2 Access points about mid-way along a PL did not cause any safety issues. Access points that were close to the merge or immediately after it tended to cause problems. However it is suggested that extra seal-widening relating for driveways should be provided, if considered necessary.

17.7.3 In Sweden, it is common practice to provide at-grade intersections and some driveway access along their 2+1 roads. On Swedish 2+1 roads, the transition starts 150 m before the intersection and stops at the intersection. In Germany, most of their 2+1 roads have semi-motorway (expressway) access controls.

17.8 Lane Widths & Tolerances

17.8.1 For 2 + 1 lanes, a Swedish review of earlier treatments showed that the lanes were increased to both 3.5 m on the passing section. For new constructions, Swedish 2+1 lanes guidelines show 3.5 m width for two lanes and 3.75 m width for the single lane.

17.9 Diverge, Merge & Transition Zones

17.9.1 Research into NZ driver behaviour shows that merges with current AUSTROADS taper length of 165 m for 110 kph operating speed gave the most favourable merge characteristics (Luther et al., 2004). However, in many cases the standard taper length had not been applied to these locations. Therefore, this item may have to be emphasised as part of any Safety Audit process.

17.9.2 Swedish literature shows that transitions were originally 300 m with 150 m each side but they are changed to 150 m going from two to one lane and 100 m going from one to two lanes.

17.10 Roadside & Edgeline

17.10.1 For revised Swedish designs, cables were partly used instead of providing 1:6 slopes on one–way sections of a Swedish 2+1 road. On two-lane sections, only existing poles, trees, etc were taken away.

17.10.2 Research has shown similar BCRs for roadside safety works compared to safety works associated with the roadway. Therefore, roadside treatments could be applied progressively in incremental steps.

17.10.3 Consider clear zoning, edge delineation (wide profile markings, edge marker posts), shoulder widening and edge barrier systems (i.e. cables, guardrail) for 2 km downstream of passing facility. Also consider for 2 km downstream of overtaking areas.

17.11 Centreline Treatments

17.11.1 German guidelines provided 0.5-1.0 m separation distance between opposing flows with no separation barrier. US reviewers recommended 1 m minimum, preferably 1.2 m on any US undivided treatments.

17.11.2 The Swedish standard for newly constructed 2+1 roads provides for 1.75 m median width for installing central median cables. The Finnish standard for newly constructed carriageway is 1.70 m median width for installing central median cables.

17.11.3 Transit should consider if future provision for central median cables is to be standard practice on 2 +1 lane roads, if not provided during initial carriageway upgrades or realignments.

17.12 Special Road User Requirements

17.12.1 Extra provision of width should be provided for pedestrians and/or cyclists. German guidelines suggest up that for SHs with < 2,500 vpd, a separate facility is needed if there are more than 60 pedestrians/peak hour, 90 cyclists/peak hour or 75 combined cyclists and pedestrians/peak hour.

17.12.2 For German SHs with more than 10,000 vpd, a separate facility is needed if there are either more than 5 pedestrians/hour, 10 cyclists/hour or 10 combined pedestrians and cyclists/hour. Wisconsin guidelines allow 1.5 m paved shoulder width for SHs with over 1,250 vpd and at least 25 cyclists/day. However, different traffic lane widths between these two agencies may affect shoulder width.

17.12.3 For farm equipment, in some cases, SVBs at 3-5 km spacings were appropriate or if journeys were shorter shoulder widening may be more effective.

17.12.4 VicRoads have conducted a review of median cable barriers with a view towards applying it to Australian roads. There was a concern amongst some Australian motorcyclists that injuries may be more serious for motorcyclists if they hit the median cable barriers or supports. There was no evidence to suggest a rise in this type of crash from Swedish records. However, Swedish conditions may be different to Australian condition. Therefore, VicRoads suggested more consultation.

17.12.5 Changes to the support posts could be considered. However, without altered support posts, injuries sustained from a motorcyclist hitting the median cables or supports would probably still be less severe than from hitting a rigid restraint, such as guardrails, guardrail posts or a concrete median wall.

18. OPERATIONS & MAINTENANCE

18.1 Signs and Markings

18.1.1 No-overtaking markings that consider both vertical and horizontal alignment have been assessed (Koorey & Gu, 2001). For horizontal alignments, it was suggested that no-overtaking markings might be considered on isolated horizontal curves.

18.1.2 NZ research does make some useful suggestions on passing lane design that Transit could investigate further (Luther et al, 2004). However, the same research did not consider the

European practice of marking merges so that vehicles from the slow lane had priority. This omission seems mainly due to perceived public resistance after consultation with roading and safety engineers.

18.1.3 For 2+1 roads in Sweden, speeds are reduced to 70 km/hour for at-grade intersections. On both sides of the road, advance double side lane closure signs are provided 400 m before and at the start of the transition. In the transition areas, delineators are on cable poles at 10 m spacings. Before transitions, a series of directional arrows are marked so that vehicles in the passing lane are directed back into the slow lane.

18.2 Scheduled Maintenance

18.2.1 Experience from Sweden estimates that on average about 2 hours each week is spent on maintaining a 33 km section of central median cable. Maintenance was scheduled for outside of peak flow periods.

18.2.2 NZ experience suggested that there is potential for night-time safety problems, if damaged or missing delineators near intersections are not repaired promptly. The gap between delineators could give the impression of a planned gap in the cable median barrier for intersections.

18.3 Emergency Services

18.3.1 For 2+1 cable medians, permanent emergency openings are provided every 3-5 km. By transitions, quick-lock openings are provided.

18.4 Testing

18.4.1 Possibly, a testing programme is required on cable end barriers and cables.

18.5 Lane Closure

18.5.1 Temporary lane closures may be required at 1,200-1,400 vph one way. If operating capacity was exceeded at least 30 times in a year, then consideration should be given to permanently closing the facility.

18.5.2 Lane closure procedures for scheduled maintenance should be established. As previously discussed, for 2 +1 lanes, overseas experience has been about 2 hours/week closure of the passing lane.

18.5.3 Transit should consider its experience with other PL closures in other locations.

18.6 Upgrades

18.6.1 Poor performance or on-going problems with existing facilities should be reported to the Transit Regional Manager.

