Zenith Model of Victoria

Technical Note 9
Overall Model Validation

Zenith Version 2.0.0

VEITCH LISTER CONSULTING PTY LTD

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Zenith Model of Victoria

Technical Note 9: Overall Model Validation

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21-05-2011	A	MV/TV	AA	MV	Draft
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Contents

1 Introduction

The Zenith travel model of Victoria is one of a family of models developed by Veitch Lister Consulting (VLC) for transport planning in Australian cities and regions.

This document is one in a series of technical notes that collectively describe the Zenith Model of Victoria.

1.1 Related Documents

This technical note is the ninth of eleven. The other technical notes are:

- Working Paper 1: Model Validation Framework and Data Sources
- Working Paper 2: Review of VISTA07
- Working Paper 3: Home Based Trip Production Model
- Working Paper 4: Non-Home Based Trip Production Model
- Working Paper 5: Household Segmentation & Travel Market Segmentation Models
- Working Paper 6: Period Allocation and Vehicle Occupancy Models
- Working Paper 7: Mode Choice Model
- Working Paper 8: Destination Choice and Trip Attraction Model
- Working Paper 9: Overall Model Validation
- Working Paper 10: Backcasting and Sensitivity Testing
- Working Paper 11: Reference Case Model Assumptions

1.2 Scope of This Document

This document describes how the recalibrated Zenith model performs in replicating a comprehensive database of observed travel demands in Melbourne. The model has been recalibrated using the VISTA07 household travel survey database.

The footprint of the recalibrated model covers the Melbourne Statistical Division (MSD), the regional cities of Ballarat, Bendigo and Geelong, and areas in between. The upgraded model includes restructured implementation procedures and revised calibration parameters for all private travel purposes, both for home-based and non-home-based private travel.

The remainder of this document is structured as follows:

- Section 2 assesses the performance of the new model in terms of its ability to replicated observed traffic volumes in Melbourne.
- Section 3 compares the model's estimates of 2008 public transport passenger demands with reported boardings of the various sub-modes (train, tram and bus)

2 Validation against VicRoads Traffic Counts

2.1 Screenline Validation against Traffic Counts

VicRoads has nominated a set of 21 screenlines for the purposes of validating strategic travel models in Melbourne.

How a model performs in replicating traffic flows crossing screenlines, by time of day, is the best indication as to whether the correct quantum of travel is being generated by a model, as well as the scale of traffic movement occurring between the various regions of the modelled area.

The locations of the VicRoads screenlines are shown in Figure 1.

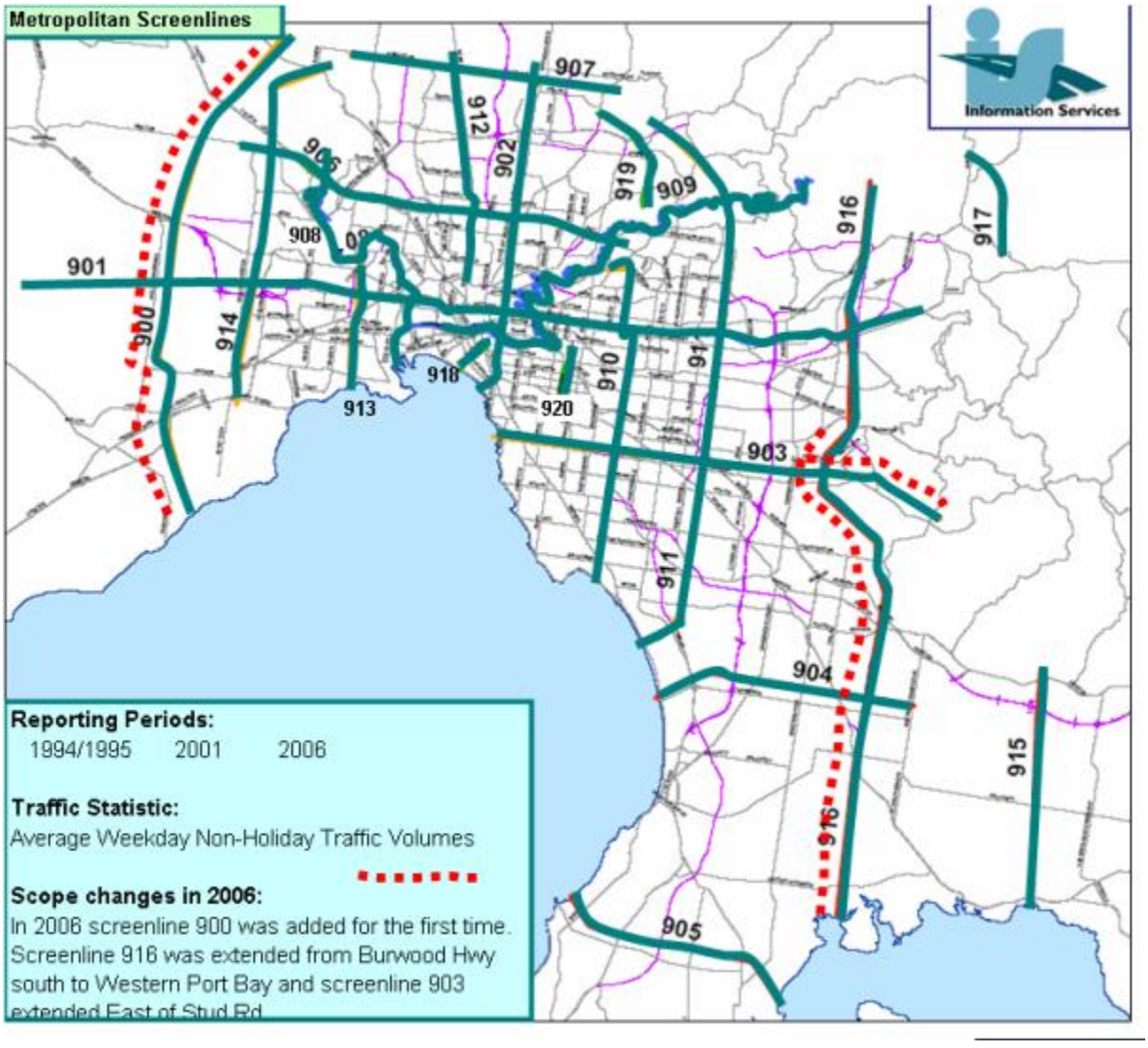

Figure 1 - VicRoads Screenlines in Melbourne

VicRoads in 2006 undertook a comprehensive series of traffic counts across the metropolitan area that included counts, by time of day, on all major roads crossing the 21 screenlines. These counts have been compared with the Zenith models estimates of travel crossing the screenlines in 2008.

This component of the validation has included comparing daily modelled traffic volumes crossing each screenline, AM peak (7:00-9:00am) and PM peak (4:00-6:00pm) comparisons - as well as by direction of travel.

2.1.1 Daily Modelled and Observed Traffic Crossing Screenlines

Table 1 compares modelled and observed total daily, weekday traffic flows crossing the 21 screenlines. Total two-way flows, as well as flows by direction are compared.

Over 10 million vehicles cross the screenlines each weekday.

In total terms the daily modelled volumes are 2.1 percent higher than the VicRoads counts, which is partly explained by the model volumes being for 2008, whereas the counts were undertaken in 2006.

On 11 of the 21 screenlines (i.e. two-thirds) there is less than a 5 percent discrepancy between modelled and observed volumes. On only 4 screenlines is the discrepancy greater than 10 percent.

The model is higher than the count by 8.0% for the most westerly screenline (900). The model is also higher on the two most easterly screenlines (915 and 917) by 25.42% and 24.6% respectively, but the latter are very low volume screenlines. The higher modelled traffic across the 900 screenline likely reflects the significant population growth which has taken place since 2006, while the 915 screenline is likely to be high because of the inclusion of the Pakenham Bypass since 2006.

Figure 2 provides a regression line scatter-plot for modelled and observed weekday traffic crossing the screenlines. An extremely high R^2 of 0.9913 is evident, with a slope of 1.0241. This is a very good outcome.

Figure 3 and Figure 4 present equivalent R^2 plots for inbound and outbound daily travel across the screenlines which, not surprisingly, presents an almost identical outcome as the daily comparison shown in Figure 2.

The Department of Transport (DoT) has stipulated model validation criteria guidelines for the acceptable performance of strategic travel models. Their acceptance criteria for screenline validation is that total 24-hour modelled screenline volumes should be:

> ***Within + or – 80.145 * $V^{-0.3953}$ % of the counted volumes, on all screenlines.***
>
> ***where V is the 24-hour volume crossing the screenline expressed in thousands***

(Source: Guidelines for Strategic Model Development: Calibration, Reasonableness Checks, Validation and Sensitivity Testing, Victorian Department of Transport, September 2010)

How the recalibrated Zenith model is performing against this DoT validation criteria is presented in Figure 5. DoT requires that all modelled screenline totals lie within the red bounds shown in Figure 5. The Zenith model easily satisfies this criteria for 80% of screenlines. Allowing for traffic growth in the period between the counts and the modelled volumes (2006-2008), and the construction of new infrastructure during this time, it is likely that all screenlines would satisfy the DoT validation criteria.

	Daily Observed_i2006 Traffic	Zenith Traffic	Difference	% Difference
900	**279,885**	**321,405**	**41,520**	**14.8%**
Inbound	140,753	160,202	19,449	13.8%
Outbound	139,132	161,203	22,071	15.9%
901	**1,050,621**	**1,078,960**	**28,339**	**2.7%**
Inbound	526,354	536,421	10,067	1.9%
Outbound	524,267	542,539	18,272	3.5%
902	**1,004,489**	**999,309**	**-5,180**	**-0.5%**
Inbound	501,356	497,835	-3,521	-0.7%
Outbound	503,133	501,475	-1,658	-0.3%
903	**717,445**	**704,291**	**-13,154**	**-1.8%**
Inbound	361,428	352,318	-9,110	-2.5%
Outbound	356,017	351,973	-4,044	-1.1%
904	**260,572**	**211,429**	**-49,143**	**-18.9%**
Inbound	129,174	104,695	-24,479	-19.0%
Outbound	131,398	106,734	-24,664	-18.8%
905	**101,532**	**95,751**	**-5,781**	**-5.7%**
Inbound	50,450	47,871	-2,579	-5.1%
Outbound	51,082	47,879	-3,203	-6.3%
906	**808,301**	**875,104**	**66,803**	**8.3%**
Inbound	403,682	436,561	32,879	8.1%
Outbound	404,619	438,543	33,924	8.4%
907	**224,292**	**219,019**	**-5,273**	**-2.4%**
Inbound	111,254	109,757	-1,497	-1.3%
Outbound	113,038	109,262	-3,776	-3.3%
908	**553,029**	**658,066**	**105,037**	**19.0%**
Inbound	277,776	328,813	51,037	18.4%
Outbound	275,253	329,253	54,000	19.6%
909	**1,142,728**	**1,146,117**	**3,389**	**0.3%**
Inbound	563,163	570,570	7,407	1.3%
Outbound	579,565	575,547	-4,018	-0.7%
910	**726,394**	**704,999**	**-21,395**	**-2.9%**
Inbound	362,172	353,111	-9,061	-2.5%
Outbound	364,222	351,889	-12,333	-3.4%
911	**930,425**	**975,881**	**45,456**	**4.9%**
Inbound	468,901	486,135	17,234	3.7%
Outbound	461,524	489,746	28,222	6.1%
912	**354,032**	**385,692**	**31,660**	**8.9%**
Inbound	176,227	192,121	15,894	9.0%
Outbound	177,805	193,571	15,766	8.9%
913	**344,824**	**346,884**	**2,060**	**0.6%**
Inbound	173,522	173,407	-115	-0.1%
Outbound	171,302	173,477	2,175	1.3%
914	**441,126**	**465,039**	**23,913**	**5.4%**
Inbound	215,504	232,276	16,772	7.8%
Outbound	225,622	232,763	7,141	3.2%
915	**70,326**	**32,471**	**-37,855**	**-53.8%**
Inbound	34,581	17,380	-17,201	-49.7%
Outbound	35,745	15,091	-20,654	-57.8%
916	**545,062**	**555,324**	**10,262**	**1.9%**
Inbound	267,746	277,346	9,600	3.6%
Outbound	277,316	277,978	662	0.2%
917	**27,422**	**34,175**	**6,753**	**24.6%**
Inbound	13,437	17,112	3,675	27.4%
Outbound	13,985	17,063	3,078	22.0%
918	**234,782**	**236,560**	**1,778**	**0.8%**
Inbound	117,579	118,185	606	0.5%
Outbound	117,203	118,375	1,172	1.0%
919	**178,486**	**182,165**	**3,679**	**2.1%**
Inbound	88,482	90,765	2,283	2.6%
Outbound	90,004	91,400	1,396	1.6%
920	**225,479**	**209,264**	**-16,215**	**-7.2%**
Inbound	149,858	139,704	-10,154	-6.8%
Outbound	75,621	69,561	-6,060	-8.0%
Grand Total	**10,221,252**	**10,437,906**	**216,654**	**2.1%**

