GHD CLIENTS | PEOPLE | PERFORMANCE

Richard Paling Consulting

Getting More from Our Roads: Evaluation of Managed Lanes on Arterial Roads

Tim Brown (GHD) and Richard Paling (Richard Paling Consulting)

Introduction

- NZTA (LTNZ) Research Project
- NZTA Managed Lanes Project
- Two part presentation:
  - Issues and effects
  - Simple modelling techniques

Research objectives

- Review local and international experience
- Examine behavioural response
- Understand measures of effectiveness
- Develop simple modelling tools for evaluating managed lanes

Managed lanes

- Pressure to make better use of road space
- Managed lane = special vehicle lane (New Zealand context)
- Allocate road space to different user classes
- Typically bus lanes or HOV lanes on arterials (no freight)
- Can be add-a-lane or convert-a-lane (much better acceptance for add-a-lane projects)

Issues

- Can be many “losers” with projects reallocating **existing** capacity
- Differential speed in lanes reduces effective capacity
- Scheme prioritisation
- Political pressure
- Lack of real world reporting of previous experience but even this is mainly on freeways
- Ineffective evaluation tools

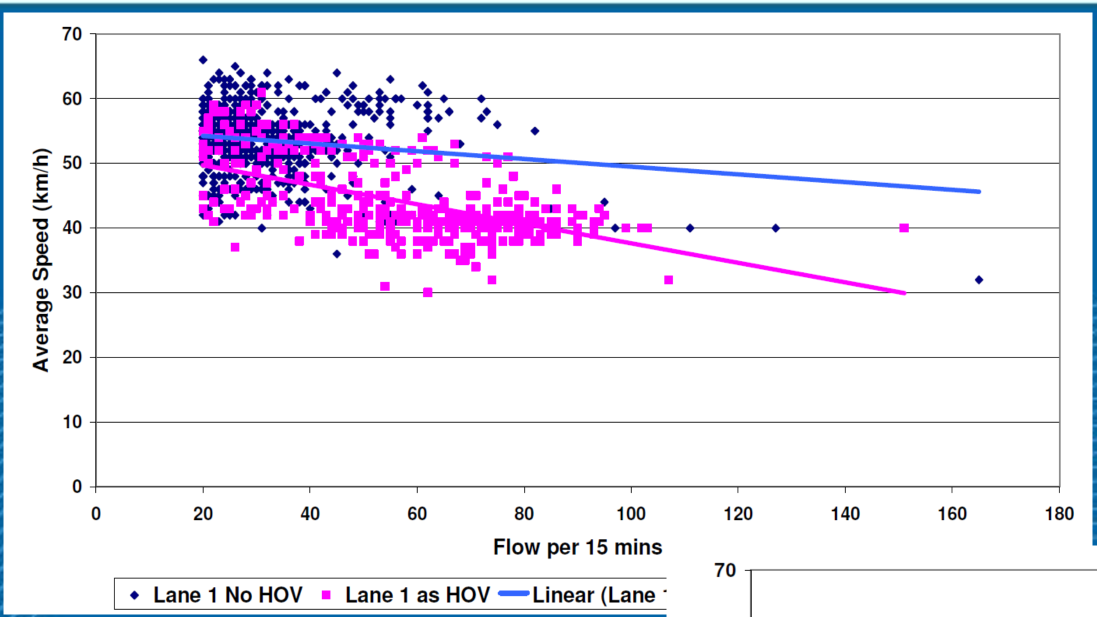
Impacts

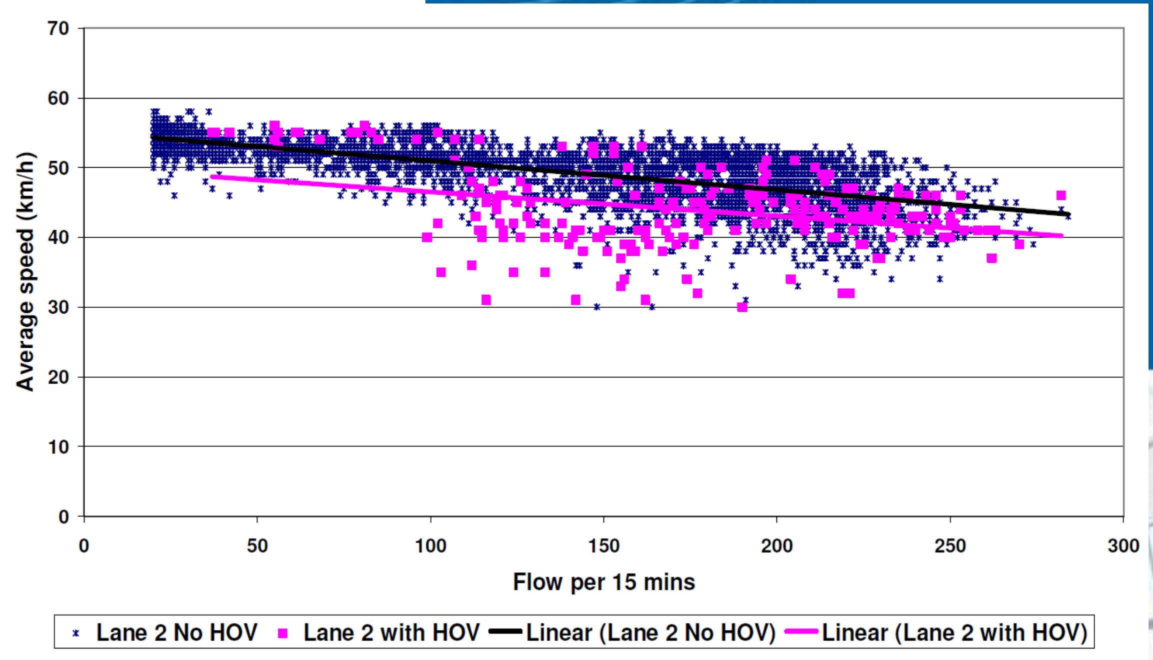
- Lane performance due to user class allocation
- Behavioural response (mode shift)
- Compliance