18.6.2 Mechanisms for implementing any standards revisions to existing passing facilities should be developed.

18.6.3 An audit of existing passing facilities is suggested, as a part of any interim and long-term strategy. Also consider possible extension of shorter facilities as an option within pre-selection of options.

18.7 Maintenance Standards

18.7.1 Development of maintenance standard is suggested for 2+1 roads with cable barriers (Bergh & Carlsson, 2000). Bridge inspections and overlay repairs should be co-ordinated to minimise traffic delays. Washing of delineators and posts, etc to be done during low traffic volumes. In some locations, provision should be allowed for snow clearing around road-markings close to the cables i.e first 400 mm of median.

18.8 ITS Measures

18.8.1 ITS measures are to be considered for high operational demand areas, crash reduction and locations with variable weather conditions.

18.8.2 ITS facilities may be fixed or mobile.

18.8.3 These measures could be useful in extending the operating range of facilities running at near-capacity.

19. COMMUNICATIONS

19.1 Transit Staff & Consultants

19.1.1 For any National Office initiatives for education and enforcement, training will have to be provided for Transit Regional staff should they be required to act as a Regional contact on these matters.

19.1.2 Training may include guidelines, specific short course and/or National Office mentoring. From a practical point of view, Transit staff and Consultants could both use multi-purpose guidelines.

19.2 Education Material

19.2.1 For standardised education conditions on resource consent applications, an information pack or pamphlet could eventually be developed for circulation.

19.2.2 Similarly, some generalised pamphlet on the role of any enforcement programme may be useful for the general public, NZ Police and HCV operators. This material may not have to be prepared by Transit but Transit may wish to have some input into the content.

19.2.3 Any changes to signs and markings should be clarified through an education programme before any enforcement policy is proposed.

19.3 Protocols

19.3.1 Liaison with Land Transport NZ, Ministry of Transport and NZ Police may require specific items of information to be exchanged. Possibly protocols would be needed e.g. information to be recorded on the effectiveness of any performance indicator, contact details of key personnel.

19.4 Media Issues

19.4.1 If other agencies are implementing Transit policy, joint communications protocols are suggested so that any responses to public, media, local government or parliamentary queries are co-ordinated.

19.4.2 Another strategy is for other agencies to agree to implement Education and Enforcement measures, as their own rather than as Transit's.

19.5 Enforcement Locations

19.5.1 Enforcement of 90 km/hour speed limit for HCVs and towing vehicles on high-volume SHs is suggested at locations with passing and overtaking problems.

19.5.2 Enforcement of speed limits is suggested on low-volume SHs for all users at crash-prone locations with high incidence of overtaking, rear end and head-on crashes.

20. MONITORING

20.1 Responsibilities

20.1.1 Responsibilities are to be established for traffic data collection, cost estimation and monitoring of overseas and NZ research.

20.2 Performance Indicators

20.2.1 A review of international research has identified several performance indicators that should be evaluated as part of research into assessing passing demand. Indicators include overtaking (passing) ratio (Morrall & Werner, 1990) and follower density (South African National Roads Agency, 2004).

20.2.2 In conjunction with some before-and-after monitoring, performance indicators are to be developed for all treatments and measures, including signs and markings, turning improvements, TDM, resource planning, education and enforcement measures.

20.3 Data Collection

20.3.1 Before-and-after studies should be conducted on newly treated roads. The current metro-count collection system can be used to record platooning effects and operating speeds but may not be in the appropriate locations or the survey period may not be appropriate for assessing demand i.e. holiday weekends.

20.3.2 Out-turn costs are to be disaggregated and forwarded to a central database.

20.3.3 Protocols should be established for the formatting of surveyed and database information.

20.4 Safety Review Mechanisms and Audit Procedure

20.4.1 NZ research into lane merge behaviour shows that tapers on various PLs do not comply with the AUSTROADS standards. Therefore, safety review mechanisms should be strengthened.

20.4.2 For staged works or interim strategies, safety auditors should consider lengths upstream (0-2 km) and downstream (0-4 km) for all treatments.

20.5 Feedback

20.5.1 Systems are to be provided for feedback and dissemination of information from/to Transit Regions and across Transit Divisions.

21. KEY FINDINGS OF PART IV

21.1 Pre-Selection of Options

21.1.1 An option pre-selection section is proposed so that a hierarchy of staged treatments can be progressively applied. Projected flows are used to ensure than treatment life is maximised. Staged development has been divided into SH sections with/without available overtaking opportunities.

21.2 Planning & Funding

21.2.1 Main issues can be categorised into funding (work packages, funding), resource planning (limited access controls, environment, resource management) and engineering planning (location, terrain, configuration, safety and crash history).

21.2.2 Work package issues relate to developing Weighted Average BCR work packages for interim and long-term strategies along SH sections. Packaging of block-funded work would require an early and accurate assessment of benefits and costs. Funding may be over 5-10 years and changes to PROMAN and possibly LTNZ on-line systems would be required.

21.2.3 A semi-motorway (expressway) standard of access for crossing and intersections should be provided within LAR classifications. Additional conditions should be placed on crossing approvals to include purpose, frequency of use and review mechanism. Also, in addition to the LAR working Group recommendations, the period of demand could be considered as land use demand may conflict with SH traffic peak periods.

21.2.4 Environmental issues were identified, such as effects on landform, water (drainage and watercourses), operational and construction effects. District Plan requirements included: revised LAR system for sections of SH with projected 10,000-25,000 vpd, alteration of adjacent land use, permitted activities on adjacent land, rural residential subdivision rules with respect to alternative road networks and education for HCV drivers within Transit submissions on proposed and upgraded developments that generate large numbers of HCV trips.

21.2.5 Engineering planning issues, such as location guidelines for PLs and SVBs are proposed taking into account safety, operational performance, driver perception, construction cost. Terrain issues relate to using terrain to optimise operational efficiency and preserving existing overtaking locations with available PSD. The configuration of passing and overtaking facilities should minimise interference with the downstream effective length. Safety and crash history issues for each site including 2 km upstream and 4 km downstream should be identified and appropriate treatments used.

21.4 Design & Construction

21.4.1 Key headings can be categorised into design (PSD, passing demand, design hour, operating flows, length and spacing), and detailing (crown and super-elevation, access and intersection, lane width and tolerances, diverge, merge and transition zones, roadside treatments, centreline treatments, special user requirements).