Table 1 - Daily Traffic at Screenlines

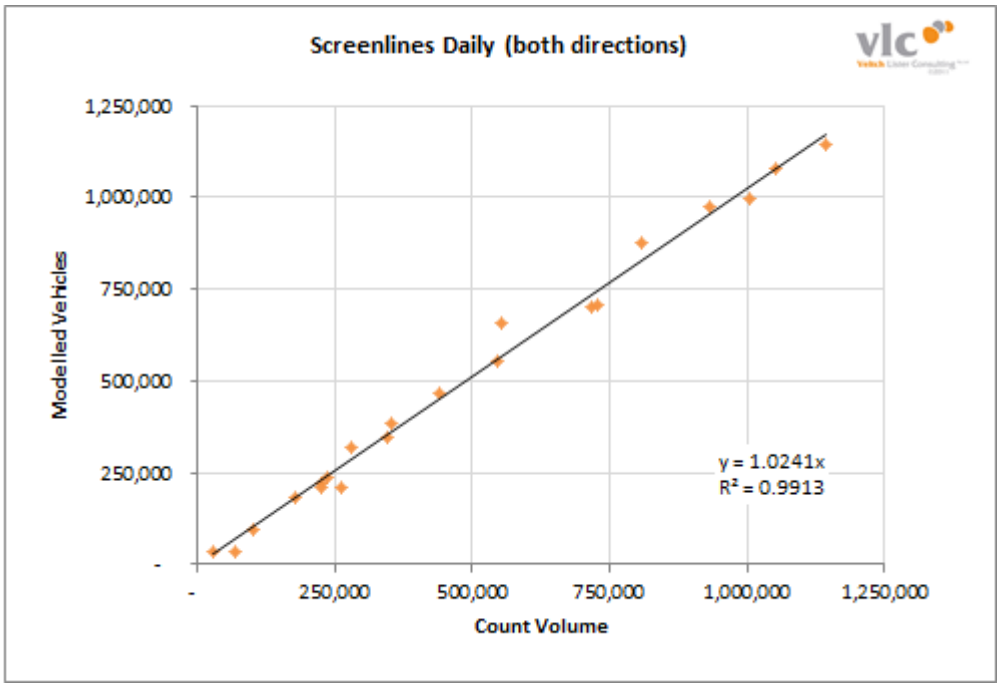

Figure 2 - Daily Screenline Totals (average weekday)

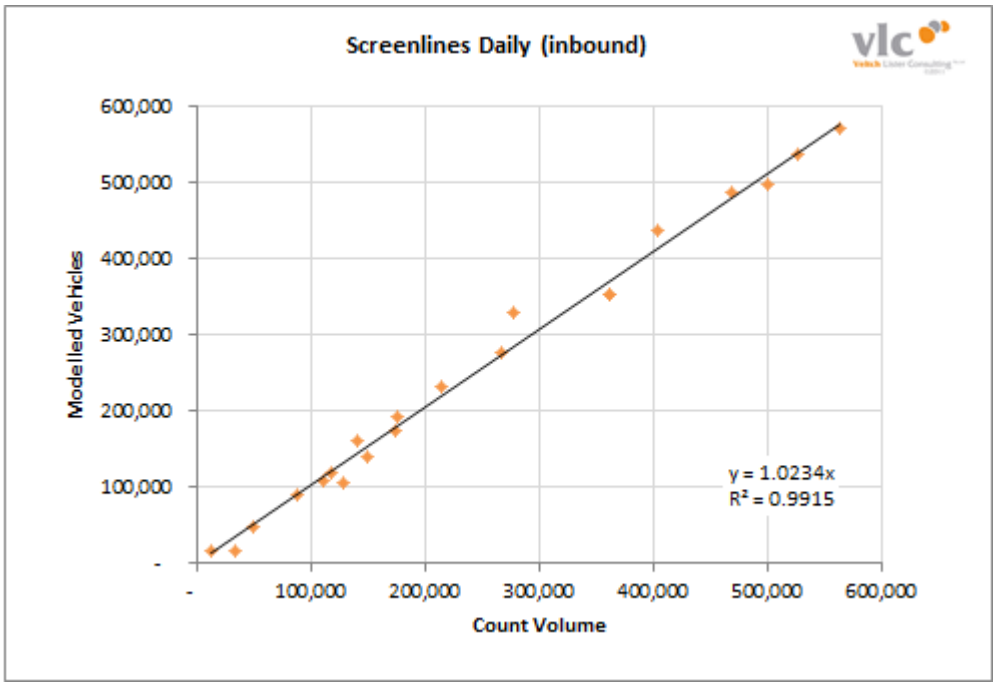

Figure 3 - Daily Screenline Totals (average weekday) - Inbound

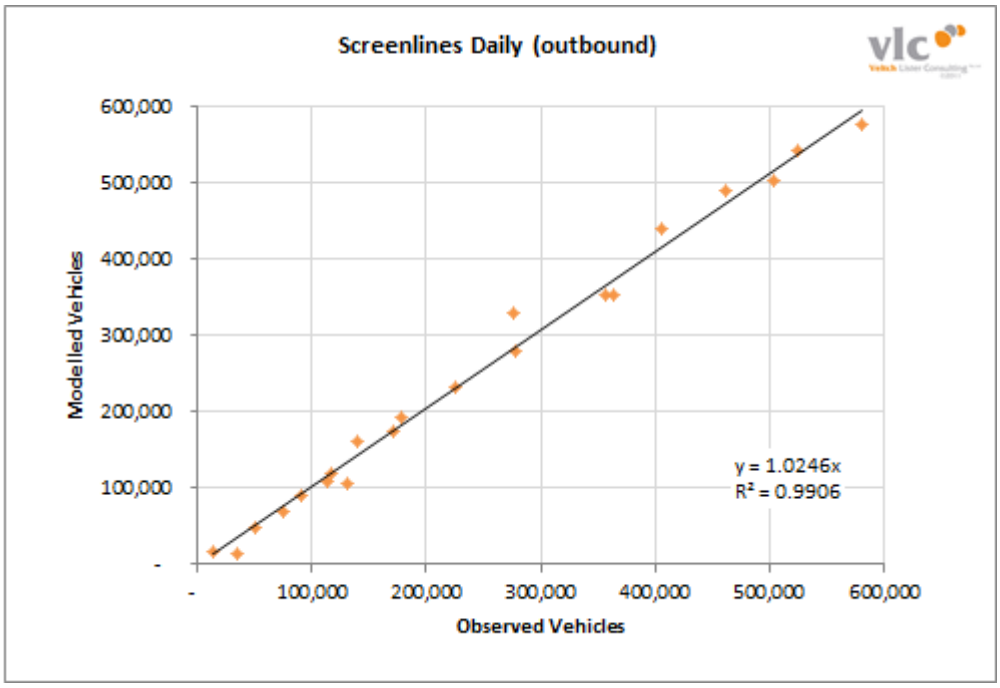

Figure 4 - Daily Screenline Totals (average weekday) - Outbound

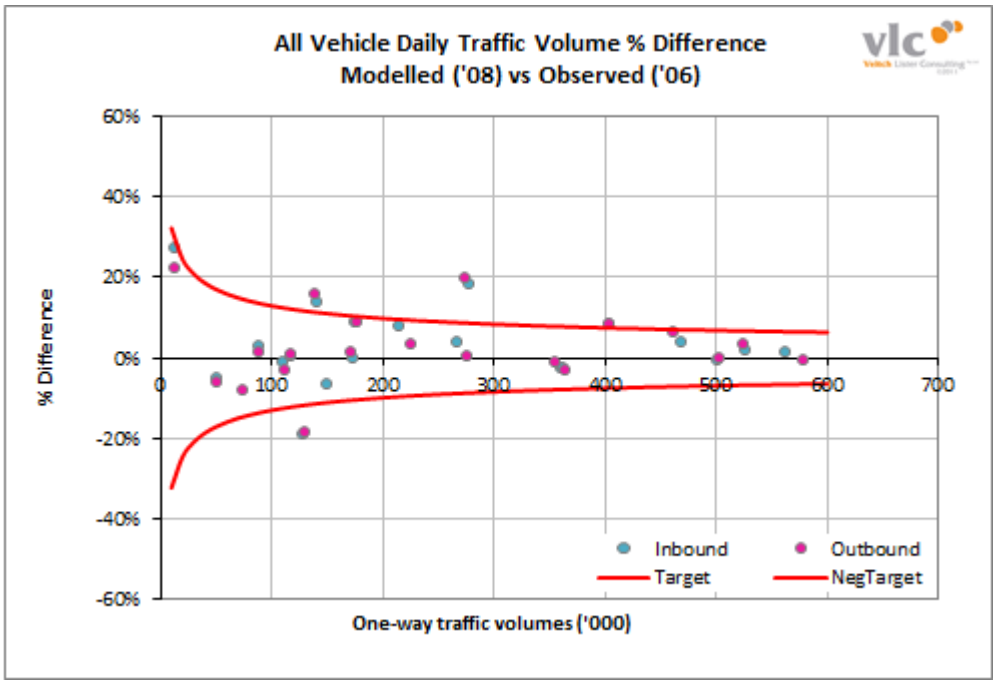

Figure 5 - Target Screenline Differences - Daily

2.1.2 AM Peak (7-9am) Modelled and Observed Traffic Crossing Screenlines

Table 2 compares modelled and observed AM peak (7:00-9:00am) weekday traffic flows crossing the 21 screenlines by direction of travel (inbound and outbound). Total two-way flows, as well as flows by direction are compared.

Over 1.5 million vehicles cross the screenlines in the two hours.

Figure 6 presents an R^2 regression scatter-plot of modelled and observed total traffic crossing the screenlines in the two-hour morning peak. The equivalent information for inbound and outbound direction of travel is presented in Figure 7 and Figure 8.

In all cases an R^2 around 0.98 – 0.99 is evident, with the slope of the regression line close to 1.0.

The Department of Transport (DoT) has stipulated model validation criteria guidelines for the acceptable performance of strategic travel models in the 2-hour peak periods. Their acceptance criteria is that modelled traffic crossing screenlines should be:

> ***Within + or – 50 * $V^{-0.3953}$ % of the counted volume, on all screenlines.***
> ***V is the 2-hour volume crossing the screenline expressed in thousands***

(Source: Guidelines for Strategic Model Development: Calibration, Reasonableness Checks, Validation and Sensitivity Testing, Victorian Department of Transport, September 2010)

How the Zenith model is performing against this DoT validation criteria is presented in Figure 9. The Zenith model meets this DoT validation criteria for 31 of the 40 directional crossings of the 20 screenlines. Again, differences are expected due to population increases between 2006 and 2008, as well as the construction of new infrastructure (e.g. Pakenham Bypass).

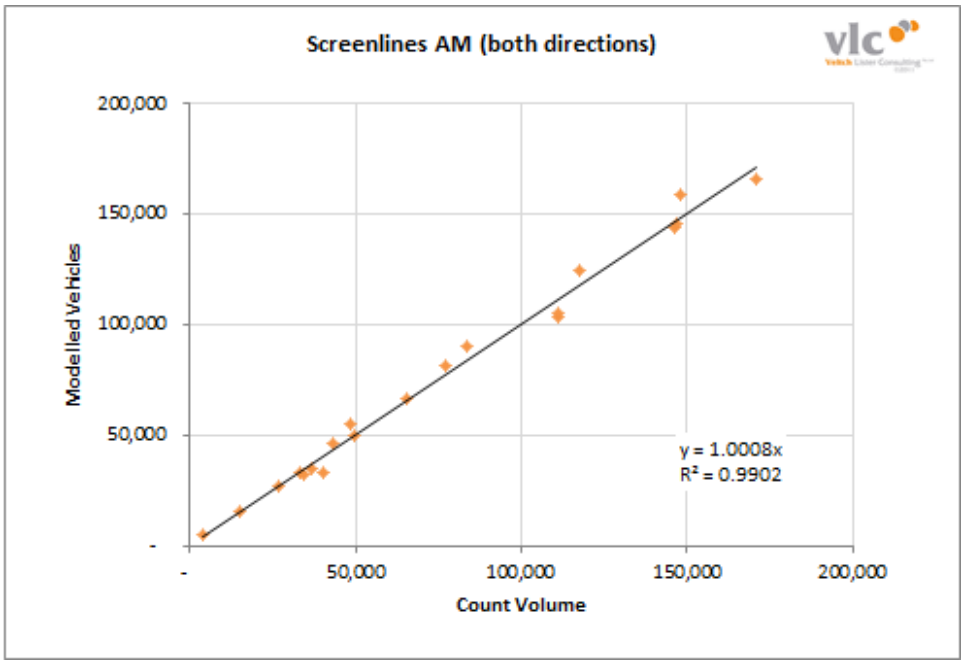

Figure 6 - AM Peak Screenline Totals (weekday)