Allocation effects

- Little evidence on effects on performance of introducing managed lanes
  - Traffic theory
  - Limited real world data
- Difficult to get user benefits from reallocation given typical Auckland traffic mixes
  - Needs precise allocations of traffic
  - Do not fit easily with groups in existing traffic
- Effect generally negative if physical capacity unchanged
  - Typically increase in cost of total travel time

Onewa Road

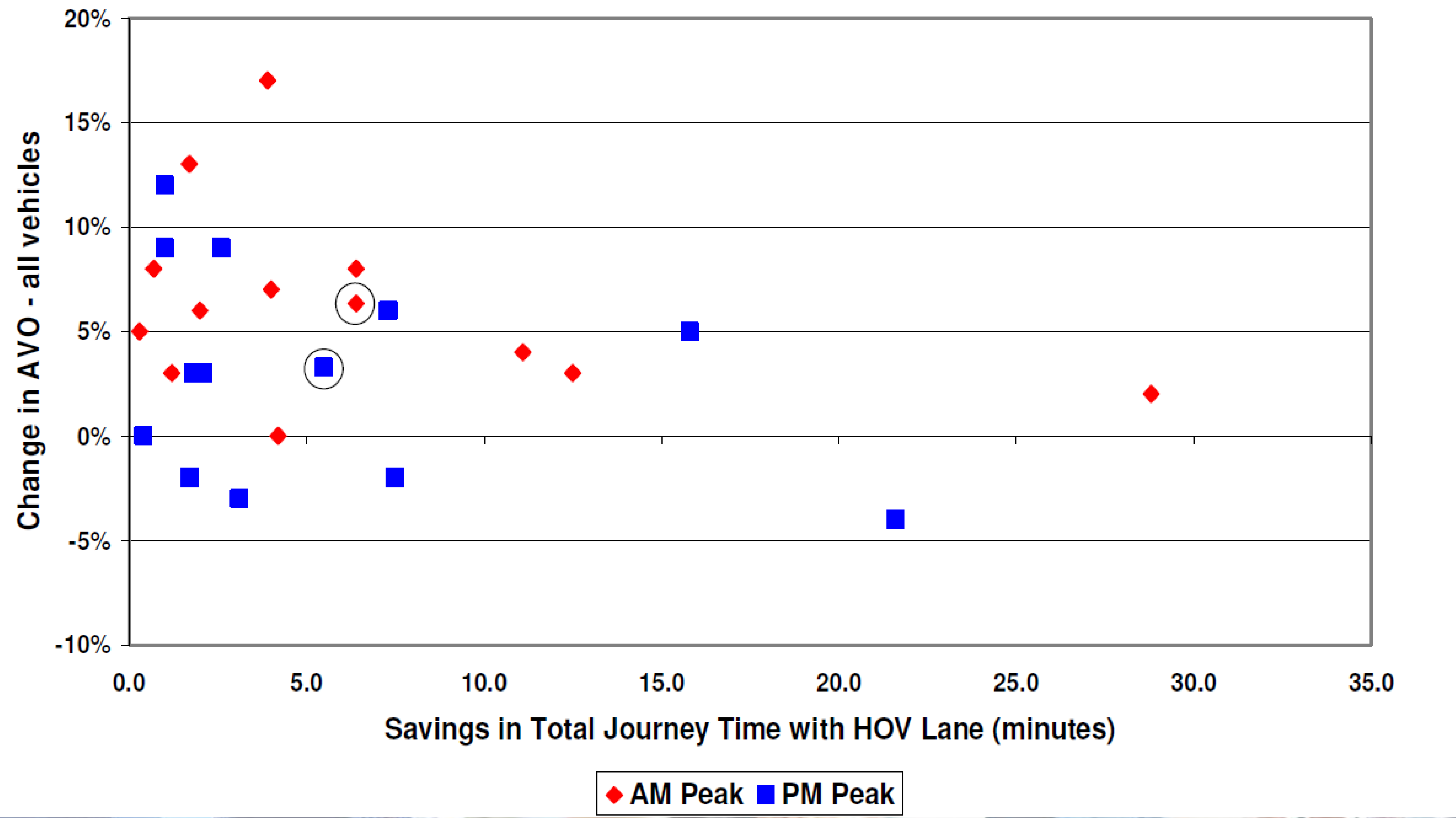

Average Speed (km/h)
70
60
50
40
30
20
10
0
0
20
40
60
80
100
120
140
160
180
Flow per 15 mins
Lane 1 No HOV
Lane 1 as HOV
Linear (Lane