21.4.2 PSD should consider different SH functions and traffic composition. An 85th percentile PSD may be required to cater for timid drivers and truck and trailers. Passing demand features include the criteria for available overtaking opportunities, suitability of demand models such as SARNAL and Morrall's Unified Model. Design hour issues involve a choice of averaged (AADT) versus peak flow periods or a combination of the two.

21.4.3 Flows will involve the capacity and operating limits. Length should consider optimal length formulae for deriving the length with spacings related to the downstream effective length for PLs and SVBs. Tack-on facilities should consider the effects on crown location and superelevation.

21.4.4 The passing facility should take into account the location of low-volume driveways, high-volume driveways and road intersections and provision for turning. Lane width and tolerances includes the effect on over-dimensioned loads.

21.4.5 Diverge, merge and transition zones will have different taper and transition length requirements, which optimise operating efficiency. Centreline treatments relate to yellow lines, gap separation of opposing flows and central median cables. Roadside treatments involve clear zoning, edge markings, shoulder widening, median cables and BCR values. Special user requirements may be required for: pedestrians, cyclists, farm equipment and motorcyclists, depending on LAR classification.

21.5 Operations & Maintenance

21.1.1 Key issues relate to operations (signs & markings, emergency services, lane closure, upgrades over-dimension vehicles, ITS) and maintenance (testing, scheduled maintenance, maintenance standards).

21.1.2 Signs and markings issues involve the amount of no-overtaking lines along a road section, intersection layouts plus slow lane versus fast lane having dominance. Emergency services require additional access points, such as at transitions. Lane closure applies to temporary and permanent closure. Facility upgrades include standards revisions, reporting procedures to Regional Transportation Planner and a higher level of treatment. Over-dimensioned vehicles may require procedures for over-width licences and if they block the lane. ITS issues relate to high demand areas, crash reduction, weather conditions, fixed or mobile equipment and extension of service life for passing facilities.

21.1.3 Testing of central median cables would be required for cables, cable ends and ramping effects for on-coming traffic. Scheduled maintenance would need to minimise delays for bridge inspections and routine maintenance. Maintenance standards relate to inspections, washing of delineators and weather-related activities i.e. snow clearance from wide profile markings, central median cables.

21.6 Communications

21.6.1 These issues centre around liaison (Transit staff and consultants, media issues) and information (education packs, enforcement locations, protocols). Transit staff and consultants would have training requirements, if they act as primary contacts. Media issues could involve either joint or single communication policies.

21.6.2 Education material could be multi-purpose or specific. Appropriate locations for enforcement will have to be identified and relayed to NZ Police. Protocols should be established with external agencies and within Transit for liaison and information presentation.

21.7 Monitoring

21.7.1 Monitoring issues are formal (Divisional responsibilities, performance indicators, safety audit, cost estimation) and informal monitoring processes (feedback). Responsibilities would be established for traffic data and costs collection, processing and storage, monitoring and dissemination of overseas research literature. Performance indicators could cover flows, operational efficiency, safety and costs for passing facilities and other measures.

21.7.2 Data collection would require guidelines for formatting and initial processing. Safety review and audit procedures could involve the review of existing passing facilities as well as a revised road section length for auditing purposes (i.e. up to 2 km upstream and up to 4 km downstream). Feedback issues would involve to/from Regions and across Divisions.

PART V. STRATEGIC & POLICY IMPLICATIONS

22. ENVIRONMENTAL ANALYSIS

22.1 External Analysis

22.1.1 Key issues have been identified within the international literature review and NZ research. The analysis identified strengths (S), weaknesses (W), opportunities (O) and threats (T). Where appropriate, actions have been suggested in italics.

22.1.2 Passing Sight Distance – An international comparison showed that AUSTROADS passing sight distances were best (S). Transit follows AUSTROADS guidelines (S). However, HCVs are travelling at about the same speed as cars, making it difficult to pass HCVs especially on flat terrain with high likelihood of opposing traffic (W). *With Land Transport NZ, Transit should consider researching the effects of in-vehicle speed controls for HCVs versus education and enforcement.*

22.1.3 Signs & Markings – NZ centreline markings are similar to AUSTROADS but do not mark horizontal restrictions (T). Restrictive markings policies overseas require more passing facilities (W). NZ research showed that there would be a nett safety benefit from marking horizontal restrictions (O) but there would also be increased delays and frustration (T). NZ research suggested, at this stage, marking of isolated horizontal curves only (O). *Transit could consider centreline markings policy for crash prone locations.* Also European signs and markings may help merging (O). *Research into European markings is suggested.*

22.1.4 Passing Demand – Transit's current network monitoring does not measure passing demand (W). Some preliminary NZ research into passing demand has already been done (S). NZ PEM procedures use set length of no-overtaking distance to assess passing demand (W). Canadian and South African passing demand models have been developed (O). *Research into these Passing Demand models and into assessment methods for passing demand is suggested.*

22.1.5 Safety – Significant NZ research on PLs, SVBs and PL driver behaviour (S) but identified an increase in downstream loss of control crashes and many PLs did not meet AUSTROADS taper standards (W). *Safety audit/review procedures need to be strengthened.* Overseas cables sometimes used on roadside instead of relying on batter slope (O). *Further research into downstream roadside treatments is suggested.* Overseas use of gap separation and central median cables showed good crash severity benefits (O). Improved centreline treatments could be used on future 2+1 lane treatments in NZ (O). *Research into use of both gap separation and central median cables is suggested.*

22.1.6 Modelling – Many SH sections have TRARR models (S) but TRARR will not be upgraded in the future (T). NZ research has identified PARAMICS and TWOPAS (operational efficiency programs) as likely options, to be used in conjunction with IHSM (safety program) (O). Transit's high-speed data capture of road geometrics has improved and may help program accuracy (O). *Monitoring of modelling developments is suggested.*

22.1.7 Low-Volume Treatments – Little research into low-volume analysis overseas (W). Currently, low-volume analysis research by TRB in USA has no budget (W). NZ research identified the Borel-Tanner Distribution as suitable for analysis and could be used for simplified PEM procedures (O). *NZ research into low-volume analysis methods is suggested.*

22.1.8 Moderate-Volume Treatments - NZ does not have an extensive 11-14 m wide carriageway to apply 2+1 lanes (W). 2+1 lane roads are suited to a specific range of conditions (T) In Waikato, NZ, a newly realigned and an upgraded 2+1 lane has been recently built and should be monitored for costs, benefits and traffic performance (O). *Research into moderate-volume analysis methods plus monitoring and feedback from Waikato Region is suggested.*