	AM Observed_i2006 Traffic	Zenith Traffic	Difference	% Difference
900	**42,826**	**46,253**	**3,427**	**8.0%**
Inbound	29,246	32,132	2,886	9.9%
Outbound	13,580	14,122	542	4.0%
901	**148,190**	**158,390**	**10,200**	**6.9%**
Inbound	86,404	89,031	2,627	3.0%
Outbound	61,786	69,359	7,573	12.3%
902	**146,095**	**143,591**	**-2,504**	**-1.7%**
Inbound	92,716	83,385	-9,331	-10.1%
Outbound	53,379	60,206	6,827	12.8%
903	**111,251**	**102,806**	**-8,445**	**-7.6%**
Inbound	60,751	56,487	-4,264	-7.0%
Outbound	50,500	46,318	-4,182	-8.3%
904	**40,287**	**32,870**	**-7,417**	**-18.4%**
Inbound	26,084	20,242	-5,842	-22.4%
Outbound	14,203	12,627	-1,576	-11.1%
905	**15,050**	**15,112**	**62**	**0.4%**
Inbound	9,033	9,988	955	10.6%
Outbound	6,017	5,124	-893	-14.8%
906	**117,672**	**124,317**	**6,645**	**5.6%**
Inbound	69,439	71,102	1,663	2.4%
Outbound	48,233	53,215	4,982	10.3%
907	**32,819**	**32,849**	**30**	**0.1%**
Inbound	18,362	21,939	3,577	19.5%
Outbound	14,457	10,909	-3,548	-24.5%
908	**83,396**	**89,580**	**6,184**	**7.4%**
Inbound	51,775	56,014	4,239	8.2%
Outbound	31,621	33,566	1,945	6.1%
909	**170,669**	**165,312**	**-5,357**	**-3.1%**
Inbound	93,949	90,840	-3,109	-3.3%
Outbound	76,720	74,472	-2,248	-2.9%
910	**111,056**	**104,660**	**-6,396**	**-5.8%**
Inbound	66,646	60,448	-6,198	-9.3%
Outbound	44,410	44,212	-198	-0.4%
911	**146,713**	**145,432**	**-1,281**	**-0.9%**
Inbound	95,965	90,133	-5,832	-6.1%
Outbound	50,748	55,299	4,551	9.0%
912	**48,256**	**55,136**	**6,880**	**14.3%**
Inbound	25,720	29,394	3,674	14.3%
Outbound	22,536	25,742	3,206	14.2%
913	**49,254**	**49,916**	**662**	**1.3%**
Inbound	30,314	31,777	1,463	4.8%
Outbound	18,940	18,139	-801	-4.2%
914	**65,265**	**65,929**	**664**	**1.0%**
Inbound	44,422	43,733	-689	-1.6%
Outbound	20,843	22,196	1,353	6.5%
916	**76,847**	**81,113**	**4,266**	**5.6%**
Inbound	48,228	51,928	3,700	7.7%
Outbound	28,619	29,185	566	2.0%
917	**3,966**	**4,600**	**634**	**16.0%**
Inbound	2,625	3,324	699	26.6%
Outbound	1,341	1,276	-65	-4.8%
918	**36,381**	**34,410**	**-1,971**	**-5.4%**
Inbound	23,318	19,684	-3,634	-15.6%
Outbound	13,063	14,726	1,663	12.7%
919	**26,592**	**26,829**	**237**	**0.9%**
Inbound	18,265	17,497	-768	-4.2%
Outbound	8,327	9,332	1,005	12.1%
920	**34,540**	**31,992**	**-2,548**	**-7.4%**
Inbound	26,669	22,887	-3,782	-14.2%
Outbound	7,871	9,106	1,235	15.7%
Grand Total	**1,507,125**	**1,511,096**	**3,971**	**0.3%**

Table 2 - AM Peak Traffic at Screenlines

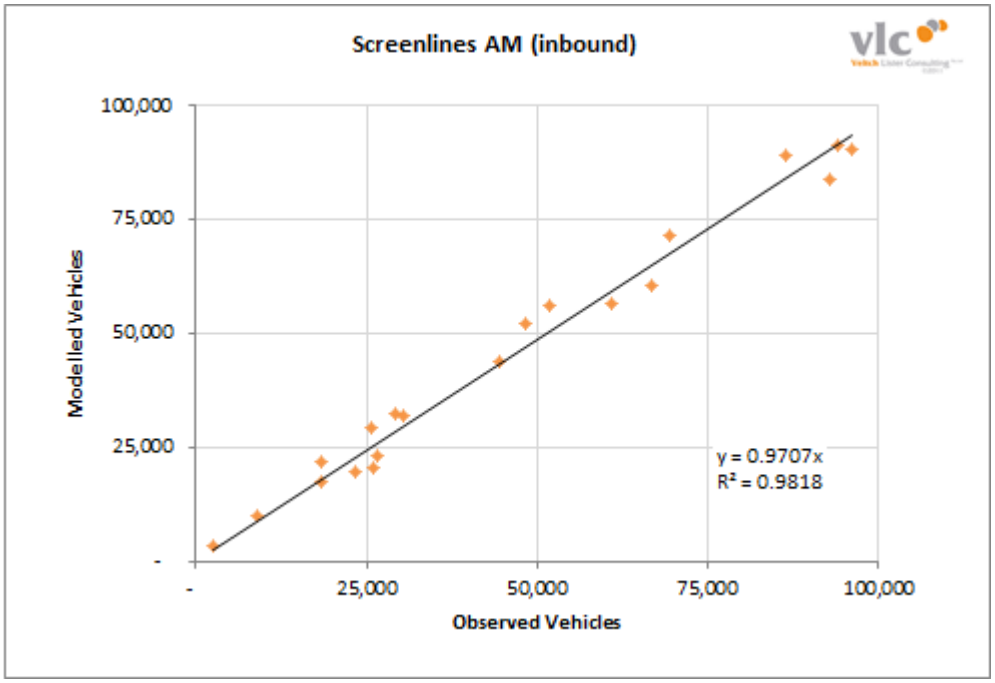

Figure 7 - AM Peak Screenline Totals (weekday) – Inbound

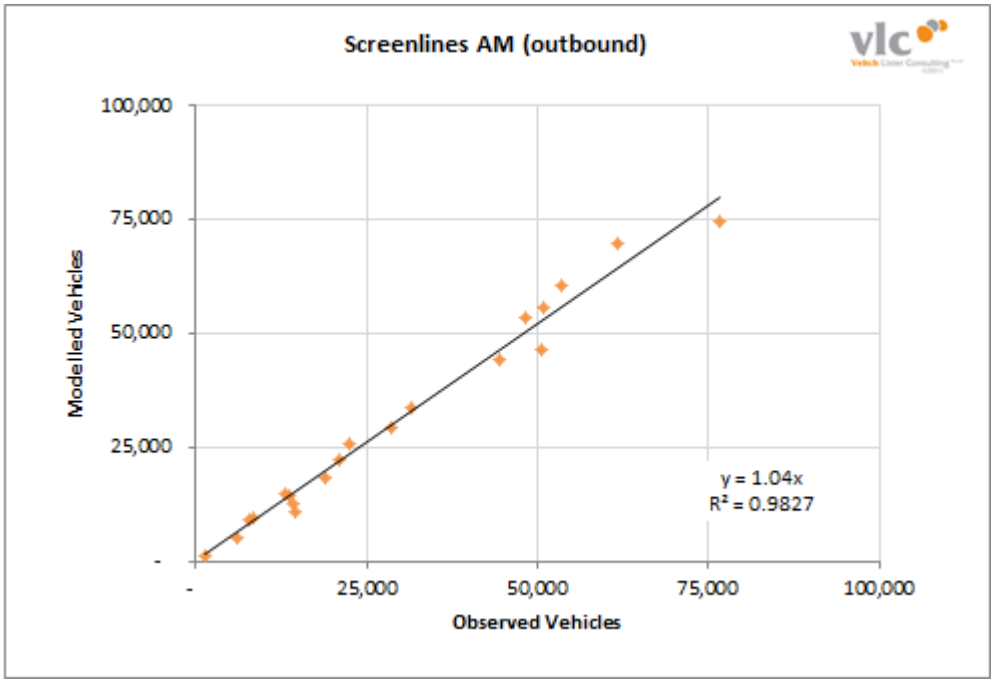

Figure 8 - AM Peak Screenline Totals (weekday) – Outbound

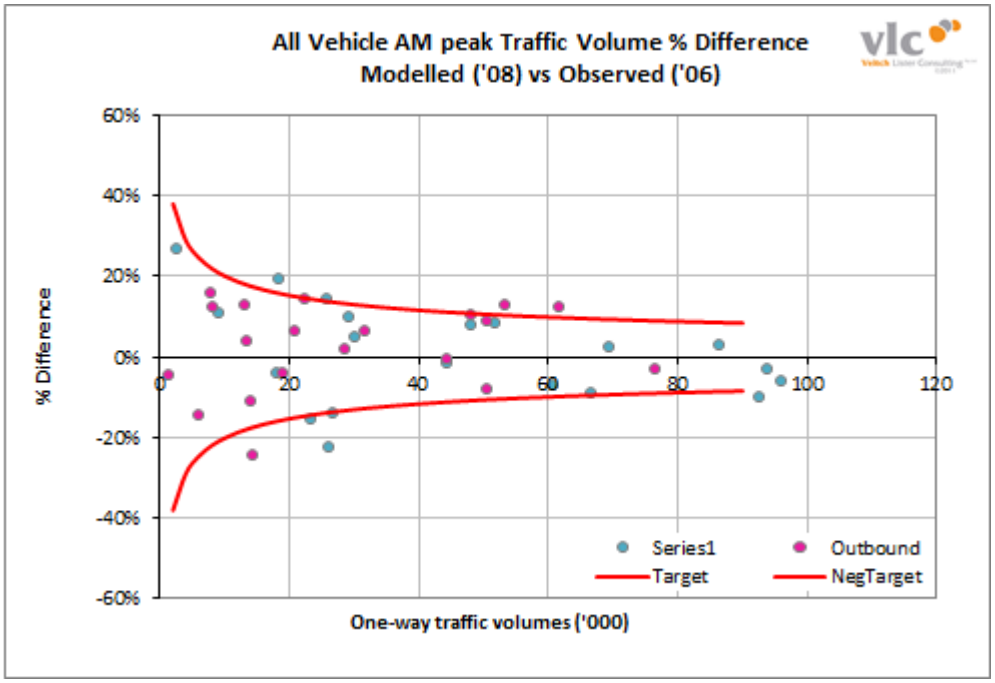

Figure 9 - Target Screenline Differences - AM Peak

2.1.3 PM Peak (4-6pm) Modelled and Observed Traffic Crossing Screenlines

Table 3 compares modelled and observed traffic crossing the screenlines by direction in the PM peak.

For 75% of the 42 cordon crossing movements the discrepancy between modelled and observed flows is less than 10 percent.

There is very close correspondence between modelled and observed flows as evidenced by the extremely high R^2 values (about 0.99) and regression slopes all close to 1.0 in Figure 10, Figure 11 and Figure 12.

How the recalibrated model is performing in relation to DoT's screenline model validation criteria for peak periods is shown in Figure 13. The validation criteria is met for all but 80% of the screenline crossing movements. Again, differences are expected due to population growth between 2006 and 2008, and the impact of new infrastructure.