Average speed (km/h)
70
60
50
40
30
20
10
0
0
50
100
150
200
250
300
Flow per 15 mins
Lane 2 No HOV
Lane 2 with HOV
Linear (Lane 2 No HOV)
Linear (Lane 2 with HOV)

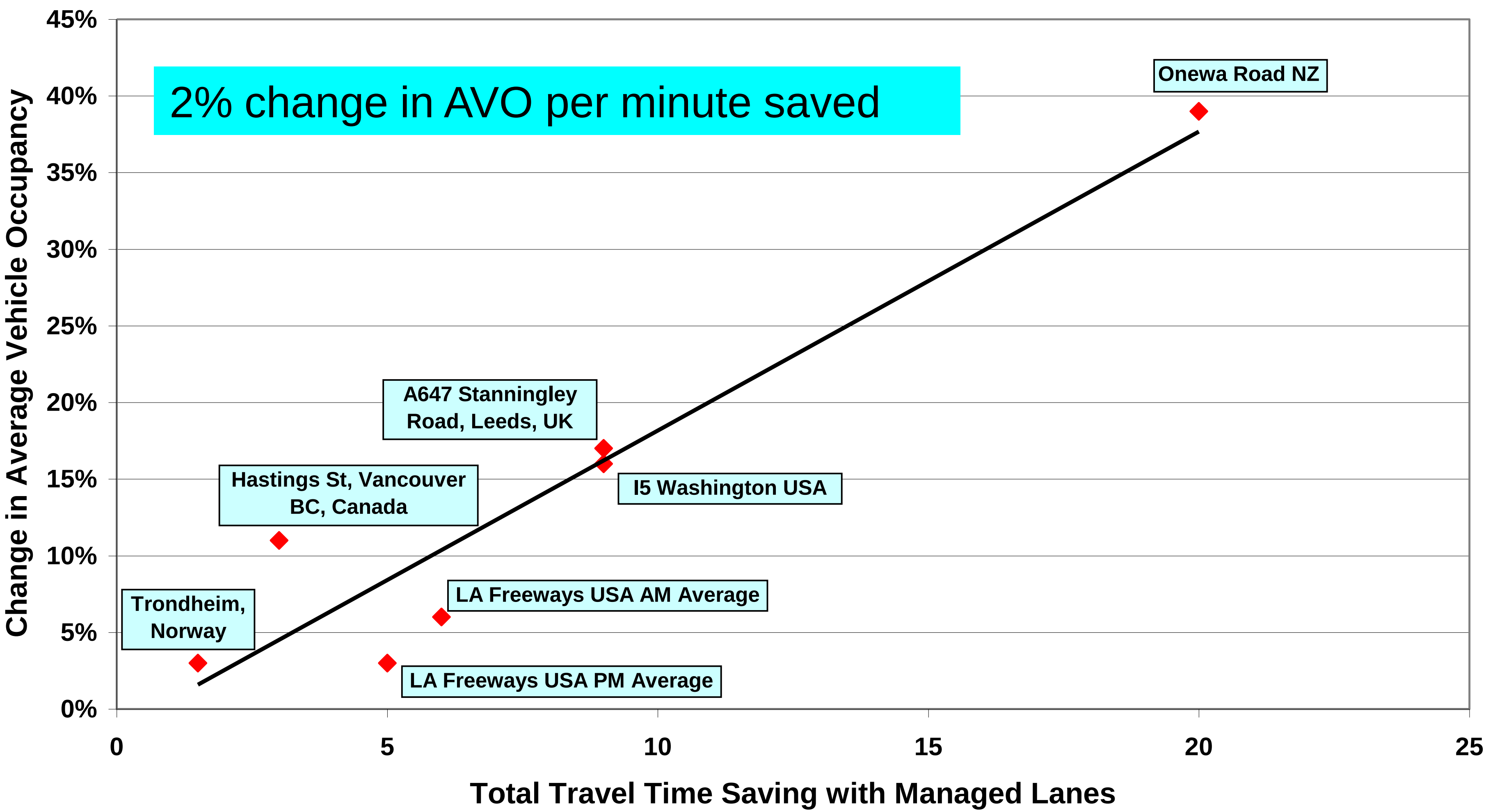
Behavioural response

- No generally accepted guidelines or even theory to assist
- Problems of measurement over time
- Response depends on site specific factors
- Very limited information on arterial roads
- Assembled information from a variety of sources to try to get general position
- Enforcement/compliance

Observed


20%
15%
10%
5%
0%
-5%
-10%
Change in AVO - all vehicles
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
Savings in Total Journey Time with HOV Lane (minutes)
AM Peak
PM Peak

Observed


2% change in AVO per minute saved
Change in Average Vehicle Occupancy
Total Travel Time Saving with Managed Lanes
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
0
5
10
15
20
25
Onewa Road NZ
A647 Stanningley Road, Leeds, UK
I5 Washington USA
Hastings St, Vancouver BC, Canada
LA Freeways USA AM Average
Trondheim, Norway
LA Freeways USA PM Average

