CONTRACT REPORT

Before and after evaluation of active advance warning signs (AAWS) installed at the Cressy railway level crossing

by David Green

for VicRoads on behalf of the Victorian Railway Crossing Safety Steering Committee (VRCSSC)

001264- February 2010

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Chris Jurewicz

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SUMMARY

VicRoads, on behalf of the Victorian Railway Crossing Safety Steering Committee (VRCSSC) commissioned ARRB to undertake a before and after evaluation study of the effectiveness of the active advance warning signs (AAWS) at improving driver approach speeds and compliance with the level crossing controls.

The before and after installation of AAWS was undertaken at the level crossing located on the Hamilton Highway in Cressy (LX1516) which was controlled by flashing lights and boom barriers.

The study involved the use of pneumatic tube traffic data loggers at the level crossing to log traffic data and the status of the railway level crossing control (e.g. flashing light only phase, boom down phase etc.). The study was undertaken over a four week period before and after the installation of the AAWS.

The key findings of the study were as follows:

1. The study was unable to conclude if AAWS influenced driver approach speeds on the approach to the level crossing. Larger sample sizes would be needed before reliable conclusions could be made.
2. The study was unable to confirm if vehicles traverse level crossings any differently, just prior to and during the period when the level crossing is active, when AAWS are installed compared to without their installation. Larger sample sizes would be needed before reliable conclusions could be made.
3. Based on a small sample size the study suggests that the AAWS did not impact on the number or timing of the violations. However a larger violation sample would be needed to conclude this with any confidence.

To establish more robust results a larger sample would be needed for many rural level crossing locations (where AAWS are typically used). This would require permanent data collection stations to enable the collection of data over an extended period (i.e. well in excess of four weeks and until sufficient samples are collected).

It is considered likely that AAWS is being treated by drivers as a supplementary device providing advanced warning of the requirement to stop at the railway crossing, rather than a mechanism to improve approach speed and compliance. It is suggested, that the greatest benefit of AAWS would be for scenarios where there is poor sight distance to the level crossing control or in providing further warning to those drivers that may be complacent or not fully alert when approaching the level crossing.

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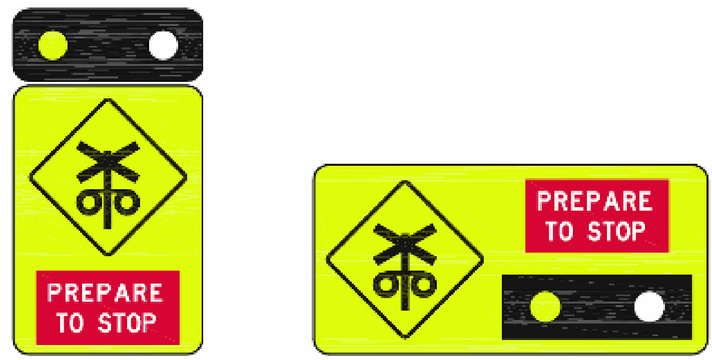
1 INTRODUCTION

Level crossing crashes have become a major concern in Victoria with the occurrence of several vehicle to train crashes in recent times that resulted in multiple fatalities and significant property damage.

An outcome of a review of level crossing safety was a proposal to install active advance warning signs (AAWS) at level crossings to improve the level of driver awareness and response to the crossing prior to the arrival of a train. Typical AAWS signs are shown in Figure 1.1.



Source: Standards Australia (2007)

Figure 1.1: Examples of active advance warning signs in a horizontal or vertical format

The AAWS are activated at a preset time prior to the level crossing control becoming active. This is dependent on the typical vehicle approach speed and distance upstream of the level crossing as outlined in Standards Australia (2007). For an 80 km/h road the AAWS may be activated 5 to 14 seconds prior to the activation of the level crossing control.

VicTrack is currently implementing an AAWS installation program at 54 level crossings across Victoria. The current controls at the 54 sites are: give-way signage, flashing lights and flashing lights and boom barriers. As part of the VicTrack program, the AAWS may also be installed along with an upgrade to the level crossing control (e.g. from flashing lights to boom barriers plus AAWS).

As major crashes at railway crossings are infrequent, it is not practicable to assess AAWS effectiveness in terms of crash reductions. Instead, changes in approach speed and compliance with crossing controls have been accepted as indicators of AAWS effectiveness.