	PM Observed_i2006 Traffic	Zenith Traffic	Difference	% Difference
900	**47,999**	**51,832**	**3,833**	**8.0%**
Inbound	16,254	18,611	2,357	14.5%
Outbound	31,745	33,221	1,476	4.6%
901	**165,229**	**173,798**	**8,569**	**5.2%**
Inbound	73,360	77,276	3,916	5.3%
Outbound	91,869	96,521	4,652	5.1%
902	**150,784**	**155,879**	**5,095**	**3.4%**
Inbound	62,357	67,077	4,720	7.6%
Outbound	88,427	88,802	375	0.4%
903	**114,301**	**111,265**	**-3,036**	**-2.7%**
Inbound	55,573	52,120	-3,453	-6.2%
Outbound	58,728	59,145	417	0.7%
904	**45,303**	**35,808**	**-9,495**	**-21.0%**
Inbound	16,405	14,587	-1,818	-11.1%
Outbound	28,898	21,221	-7,677	-26.6%
905	**17,190**	**16,551**	**-639**	**-3.7%**
Inbound	7,571	6,480	-1,091	-14.4%
Outbound	9,619	10,071	452	4.7%
906	**124,272**	**135,220**	**10,948**	**8.8%**
Inbound	53,867	59,932	6,065	11.3%
Outbound	70,405	75,288	4,883	6.9%
907	**35,030**	**35,967**	**937**	**2.7%**
Inbound	16,090	13,536	-2,554	-15.9%
Outbound	18,940	22,432	3,492	18.4%
908	**89,114**	**99,076**	**9,962**	**11.2%**
Inbound	37,038	40,746	3,708	10.0%
Outbound	52,076	58,330	6,254	12.0%
909	**170,755**	**178,733**	**7,978**	**4.7%**
Inbound	77,810	82,293	4,483	5.8%
Outbound	92,945	96,440	3,495	3.8%
910	**115,606**	**113,378**	**-2,228**	**-1.9%**
Inbound	50,239	51,125	886	1.8%
Outbound	65,367	62,253	-3,114	-4.8%
911	**152,101**	**160,307**	**8,206**	**5.4%**
Inbound	59,136	65,927	6,791	11.5%
Outbound	92,965	94,380	1,415	1.5%
912	**53,635**	**60,274**	**6,639**	**12.4%**
Inbound	25,360	28,088	2,728	10.8%
Outbound	28,275	32,186	3,911	13.8%
913	**54,721**	**54,652**	**-69**	**-0.1%**
Inbound	23,352	22,069	-1,283	-5.5%
Outbound	31,369	32,583	1,214	3.9%
914	**74,808**	**73,241**	**-1,567**	**-2.1%**
Inbound	24,239	28,093	3,854	15.9%
Outbound	50,569	45,148	-5,421	-10.7%
916	**91,563**	**89,155**	**-2,408**	**-2.6%**
Inbound	35,787	35,729	-58	-0.2%
Outbound	55,776	53,426	-2,350	-4.2%
917	**4,790**	**5,432**	**642**	**13.4%**
Inbound	1,776	2,040	264	14.9%
Outbound	3,014	3,392	378	12.6%
918	**35,280**	**36,876**	**1,596**	**4.5%**
Inbound	14,488	15,779	1,291	8.9%
Outbound	20,792	21,097	305	1.5%
919	**30,286**	**28,852**	**-1,434**	**-4.7%**
Inbound	10,750	10,946	196	1.8%
Outbound	19,536	17,906	-1,630	-8.3%
920	**33,173**	**32,172**	**-1,001**	**-3.0%**
Inbound	19,586	19,320	-266	-1.4%
Outbound	13,587	12,852	-735	-5.4%
Grand Total	**1,605,940**	**1,648,467**	**42,527**	**2.6%**

Table 3 - PM Peak Traffic at Screenlines

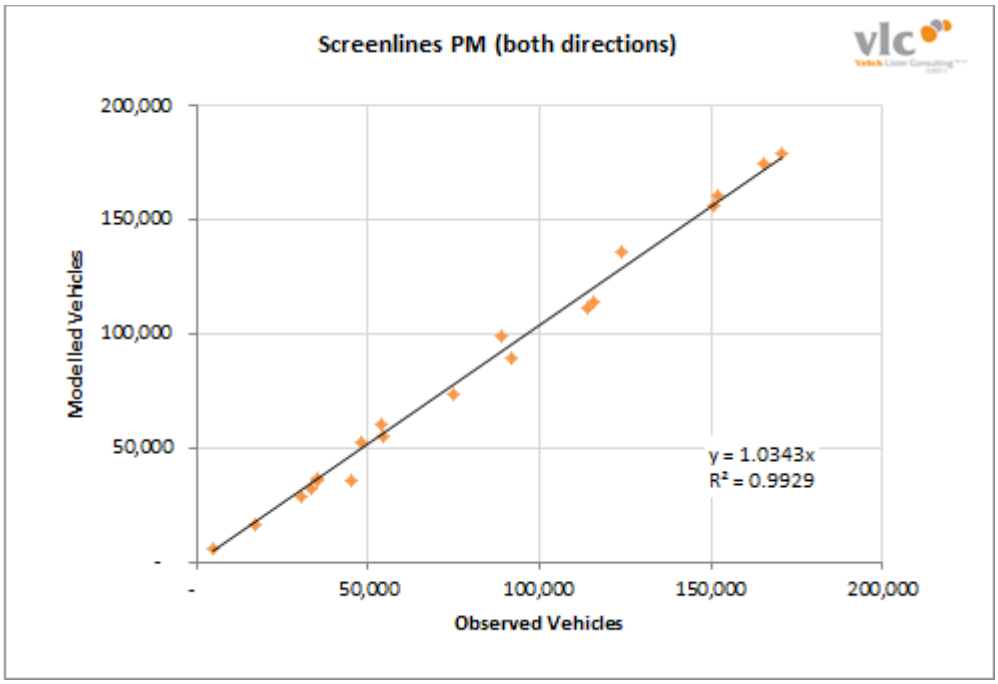

Figure 10 - PM Peak Screenline Totals (weekday)

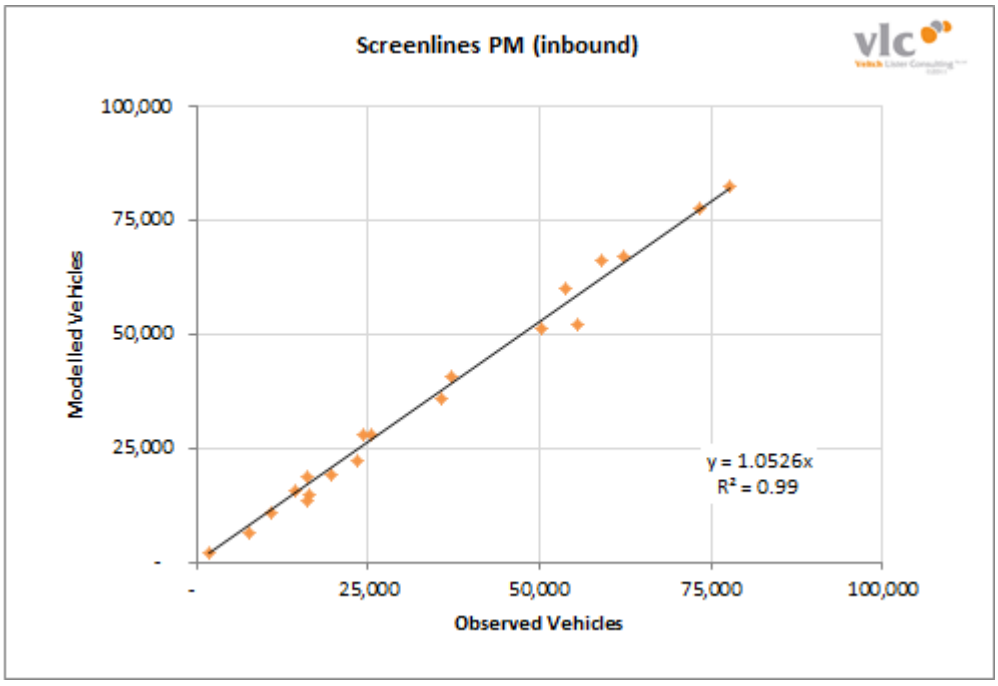

Figure 11 - PM Peak Screenline Totals (weekday) – Inbound

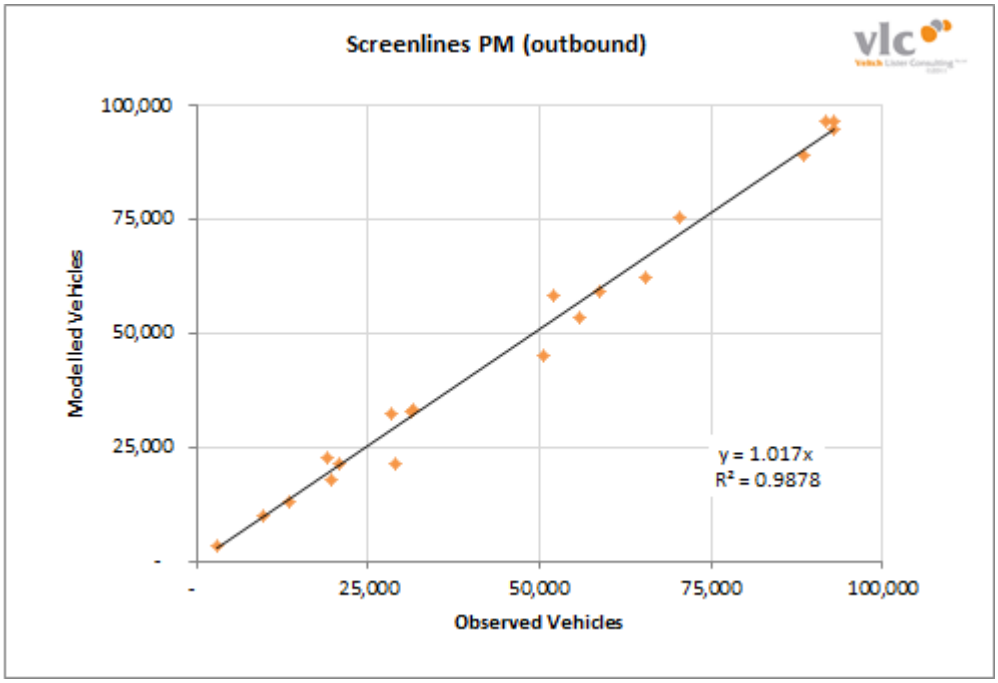

Figure 12 - PM Peak Screenline Totals (weekday) – Outbound

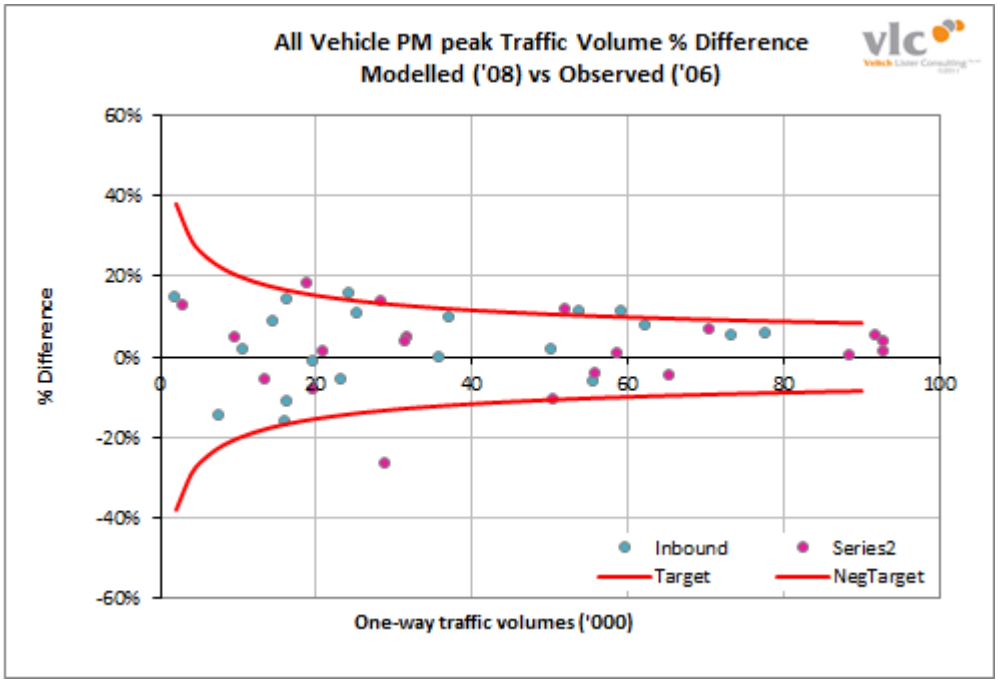

Figure 13 - Target Screenline Differences - PM Peak

2.2 Individual Traffic Count Validation

VLC has established a large database of predominantly 2006 traffic counts (sourced from VicRoads), specifically for the purpose of validating the Zenith model. The database contains 1,545 24-hour weekday counts, and 725 peak period counts.

Summary statistics in relation to the performance of the recalibrated model against the 2006 counts is presented in Table 4 and Table 5.

The model validation criteria specified by DoT with respect to replication of individual counts, as opposed to screenlines, are expressed in terms of R^2 values and slope of the regression line, route mean square error (%) and the GEH statistic. The specified targets are as follows:

- *Slope of best-fit regression line (constrained to pass through the origin) between 0.9 and 1.1.*
- *R^2 greater than or equal to 0.85.*
- *RMSE < 30%*
- *GEH < 5 for 60% of counts*
- *GEH < 10 for 95% of counts*
- *GEH < 12 for 100% of counts*

Referring to Table 4, the recalibrated Zenith model easily satisfies the R^2 and slope (gradient) criteria for all modelled time periods.

The model does not, however, satisfy the GEH statistic criteria. About 40% of counts have a GEH less than 5, as compared with the required 60%. It is however VLC's view that the GEH statistic criteria (as specified) is totally inappropriate in Australia. It is a UK derived standard that is applied in an environment where the use of "matrix estimation" techniques to "force" modelled volumes to closely approximate counts is standard practice. This practice is frowned upon in Australia.

The recalibrated model meets the RMSE validation standard for all roads carrying greater than 10,000 vpd.