Behavioural response

- With behavioural response, managed lanes look more attractive
- Higher average occupancy = less vehicles (without reassignment)
- With reductions in vehicle flows conditions can improve for all travellers
- Benefits will fall in total value of user time
- Key part of evaluation
- More robust data needed

Measures of effectiveness

- Vehicle travel time (LoS)
- Person travel time (LoS)
- Eligibility and compliance rate (is it likely to carry more people?)
- Bus/HOV journey time reliability (QTN)
- Economic impact/benefit
- Enforceability
- Public/political acceptance
- Support of policy or legislation e.g. LTMA/GPS

Quantitative evaluation

- Simple question – will it carry more people?
- Urban corridor performance
  - Intersection treatments, performance and spacing
  - Merging and lane changing (not yet considered)
  - Access, bus stops and parking
  - Link capacity

Quantitative evaluation

- Simple spreadsheet model
- Generic model applicable NZ wide
- Flexible (guide for user inputs, link or intersection based)
- Allows the user to select intersection treatments
- Uses HCM methodology (Urban Streets)
- Uses Akcelik function for mid-block speeds
- Uses TQSM/HCM for bus service analysis (under development)
- Provides graphical outputs

Limitations

- Only a single elasticity considered
- Merging and bottleneck delay not yet incorporated
- Does not accurately consider a “through-right” lane
- Model applies only for signalised intersections

GHD CLIENTS | PEOPLE | PERFORMANCE

Inputs

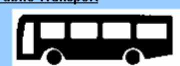
CORRIDOR ASSESSMENT MODELS - TRAFFIC INPUTS

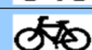
Corridor under investigation:	Albany Highway
Be investigated by:	Tim Brown
Date of investigation:	30/08/2009

GENERAL INFORMATION

Morning Commuter Peak Hour	7:30 - 8:30 a.m.	Design year forecasts available?	YES
Daytime Peak Hour	12:00 - 1:00 p.m.		
Evening Commuter Peak Hour	5:00 - 6:00 p.m.	***Turning Volumes Available?***	Yes
Base year	2006	Vehicle occupancy elasticity	0.50%
Design Year	2031	Bas patronage elasticity	4.00%
		Level of illegal usage	10%

COMPOSITION OF PEOPLE AND TRAFFIC	2006 Morning	2006 Daytime	2006 Evening	2031 Morning	2031 Daytime	2031 Evening
Link Volumes and proportion of turning traffic						
Hourly Traffic Volumes in the direction of travel						
Approximate proportion of traffic turning LEFT at traffic signals						
Approximate proportion of traffic turning RIGHT at traffic signals						
Public Transport						
Bus patronage	500			600		
Number of ALL STOPS bus services using the route	12			15		
Number of EXPRESS bus services using the route						
Number of 40 seat buses required to serve seated patronage	13			15		
Light Vehicles (includes cars, 4WD, SUV, Utes and people movers)						
% of light vehicles with driver alone (SOV)	67%			67%		
% of light vehicles with 2 occupants (HOV2)	21%			21%		
% of light vehicles with 3+ occupants (HOV3+)	9%			9%		
Average vehicle occupancy for HOV3+	3.25			3.25		
Heavy Vehicles (include trucks > 3.5t)						
% of Heavy Vehicles (includes rigid and articulated)	5%			5%		
Motorcycles						
% of total traffic is motorcyclists						
Cyclists						
Number of cyclists that use the corridor						





2006 Turning Volumes

Int No.	Side Road	2006 Morning Peak Hour Left Turn Volume	Through Movement Volume	Right Turn Volume	2006 Daytime Peak Hour Left Turn Volume	Through Movement Volume	Right Turn Volume	2006 Evening Peak Hour Left Turn Volume	Through Movement Volume	Right Turn Volume
1	Oakway Drive	56	592							
2	Appleby Road	43	525							
3	Rosebank Road	60	415	164						
4	Bass Road	108	854	3						
5	Wharf Road	59	796	20						
6	Uni 1	1	885	1						
7	Colliseum Drive	1	885	1						
8	SH17	186	473	220						

2031 Turning Volumes

Int No.	Side Road	2031 Morning Peak Hour Left Turn Volume	Through Movement Volume	Right Turn Volume	2031 Daytime Peak Hour Left Turn Volume	Through Movement Volume	Right Turn Volume	2031 Evening Peak Hour Left Turn Volume	Through Movement Volume	Right Turn Volume
1	Oakway Drive	126	1147							
2	Appleby Road	100	1219							
3	Rosebank Road	100	1048	367						
4	Bass Road	190	1500	5						
5	Wharf Road	107	1442	36						
6	Uni 1	1	1433	94						
7	Colliseum Drive	1	1314	325						
8	SH17	318	810	377						

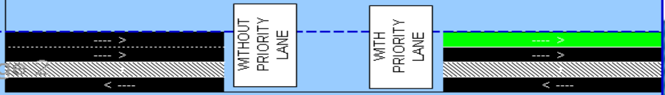
CLIENTS | PEOPLE | PERFORMANCE

Inputs

CORRIDOR ASSESSMENT MODELS - MID BLOCK

ROAD CLASSIFICATION	
Length of corridor being investigated (km)	3.500
Corridor width (including berms/verges)	31-40m
Posted speed (kph)	50
Road classification	Regional Arterial
Number of lanes in direction of travel	2
One way road or two-way road	Two Way
Parking and/or shoulder	Parking next to kerbside lane
Type of median	Flush Median
No. of traffic signals along route?	8
Roadside Development Intensity	Mix of Low and Medium
Pedestrian Activity	Low Activity
Frequency of driveway accesses	Low
Function Category	Principal - High mobility function
Design Category (score)	12
Design Category	Intermediate
Road Class	Class II
Estimated Free Flow Speed (kph)	55