22.1.9 Guidelines & Warrants – Overseas guidelines and warrants have to be adapted to NZ conditions (W). However, some guidelines would be useful to identify issues (O). Also experience with intermediate treatments, such as 2+1 lanes, has lead to revised geometrics (O). *Monitor overseas developments and adapt to NZ guidelines.*

22.1.10 Implementation – Transit Policy has a long-term goal of one passing or overtaking opportunity every 5 km (S), which does not necessarily reflect current passing demand (W). SH sections are prioritised by AADT not passing demand (W). *Development of interim and long-term strategies as Weighted Average BCR work packages are suggested.* PROMAN and LTNZ on-line are set up for individual projects (W). *Changes to these two systems are required.* Various Divisions undertake different project phases and so there is potential for different Divisional objectives (W). *Clarification and agreement on strategy objectives and Divisional roles is suggested.*

22.1.11 Monitoring - Lack of traffic performance monitoring by Transit (W). Transit's traffic data collection system is able to record traffic performance indicators (S) but locations/time periods may not suit monitoring upper limit or peak conditions (T). *In conjunction with assessing Passing Demand models, further investigation into adapting MetroCount equipment is suggested.*

22.2 Internal Analysis

22.2.1 Similar to the external analysis, key issues have been identified within Transit's policies and procedures. Where appropriate, actions have been suggested.

22.2.2 Beca Report – Transit commissioned research on developing simplified procedures for individual PLs and PLs in series to reduce reliance on TRARR (S). Possible areas for improvement are: passing opportunities based on fixed length of PSD (PLs apply to road sections with >35% of 450 m PSD), not effective for all terrains, construction costs vary over time and difficulty progressing some PL projects on Beca's implementation plans. (W). BCR graphs can be adjusted to allow for changes in construction costs and may help with some projects on Beca implementation plans (O). *Further research into altering PEM simplified procedures is suggested.*

22.2.3 PEM – BCR graphs for PLs in series (S). Possible areas for improvement are: now three methods giving different answers, results do not include driver sensitive indicators, such as bunching, does not take into account existing facilities and low-volume treatments not included i.e. SVBs and short PLs (W). Also, BCR graphs do not allow for 600-800 m PL lengths and flows above 10,000 vpd. *Further research into altering PEM simplified procedures is suggested.*

22.2.4 Access Controls – Current LAR is not effective in some locations (T). A working group has prepared draft changes to the current LAR system but the report has not gone to GMT or the Transit Board (O). Other resource planning measures, including addition of a semi-motorway (expressway) classification, were also identified in Part III Options Identification & Assessment (O). LAR data storage is not standardised between Regions (W). *Reactivate LAR working group to consider suggested additions to crossing approvals, incorporation of other measures and any* *changes to LAR database system. Consider incorporating LARs into Corridor Management Plans (CMPs).*

22.2.5 Cost Estimation Review – Scope of review includes block-funded projects, such as PLs (O). *A cost and benefits data base for passing and overtaking works is suggested.*

22.2.6 PL Policy – General focus on PLs and some SVBs (W). SH sections prioritised by AADT not passing demand (W). SH 1 and some strategic networks are given preference (W). *Change PL Strategy title and policy wording to reflect other proposed measures. Review SH sections. Review SH 1 and strategic network priority.*

22.2.7 Prioritisation - Prioritisation by AADT and crash severity (S) but also by strategic network and does not include passing demand (W). The strategic network factor may not be the best allocation of funds (W). *Prioritisation by Network should be reviewed, as part of revised PL Policy and developing interim and long-term strategies. Consider suitability of passing demand models and applicability to network and individual sites.*

22.2.8 Construction Costs – Cost variations were mainly due to extra Transit work and isolated costly items (W) rather than terrain (S). *Separation of costs and location guidelines are suggested.*

22.2.9 Funding Level – Approx $310 M required over 30 years (T). Increase in SHs requiring four-laning over next 10-25 years (T). 2+1 lane treatment may provide cost savings on proposed four-lane projects (O). Some other Transit work may have benefits for passing and overtaking, such as safety works, realignments and pavement rehabilitations (O). *A SH Forecast project review is suggested.*

22.2.10 PROMAN – Transit system and LTNZ-on line does not cater for Weighted Average BCRs (W). *PROMAN and possibly LTNZ on-line to be changed to accommodate work packages and to identify additional project features.*

22.2.11 SH Forecast – Difference in Regional allocation due to prioritisation (S) but includes Strategic Factor (W). *Review preference for SH 1 and strategic networks.* Also some Regions may be affected by PEM procedures for assessing overtaking opportunities by 450 m PSD, which does not favour PLs on flat terrain. *Consider using other Transit work plus overtaking and supporting treatments/measures.*

22.2.12 Safety Audit – Refer Safety Section 23.1.5. *Safety audit function needs to be strengthened. Review mechanism for existing facilities.*

23. POLICY CONTEXT

23.1 Key Elements

23.1.1 Key elements of any proposed policy should be:

- At low flows, minimise need for passing facilities by retaining and enhancing overtaking opportunities.
- Improved design and better use of passing facilities.
- Provide an intermediate step between two-lane and four-lane state highways.

- Apply supporting treatments and measures in conjunction with or as an alternative to passing and overtaking treatments.

23.2 Transit's Role

23.2.1 Main functions that Transit is expected to perform:

- Supply management for passing, overtaking, centreline, edgeline/roadside and intersection treatments.
- Demand management for resource planning & TDM.
- Collaboration with external agencies for education, enforcement, resource planning, research.

23.3 NZLTS Issues & Transit Goals

23.3.1 Common Transit goals and NZ Land Transport Strategy (NZLTS) principles and objectives are discussed below.

23.3.2 *Integration* – integrated in terms of activities from planning through to education, which are also Transit's key result areas. Monitoring is not a key result area but is also co-ordinated. Integrated in terms of having a wide range of use of land use planning, supply management and TDM techniques. Not fully integrated in the sense that it does not cater for all modes. However, this strategy allows for better connections between population centres and transport hubs for HCVs, buses and cars. Special user requirements are considered for pedestrians, cyclists, farm equipment and motorcyclists.