Summary	AM	PM	Total
Number of counts	725	725	1,545
Total Count Volume	1,829,977	1,948,566	24,482,643
Total Modelled Volume	1,830,414	2,006,445	25,470,011
Difference (Abs)	437	57,879	987,368
Difference (%)	0.0%	3.0%	4.0%
y			
R2			
GEH < 5	39.7%	40.7%	47.6%
GEH < 10	73.1%	74.5%	81.8%

Table 4 - Traffic Validation Summary

	Volume bins	AM	PM	Volume bins	Daily
RSME	0 - 999	60.0	48.4	0 - 4,999	64.1
	1,000 - 1,999	31.2	33.6	5,000 - 9,999	41.3
	2,000 - 4,999	26.9	26.8	10,000 - 24,999	26.7
	5,000 - 9,999	22.4	21.0	25,000 - 49,999	28.2
	10,000 +	15.2	9.3	50,000 +	22.8
	All	31.3	28.0	All	35.4

Table 5 - RMSE Statistics

The modelled versus observed R^2 regression scatter-plots for individual counts, for the three modelled time periods, are presented in Figure 14, Figure 15 and Figure 16.

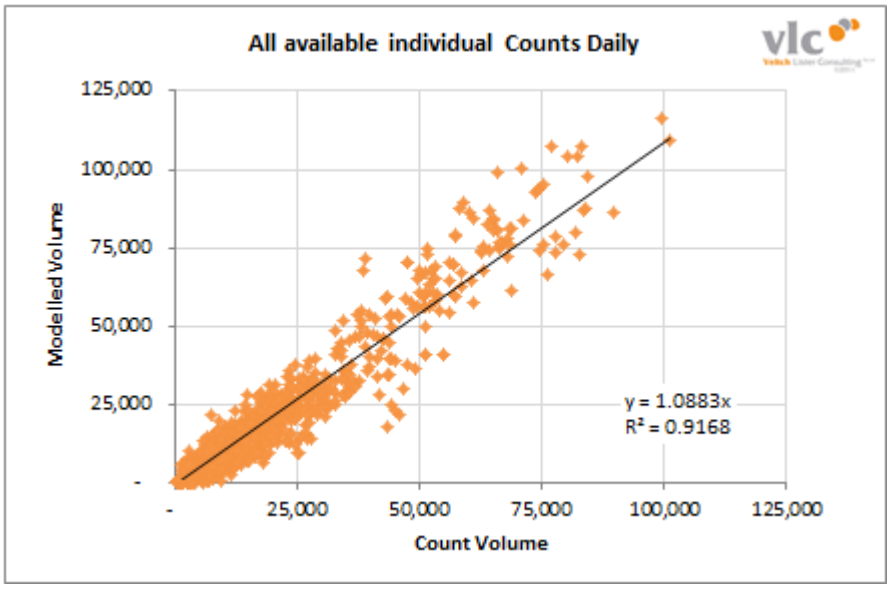

Figure 14 - Comparison with Traffic Counts - Daily

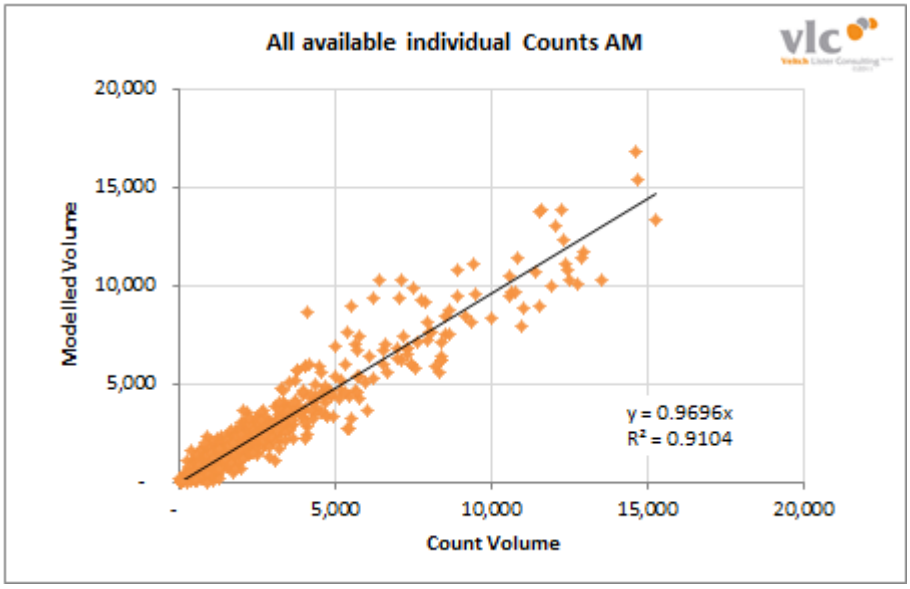

Figure 15 - Comparison with Traffic Counts - AM Peak

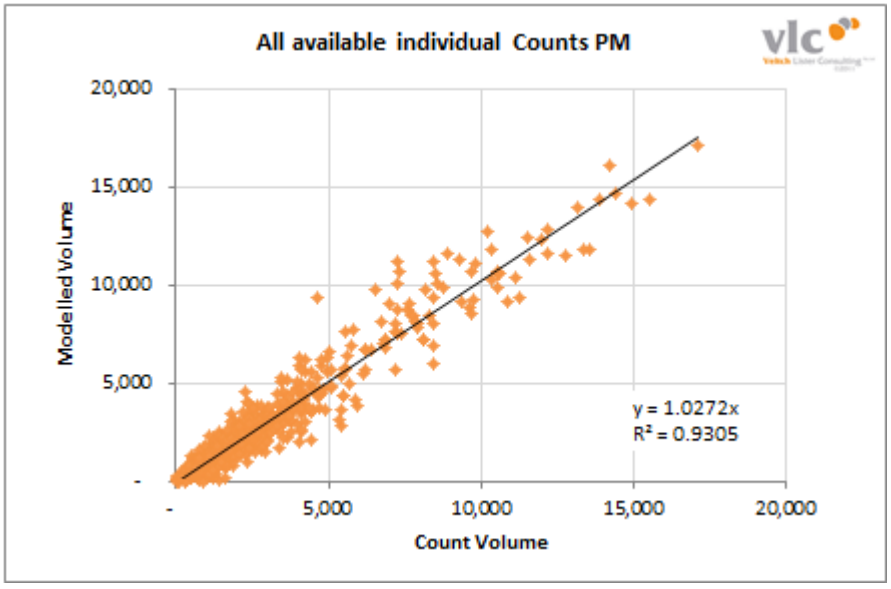

Figure 16 - Comparison with Traffic Counts - PM Peak

3 Validation against Observed Public Transport Demands

3.1 Train

3.1.1 Station Boardings

Modelled train station boardings have been compared with DOTs official estimated station boardings for 2008.

The official DOT estimates are based on the 2006 Metlink Train OD survey, factored to 2008 based on changes in validations, by station and hour of the day.

Table 6 presents the total modelled and observed (estimated) boardings for 2008, by time of day. Compared with these estimates, the model is slightly high (4.6%) in the AM Peak (7-9am), and slightly high in the PM Peak (7.7%) and over the whole day (10.1%).

Period	Observed	Model	Difference	% Difference
AM Peak	172,327	180,229	7,902	4.6%
PM Peak	153,292	165,024	11,732	7.7%
Daily	683,116	752,065	68,949	10.1%

Table 6 - Train Boardings by Period

The following sub-sections present more detailed comparisons by time of day.

3.1.1.1 Daily

Table 7 presents the total number of daily boardings by each of the 5 key line groups. The difference between model and observed estimates is generally around 10%, with the modelled estimates generally higher than observed. The largest difference occurs on the Clifton Hill group, with a difference of 16%. As will be explored in Section 3.1.2, we believe that this probable over-prediction is likely a result of demographic factors not currently included in the model.

Line Group	Observed	Modelled	Difference	% Difference
Burnley	127,007	130,729	3,722	2.9%
Caulfield	148,160	166,551	18,390	12.4%
Clifton Hill	63,902	74,188	10,286	16.1%
Northern	112,773	122,218	9,446	8.4%
CityLoop & Interchange Stations	231,274	258,379	27,105	11.7%

Table 7 - Daily Train Boardings by Line Group

Figure 17 and Table 8 present the modelled and observed estimates of daily boardings by line segment. Figure 18 presents the same comparison, but with the City Loop excluded (given its dominance). Including the City Loop (Figure 17) an R-Squared of 0.9908 is achieved, though this measure is heavily biased by the City Loop. Excluding the City Loop (Figure 18), an R-Squared of 0.917 is achieved. The

gradient (~1.078) again highlights that modelled rail boardings are slightly higher than observed estimates.

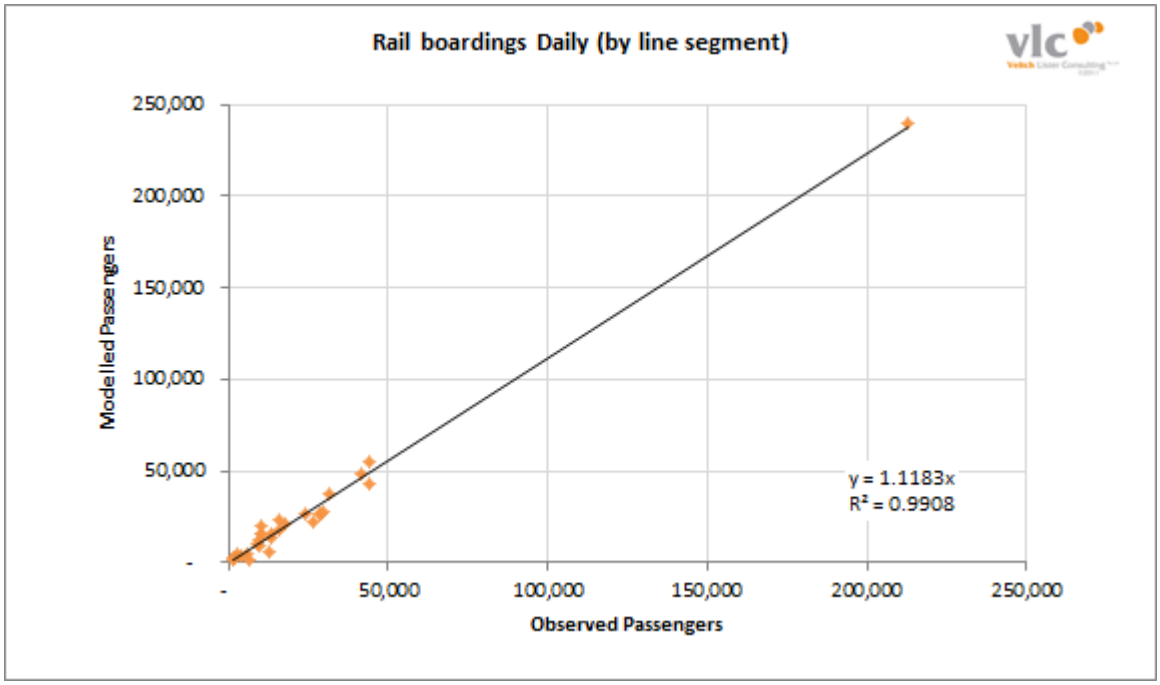

Figure 17 - Daily Train Boardings by Line Segment

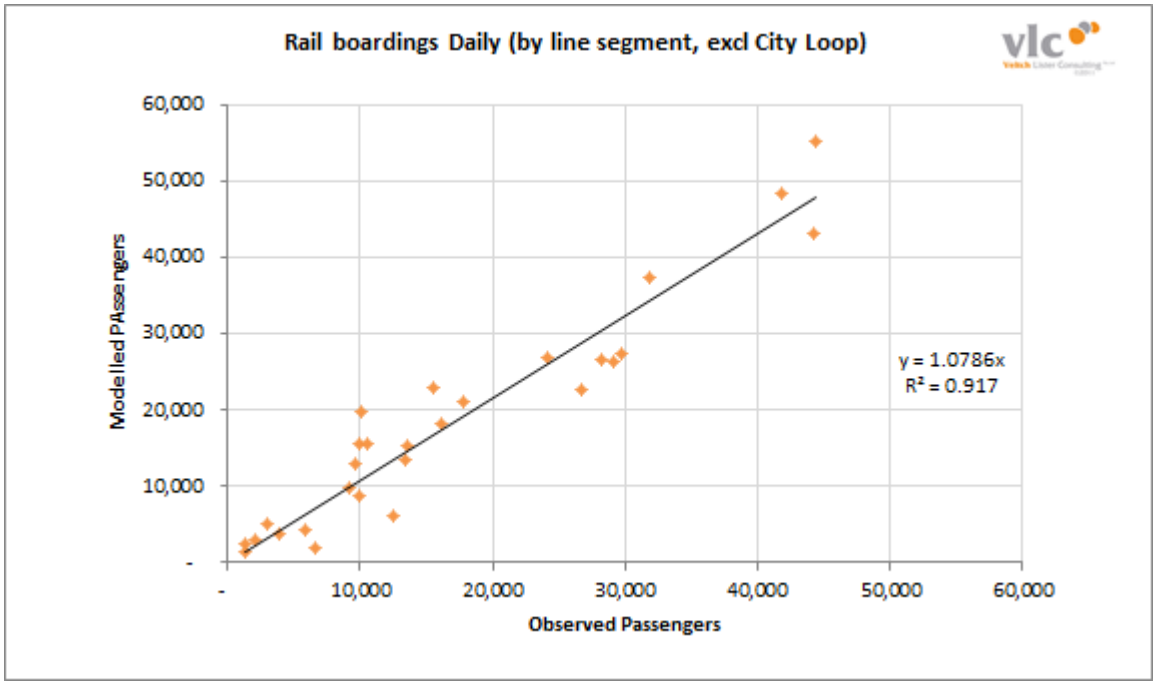

Figure 18 - Daily Train Boardings by Line Segment (excluding City Loop)