GEOMETRY	
Mid-block Capacity (vehicles per hour per lane)	1,350
Kerbside lane width	>=4.5m
Width of other lanes	3.0m - 3.5m
Speed-flow friction factor	1.0
PRIORITY LANE FRICTION FACTOR	***1.6***
Pavement width (Allows for 2.5m median)	15.7
Is there enough space to add a lane along the corridor?	Yes - investigate further
Will property acquisition be considered if needed?	No
Will the priority lane be a kerbside lane or median lane?	Kerbside Lane
Will the priority lane be an "added lane" or "converted lane"?	Converted Lane



CORRIDOR ASSESSMENT MODELS - SIGNALISED INTERSECTION TREATMENTS

GENERAL INFORMATION	
Route cycle time	140
Through movement basic saturation flow (vehicles per hour)	1800
Left turn basic saturation flow (vehicles per hour)	1650
Right turn basic saturation flow (vehicles per hour)	1700

Maximum expected DoS with this cycle time =

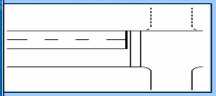
Level of traffic signal co-ordination	*4*
Relationship between arrival type and platoon ratio	1.333
Additional adjustment factor for platoon arriving during green	1.15

INTERSECTION TREATMENTS

Number of mid-block lanes does not matter for these inputs
If unrestricted queueing in short lane then consider the lane as continuous.
If there is a clearway in one or more periods, then select the layout with a continuous kerbside lane (Type 1 or Type 3)
Treat a slip lane as a short left lane and specify the "free queue" as the lane length

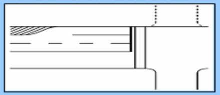
INTERSECTION LAYOUTS WITHOUT PRIORITY LANE

TYPE 1 - NO SHORT LANE



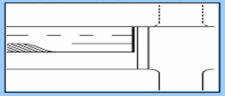
TYPE 1X FOR CROSSROADS
TYPE 1L FOR T-JUNCTION LEFT
TYPE 1R FOR T-JUNCTION RIGHT
TYPE 1P FOR PED CROSSING

TYPE 2 - SHORT LANE ON LEFT



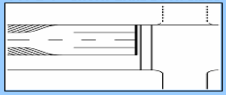
TYPE 2X FOR CROSSROADS
TYPE 2L FOR T-JUNCTION LEFT
TYPE 2R FOR T-JUNCTION RIGHT
TYPE 2P FOR PED CROSSING

TYPE 3 - SHORT LANE ON RIGHT



TYPE 3X FOR CROSSROADS
TYPE 3L FOR T-JUNCTION LEFT
TYPE 3R FOR T-JUNCTION RIGHT

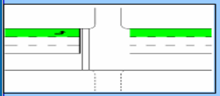
TYPE 4 - SHORT LANE BOTH SIDES



TYPE 4X FOR CROSSROADS
TYPE 4L FOR T-JUNCTION LEFT
TYPE 4R FOR T-JUNCTION RIGHT

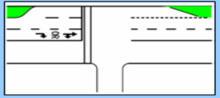
INTERSECTION LAYOUTS WITH PRIORITY LANE

TYPE 1C - Priority lane thru intersection



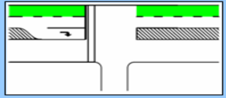
TYPE 1X FOR CROSSROADS
TYPE 1L FOR T-JUNCTION LEFT
TYPE 1R FOR T-JUNCTION RIGHT
TYPE 1P FOR PED CROSSING

TYPE 2G - General lane after priority lane



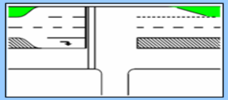
TYPE 2X FOR CROSSROADS
TYPE 2L FOR T-JUNCTION LEFT
TYPE 2R FOR T-JUNCTION RIGHT
TYPE 2P FOR PED CROSSING