23.3.3 *Safety* – balances safety against operational efficiency objectives. Safety benefits identified in BCR analysis. Safety Audit issues to be included in proposed guidelines. Reduction in National road toll by using the number of people that incur fatal and serious injuries/5 years as part of prioritisation.

23.3.4 *Access and Mobility*–maintains accessibility of SH network for freight and cars at potential problem locations. Guidelines provide for special user requirements such as pedestrian and cyclists and farm equipment.

23.3.5 *Economic Development* – recognises that traffic growth is a part of economic growth and has staged the provision of treatments to meet increased traffic demand. Allows for both freight movements and personal/business travel. Interim and long–term work packages to reflect growth in demand.

23.3.6 *Environmental & Social* - recognises that both land and transportation use can affect the other i.e. access controls, alternative networks and designations. Environmental issues to be included within proposed guidelines. Proposes intermediate passing facilities with high safety and operational advantages for typically moderate-volume peri-urban locations, usually associated with commuter routes.

23.3.7 *Public Health* – Reduction in frustration effects, such as stress.

23.4 Additional NZLTS Issues

23.4.1 In addition to Transit goals, New Zealand Land Transport Strategy (NZLTS) principles and objectives include:

23.4.2 *Sustainability* - defers the need for SH four-lane sections thereby reducing the demand for physical resources. Appropriate use of overtaking and supporting measures rather than passing facilities. Performance indicators and monitoring is provided to ensure the most effective use of resources.

23.4.3 *Responsiveness* – reduces travel time and time spent following on the SH network. Performance indicators are to be driver sensitive.

24. POLICY PRINCIPLES

24.1 Performance-Based

24.1.1 Any proposed NZ guidelines should balance operational efficiency against safety, particularly crash severity and would require the selection of appropriate performance indicators.

24.1.2 Operating efficiency indicators, such as Level of Service (LOS), have their limitations, as they are not sensitive to variations in flow. Both overseas and NZ research suggest that a measure of percentage bunching or percentage overtaking rate would be more appropriate.

24.1.3 As part of an overall range of performance measures, some measures could include: capacity, passing efficiency, cost, operating range, total crashes, crash severity and BCR. A review of Kansas guidelines provided a useful evaluation of traffic performance indicators (Mutabazi et al., 1999).

24.1.4 It should be relatively easy to collect PTSF and 85th percentile speed. Transit's Traffic monitoring system (TMS) can capture this information. However, these parameter values are not required for presentation under Transit's current format. Also current count stations may not be at the most appropriate location for assessing traffic performance or counts may be during typical periods rather than identifying high demand conditions, such as holiday weekends.

24.1.5 Any performance indicators are to be the same or compatible with computer simulated data and also in common use overseas, so that overseas experience can be easily compared. Performance indicators would have to be easily reproducible both before and after installation of facilities.

24.1.6 For initial assessment, traffic performance indicators must be easily surveyed and collected. Possibly, other performance indicators, such as overtaking rate or follower density may be required for more detailed use.

24.2 Integrated & Co-ordinated Approach

24.2.1 A co-ordinated approach through an inter-Divisional working group would be the most effective way to ensure that guidelines were comprehensive and would help with acceptance and overall implementation of the guidelines.

24.2.2 Transportation Planning and Corporate Services could look after Planning and some Funding issues. Corporate Services could look after some Funding issues. Capital Projects could look after Cost Estimates, Construction and some Design issues. Network Operations could be responsible for some Operations, Maintenance and some Design issues Corporate Strategy could look after Communications issues relating mainly to education and enforcement.

24.2.3 Any guidelines have to be flexible enough to allow for a variety of approaches within each treatment option. For moderate volumes, best results for crash reduction are achieved with good geometrics, access controls and centreline treatments.

24.2.4 Therefore, different approaches from different disciplines may achieve the same result but best results would be achieved by a co-ordinated approach, bearing in mind that in some situations not all measures can be applied.

24.3 Staged Development

24.3.1 For roads with low and moderate flows, options have to allow provision for growth. Where possible, the incremental addition or extension of facilities is desirable. For example, SVBs could be extended to short PLs and PLs in series could be infilled to form 2+1 lanes. New German guidelines have applied this modular approach to road cross-section widths.

24.3.2 However, the ability of 2+1 lanes and PLs in series to transition between two and three lanes means that larger savings can be made by deferring work on bridge widening and interchanges. Programming of moderate-volume treatments does not rely on co-ordination with these larger cost items, therefore all facilities can maximise their service life.

24.4 Appropriate for Conditions

24.4.1 There are many useful references that Transit can use to develop its overall guidelines principles but generally NZ pavement and traffic conditions have differences from overseas agencies and an understanding of the circumstances behind each guideline is required. Therefore, direct transfer of guidelines is not suggested.

24.4.2 Generally, North American guidelines are more conservative on warrants for passing lanes plus for some US and Canadian agencies their terrain may be flatter and less varied than NZ. The review of Kansas guidelines, would act as a useful reference but at the time of writing that review, the guidelines had only been in place a short time. Therefore, it was difficult to relate theory to practice. Alberta has extensive guidelines that cover both design and operations but British Columbia guidelines on PL length seem less conservative and possibly more applicable to NZ's terrain.

24.4.3 Scandinavian and European guidelines are less conservative and allow higher capacity and operating flows. Initial 2+1 dimensions seem to have been constrained to fit existing pavements, generally dimensions were 0.5-1.0 m wider for newly constructed facilities. The most value is in references that have evaluated previous guidelines, such as passing sight distance, cross-sections and 2+1 performance. Therefore, older guidelines that have been amended are favoured but some newer guidelines are more thorough in identifying issues.