Group	Line Corridor	Line Segment	Observed	Modelled	Difference	(%)
Burnley	Camberwell Corridor	Riversdale-Alamein	5,883	4,351	-1,532	-26.0%
		Ringwood East-Lilydale	9,990	15,682	5,691	57.0%
		Heathmont-Belgrave	13,464	13,374	-90	-0.7%
		East Richmond-Camberwell	29,167	26,225	-2,942	-10.1%
		East Camberwell-Ringwood	41,874	48,301	6,427	15.3%
	Glen Waverley Line	Heyington-Glen Waverley	26,630	22,797	-3,833	-14.4%
Caulfield	Dandenong Corridor	Merinda Park-Cranbourne	3,033	5,004	1,971	65.0%
		Hallam-Pakenham	10,536	15,476	4,940	46.9%
		Carnegie-Dandenong	44,205	43,081	-1,124	-2.5%
	Frankston Line	Glenhuntly-Frankston	44,388	55,253	10,865	24.5%
	Sandringham Line	Prahran-Sandringham	28,258	26,535	-1,723	-6.1%
	Hawksburn-Caulfield	Hawksburn-Caulfield	17,740	21,201	3,461	19.5%
Clifton Hill	Epping Line	Rushall-Epping	24,190	26,816	2,626	10.9%
	Hurstbridge Line	Westgarth-Hurstbridge	29,698	27,459	-2,239	-7.5%
	Jolimont-Clifton Hill	Jolimont-Clifton Hill	10,013	19,912	9,899	98.9%
Inner City / City Loop	City Loop	City Loop	212,864	240,396	27,532	12.9%
	North Melbourne	North Melbourne	2,073	3,083	1,010	48.7%
	Richmond	Richmond	6,650	2,010	-4,640	-69.8%
	South Yarra	South Yarra	9,687	12,891	3,204	33.1%
Northern	Craigieburn Line	Kensington-Craigieburn	31,887	37,245	5,359	16.8%
	Newport Corridor	North Williamstown-Williamstown	3,921	3,689	-233	-5.9%
		Seddon-Newport	9,891	8,799	-1,092	-11.0%
		Sth Kensington-Footscray	12,576	6,027	-6,549	-52.1%
		Seaholme-Werribee	16,183	18,277	2,094	12.9%
	Sydenham Line	Middle Footscray-Sunshine	9,164	9,879	715	7.8%
		Albion-Sydenham	15,595	23,013	7,418	47.6%
	Upfield Line	Macauly-Upfield	13,556	15,290	1,733	12.8%
V/Line	Melton Line	Ardeer-Melton	1,264	2,461	1,197	94.6%
	Sunbury Line	Diggers Rest-Sunbury	1,281	1,293	12	1.0%
		Total Connex	**683,116**	**752,065**	**68,949**	**10.1%**
		Total V/Line	**2,546**	**3,754**	**1,209**	**47.5%**
		Total Metro Rail	**685,662**	**755,820**	**70,158**	**10.2%**

Table 8 - Daily Train Boardings by Line Segment

3.1.1.2 AM Peak (7-9am)

Table 9 presents the number of AM Peak (7-9am) boardings on each of the 5 major line groups.

Boardings on 4 of the 5 groups are within 8% of observed estimates. The exception is the City Loop & Interchange Stations, which has very low boardings in the morning peak.

Line Group	Observed	Modelled	Difference	% Difference
Burnley	44,947	42,178	- 2,769	-6.2%
Caulfield	51,382	55,507	4,125	8.0%
Clifton Hill	23,267	24,257	991	4.3%
Northern	42,180	45,349	3,169	7.5%
CityLoop & Interchange Stations	10,551	12,938	2,387	22.6%

Table 9 - AM Peak Train Boardings by Line Group

Figure 19 and Table 10 present modelled and observed estimates of AM Peak boardings by line segment. An R-Squared of 0.89 is achieved, with a gradient of 1.03.

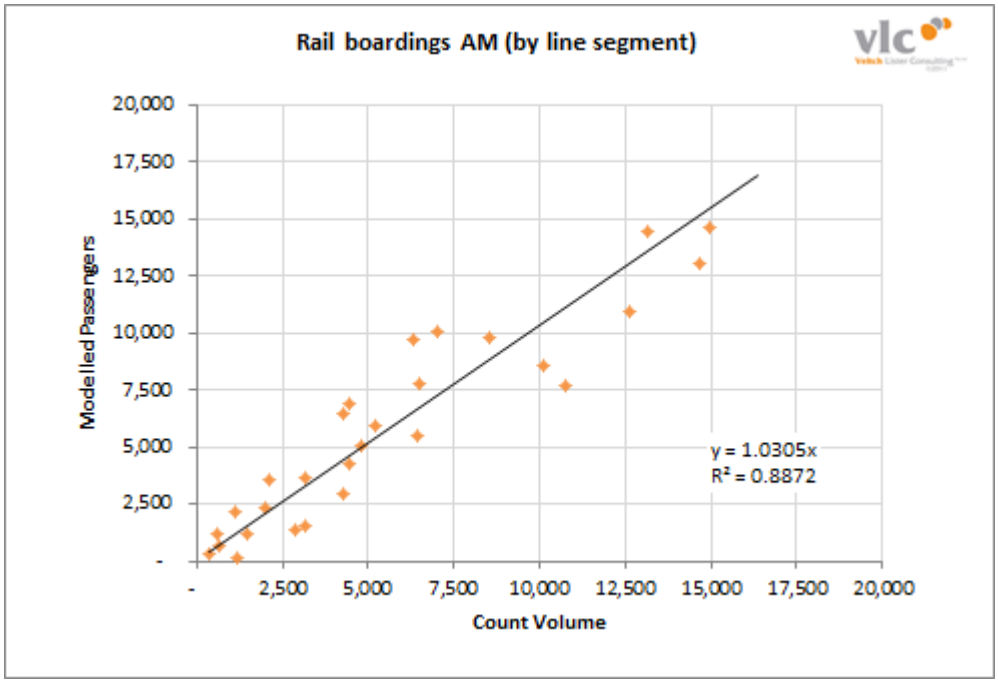

Figure 19 - AM Peak Train Boardings by Line Segment

Group	Line Corridor	Line Segment	Observed	Modelled	Difference	(%)
Burnley	Camberwell Corridor	Riversdale-Alamein	3,187	1,537	-1,650	-51.8%
		Ringwood East-Lilydale	4,424	6,912	2,488	56.2%
		Heathmont-Belgrave	5,232	5,926	694	13.3%
		East Richmond-Camberwell	6,416	5,509	-907	-14.1%
		East Camberwell-Ringwood	14,955	14,601	-353	-2.4%
	Glen Waverley Line	Heyington-Glen Waverley	10,733	7,692	-3,041	-28.3%
Caulfield	Dandenong Corridor	Merinda Park-Cranbourne	1,107	2,144	1,037	93.7%
		Hallam-Pakenham	4,295	6,425	2,131	49.6%
		Carnegie-Dandenong	14,683	13,052	-1,631	-11.1%
	Frankston Line	Glenhuntly-Frankston	16,382	20,247	3,865	23.6%
	Sandringham Line	Prahran-Sandringham	10,100	8,550	-1,550	-15.4%
	Hawksburn-Caulfield	Hawksburn-Caulfield	4,815	5,088	274	5.7%
Clifton Hill	Epping Line	Rushall-Epping	8,510	9,817	1,308	15.4%
	Hurstbridge Line	Westgarth-Hurstbridge	12,641	10,898	-1,743	-13.8%
	Jolimont-Clifton Hill	Jolimont-Clifton Hill	2,117	3,542	1,425	67.3%
Inner City / City Loop	City Loop	City Loop	7,026	10,086	3,060	43.6%
	North Melbourne	North Melbourne	349	338	-11	-3.2%
	Richmond	Richmond	1,201	174	-1,027	-85.5%
	South Yarra	South Yarra	1,975	2,340	365	18.5%
Northern	Craigieburn Line	Kensington-Craigieburn	13,171	14,399	1,228	9.3%
	Newport Corridor	North Williamstown-Williamstown	1,483	1,190	-293	-19.8%
		Seddon-Newport	4,281	2,980	-1,301	-30.4%
		Sth Kensington-Footscray	2,848	1,346	-1,502	-52.7%
		Seaholme-Werribee	6,469	7,770	1,301	20.1%
	Sydenham Line	Middle Footscray-Sunshine	3,160	3,660	500	15.8%
		Albion-Sydenham	6,319	9,728	3,409	53.9%
	Upfield Line	Macauly-Upfield	4,449	4,277	-172	-3.9%
V/Line	Melton Line	Ardeer-Melton	622	1,148	526	84.6%
	Sunbury Line	Diggers Rest-Sunbury	635	676	41	6.5%
		Total Connex	**172,327**	**180,229**	**7,902**	**4.6%**
		Total V/Line	**1,256**	**1,824**	**567**	**45.1%**
		Total Metro Rail	**173,584**	**182,052**	**8,469**	**4.9%**

Table 10 - AM Peak Train Boardings by Line Segment

3.1.1.3 PM Peak (4-6pm)

Table 11 presents a summary of PM Peak (4-6pm) boardings by each of the 5 major line groups. The difference between modelled and observed estimates is generally around 10% - the exception is the Clifton Hill group, where the modelled estimate is 25% higher than the observed. The Clifton Hill group is, however, the group with the lowest number of boardings.

Line Group	Observed	Modelled	Difference	% Difference
Burnley	18,170	16,329	- 1,840	-10.1%
Caulfield	19,505	19,527	22	0.1%
Clifton Hill	7,600	9,491	1,891	24.9%
Northern	11,487	10,123	- 1,364	-11.9%
CityLoop & Interchange Stations	96,531	109,553	13,022	13.5%

Table 11 - PM Peak Train Boardings by Line Group

Figure 20 and Table 12 present modelled and observed PM Peak boardings by line segment. In Figure 21, the City Loop is excluded to enable a clearer examination of the other line segments.

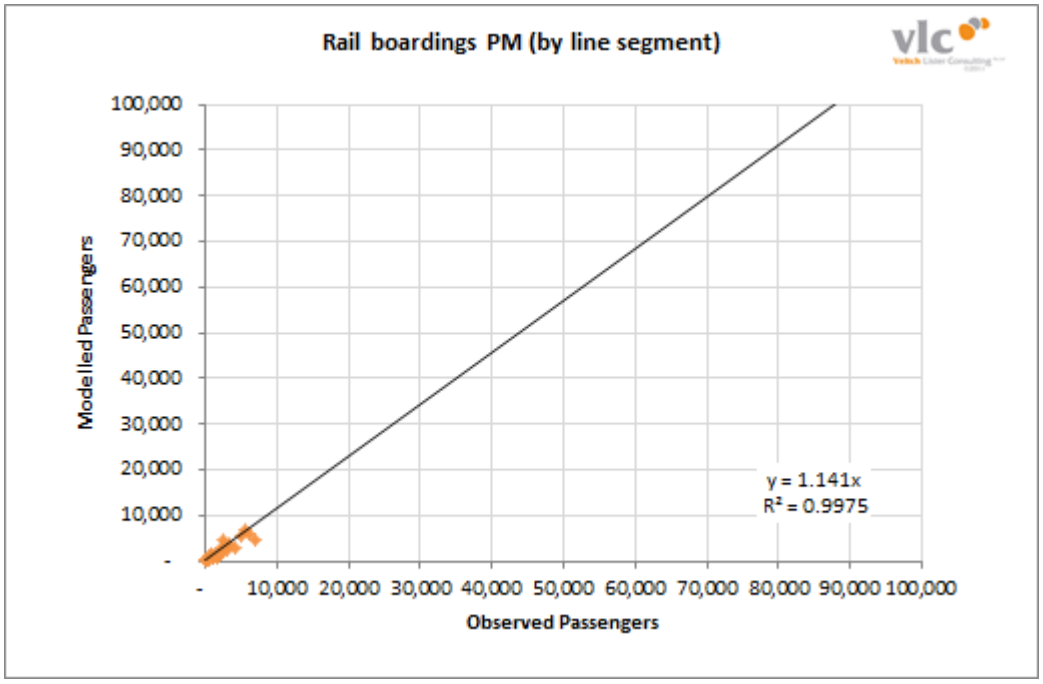

Figure 20 - PM Peak Train Boardings by Line Segment

Referring to Figure 21, an R-Squared of 0.82 is achieved, with a gradient of 0.95. The R-Squared is lower than that achieved for the AM Peak (0.89). This is due to the lower number of boardings which occur at suburban stations during the PM Peak (60% of PM Peak boardings are at City Loop stations).