TYPE 3G - General lane after priority lane



TYPE 3X FOR CROSSROADS
TYPE 3R FOR T-JUNCTION RIGHT

TYPE 4G - General lane after priority lane

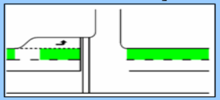


TYPE 4X FOR CROSSROADS
TYPE 4R FOR T-JUNCTION LEFT
TYPE 4L FOR T-JUNCTION RIGHT

TYPE 2Q - QUEUE JUMP

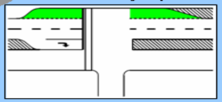
TYPE 2R-Q FOR T-JUNCTION RIGHT
TYPE 2P-Q FOR PED CROSSING

TYPE 2L - Left turn bay



TYPE 2X-L FOR CROSSROADS
TYPE 2L-L FOR T-JUNCTION LEFT

TYPE 3Q - Queue jump lane



TYPE X4-Q FOR CROSSROADS
TYPE T4-Q (R) FOR T-JUNCTION RIGHT

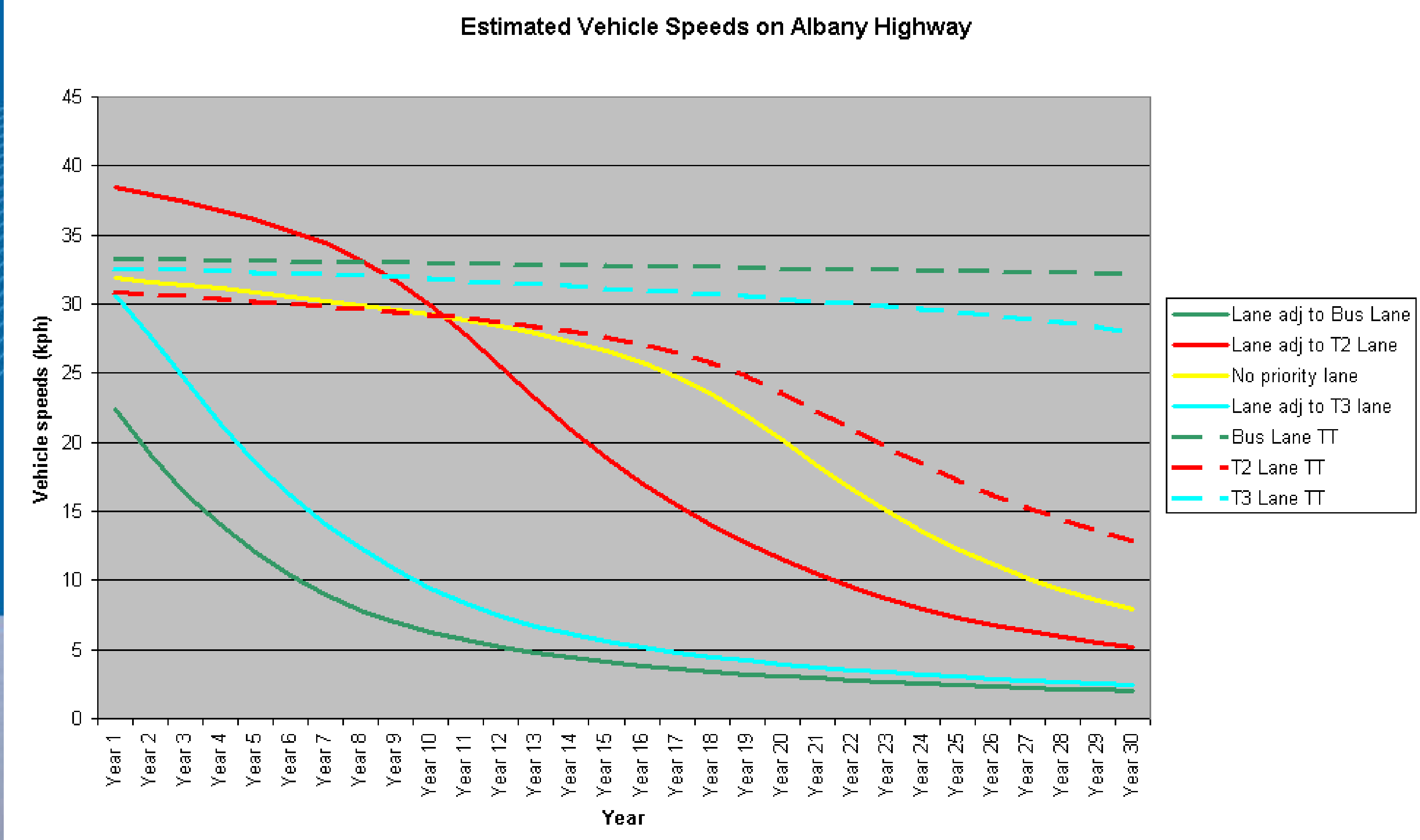
TYPE 4C - Continuous lane through

TYPE 4C FOR CROSSROADS
TYPE 4C-L FOR T-JUNCTION LEFT

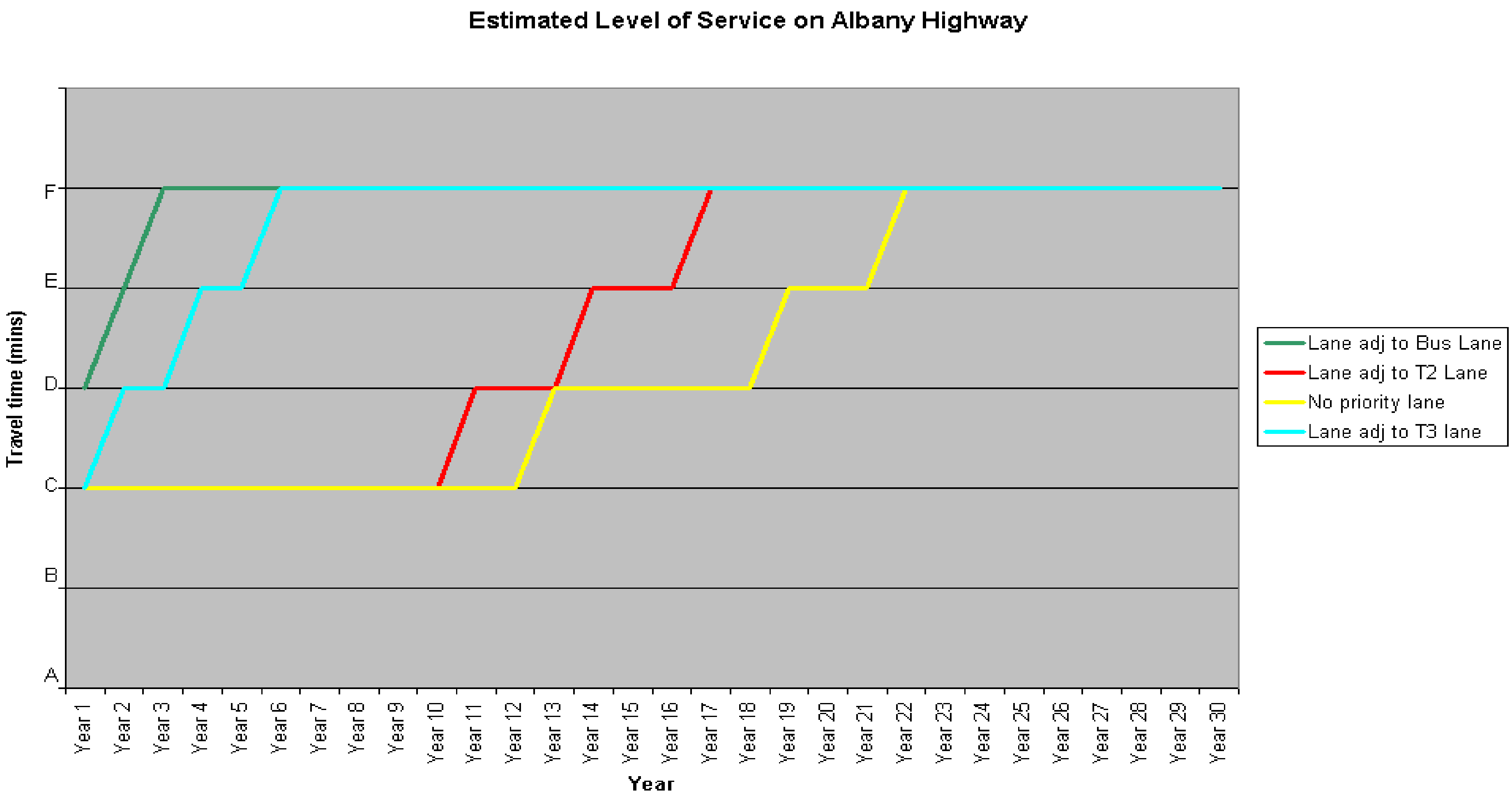
Int No.	Side Road	Layout without priority lane	Left Lane Movement/s	Right Lane Movement/s	Left Turn Pedestrian Protection	% Green Time for "Priority" Movement	Short left lane length	Kerbside Through Lane Utilisation	Layout WITH PRIORITY LANE
1	Oakway Drive	2L	Thru	Thru	Partial (6s delay)	60%			1L
2	Appleby Road	2L	Left	Thru	Partial (6s delay)	60%			1L
3	Rosebank Road	3X	Left-Thru	Right	Semi (15s delay)	40%			3X
4	Bass Road	3X	Left-Thru	Right	Partial (6s delay)	50%			3X
5	Wharf Road	3X	Left-Thru	Right	Partial (6s delay)	50%			3X
6	Uni 1	4X	Left	Right	Partial (6s delay)	50%			4C
7	Colliseum Drive	4X	Left	Right	Partial (6s delay)	50%			4C
8	SH17	4X	Left	Right	None or SCRAMBLE X-ing	40%			4X