25. SYSTEM CHANGES

25.1 Policy & Procedural Changes

25.1.1 Strategic and supporting activities are to be aligned with Transit's policies, procedures and works programme. Changes include:

- New guidelines to be developed that co-ordinate planning, funding, design, construction operation, maintenance, communication and monitoring aspects of a project over all Transit Divisions.
- Review of current SH Forecast projects to identify current four-lane projects suitable for changing to 2+1 lanes and current PL projects that should be changed to 2+1 lanes based on projected flows. Other Transit works that could benefit passing and overtaking to be identified and linked to the passing and overtaking strategy for that SH section.
- Individual projects within SH Forecast to be grouped into 10 year interim Weighted Averaged BCR packages. 25 year long-term strategies are to be identified but not included within the SH Forecast.
- As part of interim strategies, review the Strategic Network prioritisation within Transit's current PL policy. Also SH sections within Transit's PL Policy may have to be altered to reflect passing demand.
- In conjunction with interim strategies, changes to PROMAN and possibly LTNZ on- line systems would cater for work packages and to link different activities to common locations and road sections.
- In conjunction with Cost Estimation Review, centralised database of PL and SVB costs and benefits.
- Revise the current LAR classification system and standardisation of LAR approvals database to allow for any changes.
- Adapt Transit's traffic monitoring system to record traffic performance indicators at appropriate locations and time periods.
- Safety audit and review procedures should be strengthened to allow for existing and new PLs and for overtaking treatments.

25.2 Feedback Systems

25.2.1 Management initiatives are to be provided that promote feedback and collate information:

- Contact personnel for key activities, particularly costs and benefits database, monitoring of overseas developments and monitoring of performance indicators.
- Information to/from Transit Regions and Network Consultants.
- Liaise and collaboration with external agencies i.e. Land Transport NZ, Ministry of Transport, NZ Police, overseas state highway agencies.

26. KEY FINDINGS OF PART V

26.1 Strategic Analysis

26.1.1 A SWOT (strengths, weaknesses, opportunities and threats) analysis was undertaken of the external and internal environments. Key areas of influence have been identified and are described below.

26.1.2 Key external influences were: passing sight distance, signs & markings, passing demand, safety, computer modelling, low-volume treatments, moderate-volume treatments, guidelines & warrants, implementation and monitoring.

26.1.3 Key internal influences were: Beca report, Project Evaluation Manual (PEM), access control, cost estimation review, current Passing Lane Policy, prioritisation, construction costs, funding level, PROMAN, SH Forecast and safety audit/review.

26.1.4 Further research has been identified for key external influences and is discussed under Section 27 Further Research. A number of actions/system changes are suggested for key internal influences and are discussed individually under Section 27.11 Conclusions.

26.2 Context

26.2.1 Key elements of any new Policy should be:

- At low flows, minimise need for passing facilities by retaining and enhancing overtaking opportunities.
- Improved design and better use of passing facilities.
- Provide an intermediate step between two-lane and four-lane state highways.
- Apply supporting treatments and measures in conjunction with or as an alternative to passing and overtaking treatments.

26.2.2 Transit's role involves both supply and demand management, as well as collaborating with other agencies. The Policy compares favourably against the NZLTS principles and objectives and Transit NZ goals. Particular strengths are: integration of a wide range of infrastructure and non-infrastructure solutions, economic development, improved road safety, access and mobility for freight.

26.3 Principles

26.3.1 Suggested Policy principles include: performance-based, integration & co-ordination, stage development and appropriate for use. Other principles may be added in the future.

26.3.2 Performance-based - Any assessment of performance has to include both operational efficiency and road safety. The selection of performance indicators should consider parameters that are easily understood by the general public e.g. reduction in following queue size.

26.3.3 Integration & Co-ordination - A wide range of treatments and measures will be applied. This wide range will require a co-ordinated approach. Where, possible passing and overtaking projects are to be independent of larger projects, as this would enable more flexibility with development.

26.3.4 Staged Development - Incremental development of the two-lane network should match traffic growth. Treatment options are to allow for progressive extension of existing facilities and/or incremental additions that infill between existing infrastructure.

26.3.5 Appropriate for use - Overseas research helps to provide an insight into future development options. However, overseas applications may have to be modified to suit NZ road and traffic conditions. Also, separate NZ-based research would be advisable to confirm overseas.

26.4 **Systems**

26.4.1 To enable better implementation, changes to current policy and procedures include:

- New guidelines that co-ordinate Transit key tasks.
- Review of SH Forecast projects.
- Staged development as interim (10 year) and long-term 925-30) year strategies.
- Review strategic network prioritisation within current prioritisation system.
- PROMAN and if possible LTNZ online adapted so that handling weighted average BCR packages is easier.
- Centralised database for benefits and costs.
- LAR classification system to allow for semi-motorway (expressway) level of access.
- LAR database to be standardised across Transit Regions.
- The traffic monitoring system should be adapted to record network demand.
- As well as new facilities, safety audit/review procedures should be altered to allow for evaluating existing facilities.
- Identified key contact personnel and improved feedback systems with Transit Regions and external agencies.

PART VI. CONCLUSIONS & RECOMMENDATIONS

27. CONCLUSIONS

27.1 Current Passing Lane Policy

27.1.1 Policy title and wording should be changed to accommodate the change in emphasis to a passing and overtaking strategy with supporting measures.

27.1.2 As part of any interim and/or long-term strategies, road sections and priorities generally by AADT within the current Transit PL policy may have to be revised to accommodate both terrain and AADT, using passing demand or similar, as a performance indicator.

27.1.3 As part of any interim and/or long-term strategies, the Strategic Network factor should be reviewed so that work packages can be prioritised.

27.2 State Highway Forecast Review

27.2.1 To more accurately assess level of funding, a review of Transit's SH Forecast projects is suggested.

27.2.2 Some four-lane projects have an estimated total cost of $1,800 M. Assuming that a $200M project with structures is suitable for 2+1 lanes, about $140 M could be saved by using 2+1 treatments, which cost less and defer costs on bridge widening and grade-separated interchanges.

27.2.3 A 2+1 lane road would generally be suitable for peri-urban or rural areas where i) AADTs are 10,000-20,000 vpd with one-way flows less than 1,200-1,400 vph, ii) crash severity is a problem and iii) flows on local roads and access driveways can be easily controlled by a semi-motorway (expressway) standard of access through LARs and/or minor intersection works, iv) existing high-cost structures, such as bridges have a long service life and v) route not identified for tolling.

27.2.4 Over the next 10-25 years, some SH sections, not currently scheduled for four-laning may have projected AADTs of 10,000-20,000 vpd. Transit may be able to achieve additional savings, by planning 2+1 lanes for those locations.

27.2.5 Currently, where possible, Transit co-ordinates other work, such as area wide pavement treatments and safety works, to occur in conjunction with some PL projects. A review would identify other Transit work that would occur at the same location. If appropriate, projects would be co-ordinated to occur at the same time.