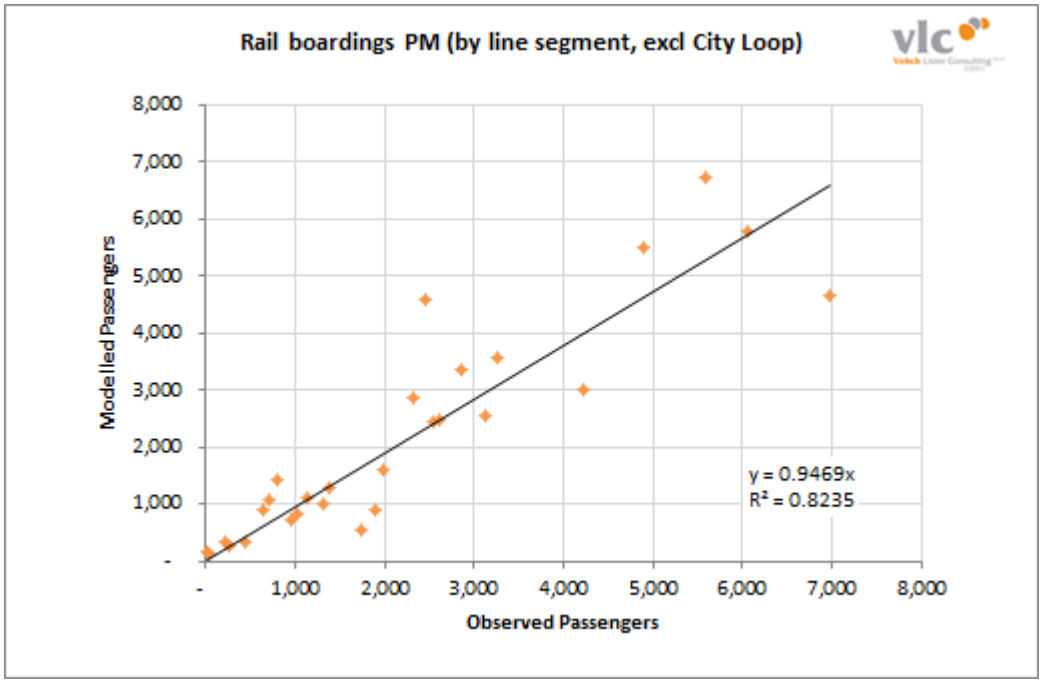

Figure 21 - PM Peak Train Boardings by Line Segment - excluding City Loop

Group	Line Corridor	Line Segment	Observed	Modelled	Difference	(%)
Burnley	Camberwell Corridor	Riversdale-Alamein	449	342	-106	-23.7%
		Ringwood East-Lilydale	706	1,064	358	50.7%
		Heathmont-Belgrave	1,328	1,013	-315	-23.7%
		East Richmond-Camberwell	6,965	4,655	-2,310	-33.2%
		East Camberwell-Ringwood	5,594	6,715	1,121	20.0%
	Glen Waverley Line	Heyington-Glen Waverley	3,127	2,540	-587	-18.8%
Caulfield	Dandenong Corridor	Merinda Park-Cranbourne	258	268	10	3.8%
		Hallam-Pakenham	810	1,423	613	75.7%
		Carnegie-Dandenong	6,054	5,775	-279	-4.6%
	Frankston Line	Glenhuntly-Frankston	4,889	5,495	606	12.4%
	Sandringham Line	Prahran-Sandringham	4,230	2,993	-1,236	-29.2%
	Hawksburn-Caulfield	Hawksburn-Caulfield	3,264	3,573	309	9.5%
Clifton Hill	Epping Line	Rushall-Epping	2,544	2,446	-97	-3.8%
	Hurstbridge Line	Westgarth-Hurstbridge	2,605	2,471	-134	-5.2%
	Jolimont-Clifton Hill	Jolimont-Clifton Hill	2,451	4,574	2,123	86.6%
Inner City / City Loop	City Loop	City Loop	91,806	105,243	13,437	14.6%
	North Melbourne	North Melbourne	652	911	259	39.8%
	Richmond	Richmond	1,744	547	-1,196	-68.6%
	South Yarra	South Yarra	2,330	2,852	522	22.4%
Northern	Craigieburn Line	Kensington-Craigieburn	2,864	3,343	479	16.7%
	Newport Corridor	North Williamstown-Williamstown	228	328	100	44.1%
		Seddon-Newport	951	732	-219	-23.0%
		Sth Kensington-Footscray	1,907	910	-998	-52.3%
		Seaholme-Werribee	1,141	1,103	-38	-3.3%
	Sydenham Line	Middle Footscray-Sunshine	1,021	823	-198	-19.4%
		Albion-Sydenham	1,395	1,272	-122	-8.7%
	Upfield Line	Macauly-Upfield	1,980	1,611	-369	-18.6%
V/Line	Melton Line	Ardeer-Melton	25	166	141	551.2%
	Sunbury Line	Diggers Rest-Sunbury	40	120	80	201.7%
		Total Connex	**153,292**	**165,024**	**11,732**	**7.7%**
		Total V/Line	**65**	**286**	**221**	**337.9%**
		Total Metro Rail	**153,358**	**165,310**	**11,953**	**7.8%**

Table 12 - PM Peak Train Boardings by Line Segment

3.1.2 CBD Cordon

Modelled AM Peak, inbound line loads have been compared with DOT (observed) estimates at a cordon surrounding the CBD. The various lines have been grouped according to the four major suburban line groups.

Overall modelled demand is 3.5% lower than the observed estimates. This overall difference is largely a result of differences on the Burnley group, where the model is 14% lower than observed estimates.

	Observed	Modelled	Difference	(%)
Northern	**35,151**	**37,240**	**2,089**	**5.9%**
Williamstown	4,029	2,216	-1,813	-45.0%
Werribee	7,075	8,426	1,351	19.1%
Sydenham	8,898	12,026	3,128	35.2%
Craigieburn	11,805	11,268	-537	-4.6%
Upfield	3,344	3,305	-39	-1.2%
Clifton Hill	**17,020**	**15,037**	**-1,983**	**-11.7%**
Epping	6,549	7,067	518	7.9%
Hurstbridge	10,471	7,970	-2,501	-23.9%
Burnley	**31,137**	**26,884**	**-4,253**	**-13.7%**
Camberwell	23,126	21,142	-1,984	-8.6%
Glen Waverley	8,011	5,742	-2,269	-28.3%
Caulfield	**36,741**	**36,653**	**-88**	**-0.2%**
Dandenong	15,889	14,585	-1,304	-8.2%
Frankston	12,595	15,288	2,693	21.4%
Sandringham	8,257	6,780	-1,477	-17.9%
Total	**120,047**	**115,814**	**-4,233**	**-3.5%**

Table 13 - Load at CBD Cordon by Line (AM Peak Only)

3.2 Tram

Modelled tram demands have been compared with observed estimates obtained through the 2008 Tram OD survey.

Table 14 presents total tram boardings by time of day and direction. Over the entire day, the model's estimates are 18% lower than estimates obtained from the Tram OD survey. This difference is quite consistent across both directions – up and down – and appears to be most pronounced to the non-peak periods (inter peak and off peak).

Generally speaking, the relativity between up and down demands is consistent between modelled and observed estimates.

		Observed_i1 Passengers	Zenith Passengers	Difference	% Difference
AM	UP	60,595	49,945	- 10,650	-17.58%
	DOWN	40,664	35,828	- 4,836	-11.89%
MD	UP	124,345	97,228	- 27,117	-21.81%
	DOWN	122,450	86,052	- 36,398	-29.72%
PM	UP	45,275	47,132	1,857	4.10%
	DOWN	58,215	55,129	- 3,086	-5.30%
OP	UP	54,782	44,215	- 10,566	-19.29%
	DOWN	60,418	46,325	- 14,093	-23.33%
Daily	UP	284,996	238,519	- 46,476	-16.31%
	DOWN	281,746	223,334	- 58,412	-20.73%

Table 14 - Tram Boardings by Time of Day and Direction

Table 15 further segments tram demands by individual route, while Figure 22, Figure 23 and Figure 24 present scatter plots of the AM Peak, PM Peak and Daily tram route boardings. In the AM Peak, an R-Squared of 0.45 and gradient of 0.77 is achieved. In the PM Peak an R-Squared of 0.55 is achieved, with a gradient of 0.72, while across the entire day an R-Squared of 0.60 is achieved with a gradient of 0.78.

		AM		MD		PM		OP		Daily	
		Observed_i1 Passengers	Zenith Passengers	Observed_i1 Passengers	Zenith Passengers	Observed_i1 Passengers	Zenith Passengers	Observed_i1 Passengers	Zenith Passengers	Observed_i1 Passengers	Zenith Passengers
1	UP	2,011	2,895	4,650	9,136	2,224	5,449	2,730	4,084	11,614	21,564
	DOWN	1,790	4,316	5,806	9,218	2,805	4,617	3,143	4,101	13,543	22,253
3	UP	2,583	1,246	3,403	2,720	1,185	1,143	4,527	1,541	11,698	6,649
	DOWN	1,009	687	4,930	1,929	2,124	994	2,638	1,171	10,700	4,782
5	UP	1,173	1,053	3,630	2,107	1,011	1,200	738	1,370	6,551	5,731
	DOWN	902	647	2,406	1,547	1,870	973	594	969	5,772	4,135
6	UP	2,318	1,749	4,534	3,164	2,131	1,750	1,415	1,772	10,397	8,434
	DOWN	1,290	855	4,282	2,375	2,628	1,495	1,503	1,601	9,702	6,326
8	UP	3,531	4,725	6,586	7,202	3,386	2,570	4,369	3,726	17,871	18,223
	DOWN	2,902	2,018	7,320	6,426	3,250	4,892	2,857	3,862	16,329	17,197
16	UP	1,816	2,382	7,027	5,586	2,902	2,198	3,273	2,924	15,017	13,091
	DOWN	1,491	3,268	6,913	5,375	3,064	2,465	4,195	2,721	15,662	13,829
19	UP	3,445	2,329	9,554	5,924	2,127	3,628	2,519	1,999	17,643	13,880
	DOWN	2,261	1,530	8,754	4,743	3,533	2,598	3,244	2,275	17,791	11,146
24	UP	509	905	79	154		113			588	1,173
	DOWN					641	1,941			641	1,941
30	UP	456	213	1,012	1,493	491	2,063	54	1	2,012	3,769
	DOWN	367	337	1,076	488	325	601	50	2	1,818	1,429
48	UP	2,392	1,742	3,202	2,378	954	505	1,619	978	8,166	5,603
	DOWN	1,277	798	3,845	1,982	2,087	1,278	2,551	1,402	9,759	5,460
55	UP	4,777	2,054	3,175	3,302	1,365	1,382	1,462	1,351	10,779	8,089
	DOWN	1,472	1,050	3,384	2,986	2,726	2,100	1,677	1,555	9,259	7,691
57	UP	2,696	1,600	6,705	2,876	1,328	1,038	3,135	1,123	13,863	6,637
	DOWN	909	542	5,871	2,599	2,793	1,852	3,668	1,486	13,240	6,479
59	UP	4,649	1,774	6,826	3,376	2,344	967	1,762	1,225	15,580	7,342
	DOWN	1,515	672	6,912	2,964	3,756	1,901	2,831	1,499	15,013	7,037
64	UP	1,670	1,607	3,910	2,921	1,311	1,375	1,336	1,691	8,226	7,593
	DOWN	1,294	786	3,028	2,322	2,015	1,410	1,769	1,448	8,105	5,966
67	UP	2,033	2,246	3,732	3,540	1,019	1,417	1,227	2,076	8,011	9,279
	DOWN	1,284	898	3,969	2,051	1,810	1,530	1,960	1,365	9,022	5,844
70	UP	1,272	1,341	3,022	2,619	823	725	1,319	935	6,435	5,621
	DOWN	804	672	2,847	2,316	1,632	1,228	1,961	1,237	7,243	5,452
72	UP	1,441	1,553	5,281	3,888	1,769	1,710	1,644	2,013	10,135	9,164
	DOWN	1,241	1,039	3,932	2,744	1,719	1,477	3,309	1,582	10,200	6,842
75	UP	4,706	2,220	7,055	3,979	2,179	1,342	4,891	1,620	18,831	9,162
	DOWN	3,135	1,557	7,373	3,773	3,196	2,293	5,508	2,135	19,211	9,758
78	UP	631	1,291	2,082	3,412	859	1,381	273	419	3,845	6,503
	DOWN	613	1,130	2,576	2,543	634	804	212	195	4,034	4,672
79	UP							578	718	578	718
	DOWN							608	1,256	608	1,256
82	UP	339	405	2,020	1,218	731	466	623	311	3,713	2,401
	DOWN	338	530	1,845	1,169	531	383	376	119	3,090	2,201
86	UP	2,753	1,247	10,806	5,087	4,917	5,102	4,466	2,657	22,942	14,093
	DOWN	4,335	3,018	10,407	5,934	2,724	2,345	3,780	2,196	21,245	13,492
96	UP	5,045	1,669	8,900	3,942	2,927	2,419	3,500	1,969	20,371	9,999
	DOWN	3,105	1,503	9,171	3,501	4,233	4,212	2,796	1,650	19,305	10,866
109	UP	4,545	6,085	10,241	8,905	4,523	3,641	3,888	3,733	23,196	22,365
	DOWN	5,161	3,950	8,573	7,827	4,809	5,925	5,472	4,973	24,014	22,674
112	UP	3,809	4,196	6,919	7,494	2,774	2,540	3,438	3,978	16,938	18,207
	DOWN	2,175	3,330	7,235	8,448	3,316	4,121	3,718	5,369	16,444	21,268
Grand Total		**101,259**	**83,660**	**246,795**	**181,684**	**103,490**	**99,557**	**115,199**	**90,385**	**566,742**	**455,286**