Richard Paling Consulting

Outputs – Vehicle speeds

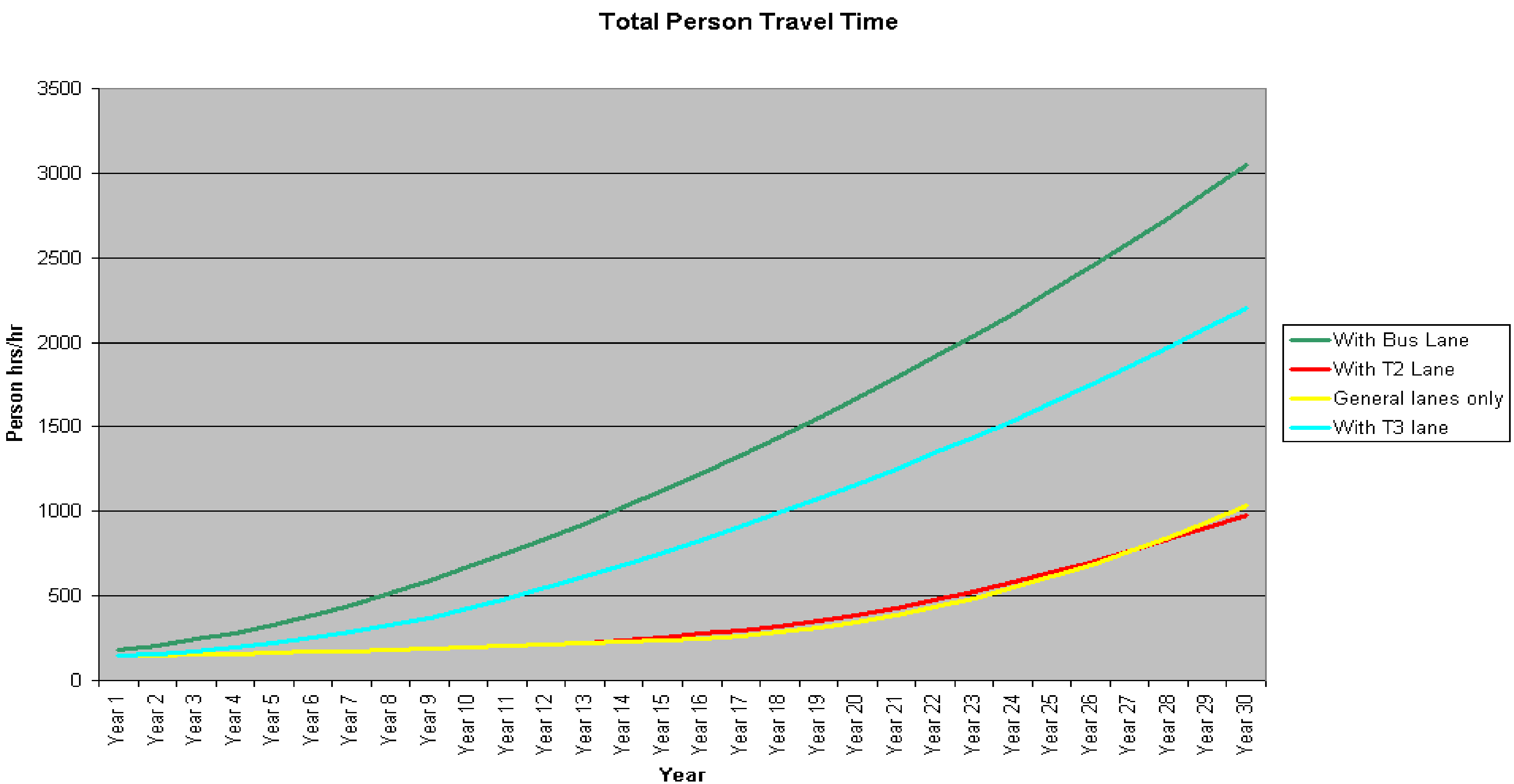


Outputs – Level of Service



Richard Paling Consulting

Outputs – Person travel time



Enhancements

- Daytime profiles for clearway assessment
- Inclusion of bus stopping times into assessment
- Estimates of bus journey time reliability as an output
- Economic assessment of benefits
- Sensitivity analysis of elasticity
- Allow freight in the managed lanes.

Summary

- Research project due mid-year
- Simple spreadsheet for “quick” assessment
- Effective method for assessment, and quantitative
- Long term behavioural response – more robust data needed
- Allocation effect needs to be considered
- Enforceability and compliance need to be considered.
- Judge each project on its merits.

Supplementary info

- AVO = 1.2 to 1.25 (Ramp meter)
- 20-30% eligible, 10% violation rate (Ramp meter)
- A lot of data in Sydney but mixed results (RTA regular monitoring program)
- ARR308 (Get this info)

CLIENTS | PEOPLE | PERFORMANCE

Richard Paling Consulting

Supplementary info

HOV facility	Period	Length	Person throughput on HOV lane (persons / hour)	Person throughput on normal adjacent lane (persons / hour)	% difference in person throughput
Military Rd – T3	a.m. (inbound)	7.99 km	3,953	1,500	164%
Military Rd – T3	p.m. (outbound)	2.33 km	4,539	1,400	224%
Epping Rd – T3 / T2	a.m. (inbound)	8.13 km	3,096	1,000	209%
Epping Rd – T3	p.m. (outbound)	4.34 km	1,037	1,082	-4%
Pacific Hwy – T3	p.m. (outbound)	4.71 km	692	1,213	-43%
Great Western – T2	a.m. (inbound)	9.47 km	860	1,136	-24%

HOV facility	Period	Length	Travel time changes	Travel time saving (%)
Military Rd – T3	a.m. (inbound)	7.99 km	-15.10 min	-41%
Victoria Rd – T3	a.m. (inbound)	9.57 km	-12.67 min	-31%
Great Western Hwy – T2	a.m. (inbound)	9.47 km	-2.72 min	-18%
Pacific Hwy – T3/T2	p.m.(outbound)	4.71 km	+1.77 min	+18%
William St – T2	a.m.(inbound)	0.73 km	+1.79 min	+97%

Corridor	Average car occupancies (persons per vehicle)			
	Transit lane		General purpose lanes	
	1992	2006	1992	2006
Victoria Rd T3 – a.m. inbound	1.83	1.59	1.18	1.17
Military Rd T3 – a.m. inbound	2.66	2.25	1.18	1.18
Epping Rd T3/T2 – a.m. inbound	1.90	1.47	1.17	1.13
Great Western Hwy T2 – a.m. inbound	-	1.50	-	1.15
Great Western Hwy T2 – p.m. outbound	-	1.55	-	1.25

Akcelik link function