27.2.6 Different Transit Divisions may have planned different activities along a SH section and some of these projects could assist passing, overtaking or supporting measures, for example safety works, seal-widening, realignments, pavement rehabilitations and intersection upgrades.

27.3 Interim & Long-Term Strategies

27.3.1 Following on from Project Review, Weighted Averaged BCR packages of passing and overtaking treatments should be identified for the next 10 years. Long-term packages would also be identified but not included within the Weighted Averaged BCR Packages.

27.3.2 Section evaluation should also consider other supporting measures, timing issues for LAR controls, planned intersection upgrades and the remaining service life of higher cost structures, such as bridges.

27.3.3 Where appropriate, Transit should consider incorporating these interim and possibly long-term strategies into Transit's Corridor Management Plans.

27.4 Guidelines

27.4.1 An inter-divisional working group of about say 5-6 representatives, with terms of reference and sunset clause, would be used to initially establish guidelines, interim and long-term strategies, research requirements and to identify other scheduled Transit works.

27.4.2 Guidelines are suggested to cover all aspects of project development, namely planning, funding, design, construction, operations and maintenance, communications and monitoring. A section for pre-selection of options is suggested.

27.4.3 A set of underlying principles is required namely, performance-based, staged development, co-ordinated approach and appropriate for NZ conditions.

27.4.4 Some guidelines issues have already been identified in Part IV. However, more issues may arise through further consultation with other Divisions and the establishment of an inter-Divisional working group.

27.5 LAR Classification

27.5.1 A revised LAR classification system is suggested to reflect a graduated level of access control and would build on previous work undertaken by Transit in this area. Suggested recommendations are provided within the Draft LAR Working Group Report.

27.5.2 However, it is suggested that any recommendations are provided via a reactivated LAR working group. Given that functions and the structure of Transit may have changed since developing the Draft Report, the composition of the Working Group may now be different.

27.5.3 Best results for operational efficiency and safety on 2+1 lane roads were achieved when semi-motorway (expressway) access controls on local roads and access driveways were used in conjunction with good road geometrics and centreline treatments such as central median cables and gap separation of flows.

27.5.4 The Working Group may wish to take other resource planning measures into account, when applying LAR measures. For alternative tolled routes, designation measures also have to be considered. Alternative roading networks could be more effective for locations with a high proportion of local traffic.

27.5.5 In some cases, a combination of resource planning measures could be applied to optimise/protect future development options for a section of SH. With any LAR, if other resource planning measures were also in place then the combination of those measures could allow for some flexibility in how LAR measures were applied.

27.5.6 Submissions on District Plans and Regional Land Transport Strategies may be another way to strengthen local roading networks and influence land use adjoining SH sections.

27.5.7 In conjunction with any revised LAR, the LAR database is in the process of being standardised and new items, such as additional approval conditions may have to be added.

27.6 PROMAN Changes

27.6.1 Current Transit and Land Transport funding systems are set up for individual projects rather than packages of projects. Alterations will be required to Transit's and possibly Land Transport NZ's computer systems to accommodate packages and to identify features within Weighted Average BCR packages for easier analysis:

- Road section.
- Terrain.
- Project length excluding tapers.
- Individual types of options i.e. SVBs, PLs, shoulder widening, etc.
- Individual Weighted Average BCR packages along a SH section. There may be more than one work package for a SH section.
- Number of individual PLs and SVBs within each package rather by project. Some projects have short four-lane sections or cover a number of sites.
- Packages linked to extra Transit works that will occur at the same time and location but are not part of the Weighted Averaged BCR package.
- Packages to be linked to other Transit work occurring within the SH section that would help passing and overtaking but does not occur at any PL locations e.g. roadside/edgeline treatments.
- Packages to be linked to individual passing and overtaking treatments within other Transit work, such as realignments, pavement rehabilitations that are not included within the Weighted BCR package but would be applied to a SH section.
- Ability to progressively drop off projects as they are completed but to retain other later projects.

27.7 Cost Estimation Review

27.7.1 As part of Transit's Cost Estimation Review, centralised collection of costs and benefits for all passing and overtaking block projects is suggested. To secure funding for these Weighted Averaged BCR packages, accurate estimates for both costs and benefits are required early within the development process, so that packages do not have to be unbundled or work stopped at a later date.

27.7.2 Traffic benefits will require easily surveyed performance indicators that are driver sensitive and can be easily related to PEM procedures that are terrain based.

27.8 Traffic Monitoring

27.8.1 Subject to any evaluation of Passing Demand Models, such as SANRAL and Unified models. Transit's traffic monitoring system could be used to collect traffic performance data. Under Transit's current requirements, the data is collected but not processed into a useful form.

27.8.2 However, there are still some issues relating to survey location and period that would need to be resolved. Currently, the system is set up to record average effects rather than peak or limit effects.

27.9 Safety Audit & Review

27.9.1 NZ research showed some PL merge tapers did not comply with AUSTROADS guidelines. In some cases, the width of sealed shoulder was below Transit's minimum width of 1.5 m. A review of existing facilities may provide low-cost improvements for safety and operational efficiency. Safety Auditing of proposed facilities and safety review of existing facilities should include up to 2 km upstream and up to 4 km downstream of facilities.

27.10 Feedback Systems

27.10.1 Consultation and liaison with appropriate Transit National Office, Transit Regional, and Transport NZ, NZ Police and Ministry of Transport staff is needed so that information can be collected and disseminated to appropriate contacts. Also education and enforcement issues have to co-ordinated.

27.10.2 Delegated responsibilities to specific Transit staff would ensure on-going monitoring of traffic indicators, cost estimation and overseas guidelines development, primary contacts for external agencies.

27.10.3 In conjunction with consultation and delegated duties, a network of contacts should be established so that design and performance information is disseminated among Transit Regions and if appropriate amongst Transit's Network Consultants.

27.10.4 In conjunction with establishing guidelines, if appropriate, liaison and collaboration with overseas SH agencies would be beneficial in terms of information and experience on design and operational issues. If appropriate, for SH agencies with similar network issues, such as width, research might be co-ordinated or jointly undertaken then adapted to NZ conditions.

27.11 Further Research

27.11.1 PEM procedures should be altered to reflect cost differences between current PEM cost estimates and Transit's current total costs. Any alteration should be flexible enough to allow for further increases as more difficult sites are developed.