Table 15 - Tram Route Boardings by Time of Day

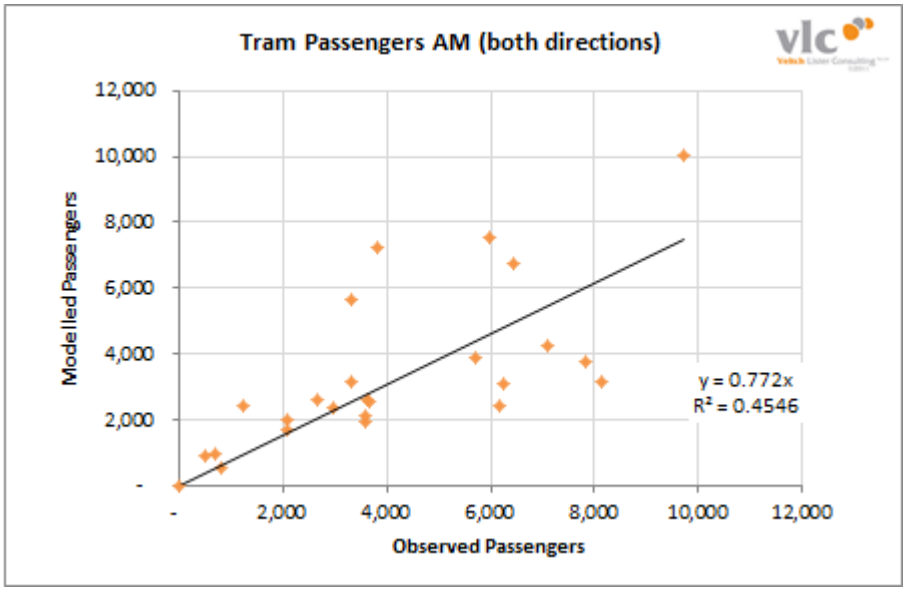

Figure 22 - AM Peak Tram Boardings by Route

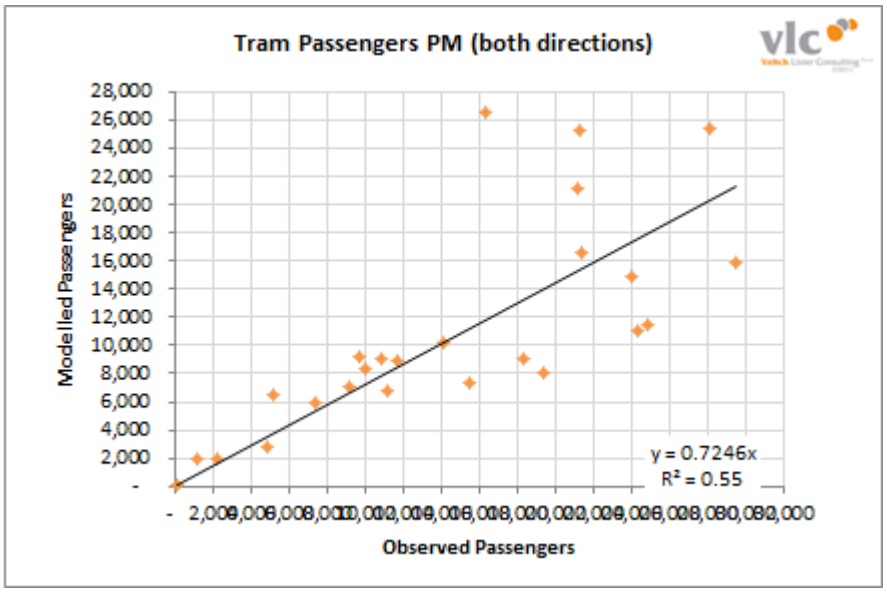

Figure 23 - PM Peak Tram Boardings by Route

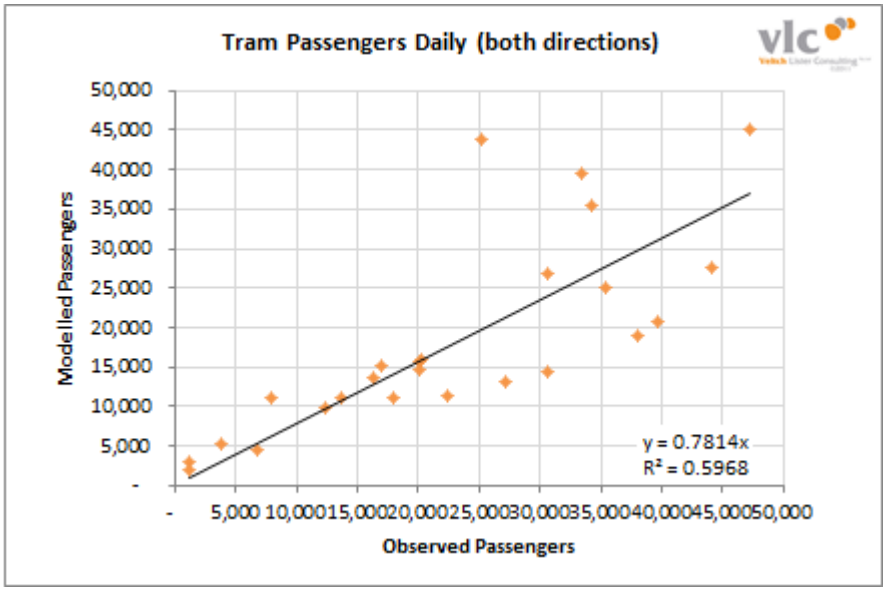

Figure 24 - Daily Tram Boardings by Route

3.3 Bus

Modelled bus demands have been compared with DOT estimates. These estimates are based on ticket validations in 2008, factored up to reflect an assumed average global "validation rate" of 89%.

Table 15 presents a summary of observed and modelled bus boardings by time of day. In the AM Peak the modelled estimates are 4% higher than observed. In the PM Peak and non-peak periods, modelled estimates are approximately 2% and 13% low respectively, resulting in a daily difference of 3%.

Period	Observed	Modelled	Difference	% Difference
AM Peak	70,879	73,845	2,966	4.2%
Non Peak	194,138	189,939	- 4,199	-2.2%
PM Peak	58,037	50,584	- 7,453	-12.8%
Daily	323,054	314,368	- 8,685	-2.7%

Table 16 - Bus Boardings by Time of Day

Table 17 presents a comparison of modelled and observed bus boardings by bus category, and time of day. There is generally very close agreement between the modelled and observed estimates for each category, for all times of the day. The one exception is Smart Bus routes, where the model is considerably higher. We believe this to be due to changes in the bus network (ie. expansion of Smart Bus network, particularly the inclusion of route 903) which have been included in the Zenith model, but which are not part of the observed bus data. The observed estimates are based on validations during March, May, August and October of 2008, while the Zenith PT network is based on November 2009.

Bus Category	AM		MD		PM		Daily	
	Observed	Zenith	Observed	Zenith	Observed	Zenith	Observed	Zenith
Commuter	488	213	128	77	286	389	901	680
Coverage	17,382	19,957	49,642	44,157	14,039	10,908	81,062	75,023
Direct	25,719	21,404	68,498	63,028	21,442	18,487	115,659	102,919
Hybrid	18,743	16,498	50,845	39,151	14,612	9,982	84,200	65,631
InterTown	2,740	4,845	7,432	11,078	2,216	3,061	12,388	18,984
SmartBus	5,028	10,917	16,434	32,254	4,928	7,662	26,389	50,833
Special	780	10	1,159	194	515	94	2,454	299
Grand Total	**70,879**	**73,845**	**194,138**	**189,939**	**58,037**	**50,584**	**323,054**	**314,368**

Table 17 - Bus Route Boardings by Route Category

Table 18 presents a comparison of bus route boardings grouped by region. Again there is a very high level of agreement between modelled and observed estimates. The exceptions are Smart Bus (for the reasons outlined above), Middle North and Middle West. The differences for the Middle North and Middle West regions are likely caused by the inclusion of Smart Bus route 903 in the Zenith network, which (in Zenith) carries 25,000 passengers daily, and runs as an orbital through the heart of the Middle North and Middle West regions.

Given the noted differences in the bus network, it will be useful to perform a similar comparison using more recent data, and with a consistent bus network.

Region	AM		MD		PM		Daily	
	Observed	Zenith	Observed	Zenith	Observed	Zenith	Observed	Zenith
Brimbank	2,407	2,521	6,521	5,183	1,741	1,130	10,669	8,835
Central Melbourne	13,388	9,718	31,486	33,186	10,645	11,248	55,519	54,153
Doncaster/Whitehor	3,971	4,181	8,947	9,140	3,143	2,493	16,061	15,815
Frankston	1,366	1,787	4,671	4,525	1,077	961	7,113	7,273
Hume	2,226	2,558	5,737	5,928	1,660	1,425	9,623	9,911
Inner East	319	85	675	242	117	33	1,111	359
InterTown	2,136	3,434	5,427	7,456	1,699	2,068	9,261	12,958
Melton	356	522	1,024	1,221	236	282	1,616	2,025
Middle North	5,878	3,347	17,499	9,744	4,858	2,307	28,234	15,398
Middle West	6,358	3,684	19,285	8,996	5,250	2,137	30,893	14,817
Mornington	905	1,893	3,230	5,475	739	1,195	4,874	8,564
Outer East	6,002	8,193	15,657	17,483	5,020	5,139	26,678	30,815
Outer South East	2,504	3,509	6,770	7,861	1,949	1,911	11,223	13,281
SmartBus	2,824	7,444	8,622	21,602	2,679	4,753	14,126	33,799
South East	15,753	15,080	44,935	38,515	13,424	10,620	74,112	64,215
Sunbury	283	316	727	582	164	142	1,174	1,040
Whittlesea	2,664	3,524	8,603	8,069	2,334	1,700	13,602	13,294
Wyndham	1,538	2,049	4,324	4,731	1,304	1,039	7,166	7,819
Grand Total	**70,879**	**73,845**	**194,138**	**189,939**	**58,037**	**50,584**	**323,054**	**314,368**

Table 18 - Bus Route Boardings by Region

Finally, Table 19 presents bus route boardings grouped by route series (200s, 300s, etc). Again, there is a high level of agreement between the modelled and observed estimates. The major exceptions are the 400s and 500s where the model tends to be lower, and the 900s where the model is higher. Once again, these differences are related to the expansion of the Smart Bus network, particularly the inclusion of Route 903. The 400s and 500s predominantly serve the Middle North and Middle West regions, through which Route 903 now runs.

	AM Peak Observed Passengers	Zenith Passengers	Off Peak Observed Passengers	Zenith Passengers	PM Peak Observed Passengers	Zenith Passengers	Daily Observed Passengers	Zenith Passengers
200	9,963	8,354	28,921	28,840	8,536	8,435	47,420	45,628
300	5,590	4,070	8,575	9,077	3,862	4,123	18,027	17,270
400	12,858	10,336	35,447	24,975	9,859	5,863	58,164	41,174
500	11,016	10,449	32,404	25,753	9,138	6,121	52,559	42,323
600	7,979	8,973	19,394	18,994	6,229	5,815	33,601	33,782
700	11,481	13,461	31,481	32,899	9,702	8,991	52,664	55,350
800	9,810	10,434	30,112	25,819	8,430	5,942	48,351	42,195
900	2,182	7,649	7,805	23,429	2,280	5,222	12,267	36,300
Grand Total	**70,879**	**73,726**	**194,138**	**189,785**	**58,037**	**50,512**	**323,054**	**314,023**

Table 19 - Bus Route Boardings by Route Series