27.11.2 Methods for assessing overtaking opportunities should be revised within the current PEM procedures. Higher HCV and traffic volumes have increased the likelihood of following traffic and opposing traffic on NZ roads.

27.11.3 A simplified PEM procedure for low-volume treatments is required. One of the deficiencies of low-cost treatments is the lack of research into analysis methods. American agency TRB is trying to develop a research project on analysis methods for low-volume treatments. Progress should be monitored. Previous NZ research has suggested using the Borel-Tanner distribution as a simplified method for evaluating SVB passing demand. This method should be investigated further. If appropriate, current PL procedures should be extended to cover short PLs, if BCRs cannot be altered to include 600-800 m PL lengths.

27.11.4 More research of taper design and merge efficiencies could increase the range of locations where 2+1 and PL in series could be applied. Both 2+1 lanes and PLs in series are constrained by capacity of one-way flows at merge tapers. Overseas experience suggests one-way flows can be 1,200-1,900 vph with varying results.

27.11.5 European lane markings that make the slow lane at the merge and directional arrows near the merge and direct vehicles that have passed, back into the dominant lane are initiatives that could build on recent NZ research into driver behaviour on passing lanes. TDM measures should also be investigated to assist with merging behaviour. Current NZ research into merging behaviour should also be monitored.

27.11.6 Continued research into computer modelling is suggested. Better computer models are needed to assess benefits in a combined manner rather than separately. As there will be no more upgrading of TRARR, other models will need to keep up with improvements in computer-simulation.

27.11.7 These models will also have to easily convert current TRARR models of various SH sections within NZ. Developments with high-speed data capture of road geometrics may mean that models can be more accurately calibrated.

27.11.8 In conjunction with evaluating simple mathematical models for assessing demand, such as the Unified Traffic model and SANRAL model, appropriate monitoring system with appropriate performance indicators should be investigated. If possible, MetroCount equipment or similar should be adapted.

27.11.9 Transit should liaise with Land Transport NZ, Ministry of Transport and NZ Police regarding the effect of using in-vehicle speed controls in HCVs on safety and operational efficiency. Any effectiveness measures should be compared against suggested targeted education and enforcement at problem locations.

28. RECOMMENDATIONS

28.1 It is recommended that the following items be adopted:

Passing Lane Policy

i) Current title of Passing Lane policy to be changed to Passing and Overtaking Policy to reflect the use of passing, overtaking and supporting treatments and measures.

ii) Within Transit's current Passing Lane Policy, review wording to reflect that SH sections and their priorities should allow for a wider range of treatment and measures and if appropriate report to Transit Board with any suggested policy changes.

Guidelines

iii) Transit guidelines to be developed for passing, overtaking and supporting treatments and measures.

iv) For preparation of Transit guidelines, an inter-Divisional working group with terms of reference and sunset clause to be established.

SH Forecast Review

v) Review of projects in current SH forecast to identify i) more appropriate treatments for some projects and ii) other Transit activities that would help passing, overtaking and other supporting treatments/measures.

Interim & Long Term Strategies

vi) Develop interim and long-term strategies for individual State Highway sections together with Weighted Average Benefit Cost Ratio packages of projects and if appropriate, suggest a revised funding level for the Transit Board to consider.

vii) If appropriate, consider inclusion of interim and long-term strategies within an existing Transit's Corridor Management Plans for SH sections and if appropriate within any Regional Land Transport Strategy and/or District Plan.

PROMAN

viii) In consultation with Land Transport NZ, both Transit's and Land Transport NZ's financial and project management systems are to be altered to allow for Weighted Average Benefit Cost Ratio packages and easier identification of some project features.

LAR Classifications

ix) Work to continue on a revised Limited Access Road classification system including possible semi-motorway (expressway) standard and additional conditions for crossing approvals. Report separately to the Transit Board, if there are any policy changes.

x) In conjunction with any revised Limited Access Road classification, the Limited Access Road database is in the process of being standardised and new items and/or fields of information may have to be added.

xi) In conjunction with any revised Limited Access Road classification, consider the use of other resource planning measures, such as alternative roading networks, designations and changes to District Plans and Regional Land Transport Strategies.

Cost Estimation Review

xii) In conjunction with Transit's Cost Estimate Review, a costs and benefits database of passing and overtaking treatments is to be established and maintained.

Traffic Monitoring

xiii) In conjunction with assessing passing demand models and determining appropriate performance indicators, investigate the suitability of Transit's traffic monitoring system as a traffic performance monitoring system and adapt the system, if appropriate.

Safety Audit & Review

xiv) Development of safety review mechanisms for existing passing and overtaking treatments.

xv) Safety audit/review of proposed/existing passing and overtaking treatments and any relevant supporting treatments to include up to 2 km upstream and 4 km downstream of the treatment.

Feedback Systems

xvi) Consultation and liaison with appropriate staff from Transit National Office, Transit Regions, Land Transport NZ, NZ Police and Ministry of Transport with primary contacts within Transit for external agencies.

xvii) If appropriate, liaison and collaboration with overseas state highway agencies with similar network issues, particularly carriageway width.

xviii) Delegated responsibilities for:

- Monitoring and reporting of performance indicators.
- Establishment and maintenance of costs and benefits database for passing, overtaking and supporting individual options.
- Monitoring and review of NZ and overseas research and developments.
- Collection and dissemination of information on passing, overtaking and supporting individual options from/to Transit Regions and Network Consultants
- Any other key responsibility that is identified.

Further Research

xix) Improvements to current Economic Evaluation Manual procedures, including:

- Clear description of items covered by estimated construction costs.
- Alteration of BCR graphs to allow for 600-800 m PL lengths and to cover AADTs above 10,000 vpd without constraining one–way flows.
- Reassessment of current PSD criteria for overtaking opportunities.
- Expand simplified procedures for low-volume passing and overtaking treatments.
- Develop simplified procedures for intermediate treatments on SH sections with projected AADTs between 10,000-20,000 vpd.

xx) Improved taper design and merge behaviour.

xxi) Modelling of combined operational and safety effects.

xxii) Assessment of simple passing demand models for the SH network.

xxiii) Influence of in-vehicle speed controls for HCVs on passing opportunities, operational efficiency and safety with comparison against education and enforcement measures.

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