In 2008, a study was undertaken to compare driver approach speeds and compliance at a boom gate and flashing light controlled railway level crossing site with AAWS (Inverleigh railway level crossing) to one without AAWS (Cressy railway level crossing) with inconclusive results. AAWS have now been installed at the Cressy railway level crossing, creating the opportunity for a before and after driver behaviour comparison at that site.

VicRoads on behalf of VRCSSC has commissioned ARRB to undertake a before and after evaluation of AAWS installed at the Cressy level crossing using data and analysis from the 2008 study for the before scenario and a new set of data from 2009 as the post-AAWS installation scenario. This report describes the study undertaken and its findings.

2 METHOD

This section of the report describes the evaluation methods used in this study.

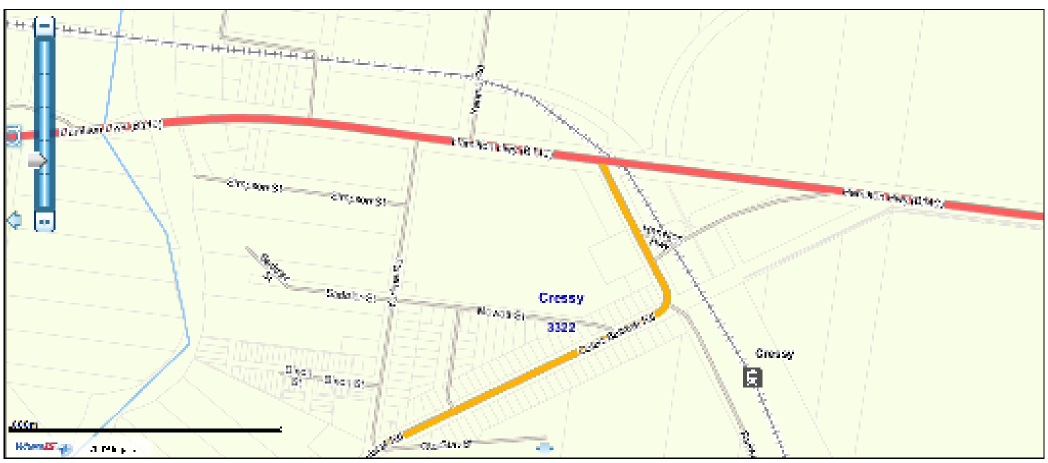
2.1 Site Selection

AAWS have now been installed at the Cressy level crossing. Before their installation, this site was used in a comparative study (Green 2009) with a site where AAWS were installed (Inverleigh level crossing). The data for the Cressy site during the previous comparative study will be used as before data.

Details of the Cressy level crossing used in this study are outlined in Table 2.1 and shown in Figure 2.1. Photos and construction drawings of the site are shown in Appendix A.

Table 2.1: Sites to undertake the study

Control type	Level crossing no.	Road name	Location	VicRoads reference	Speed limit	Photos and plans
Flashing lights plus boom barriers	LX1516	Hamilton Hwy	Cressy	92 C2	80 km/h	Appendix A



Source: www.whereis.com (2009)

Figure 2.1: Location map of the Cressy railway level crossing

The before and after evaluation was limited to one site due to the limited availability of sites which could meet the following criteria:

- installation of AAWS was the only upgrade to the level crossing
- the road speed limit was 80 km/h or greater
- the project could be co-ordinated with the commissioning schedule of the AAWS works
- located sufficiently close to Melbourne to keep data collection costs reasonable

- the presence of a reasonable number of train and vehicle interactions
- the crossing was located in a rural area.

2.2 Data Collection

Data for the before and after scenarios was collected using pneumatic tube traffic loggers. One of the loggers was interfaced with the signal controller (enabling the logging of both the vehicles travelling over the level crossing and the signal crossing activation). The loggers used are outlined in Figure 2.2.

Pneumatic tube loggers were used in this investigation for the following reasons:

- The four week duration of the survey required an automated process to collect a reasonable number of vehicle-to-train interactions.
- The equipment has been used in previous level crossing safety studies.
- Alternative speed logging equipment that could be interfaced with the railway level crossing control hardware was prohibited by cost and availability.

All loggers were synchronised with the logger installed at the level crossing. The AAWS was activated at a preset time in advance of the level crossing controls activating, therefore no logger needed to be interfaced with the AAWS.

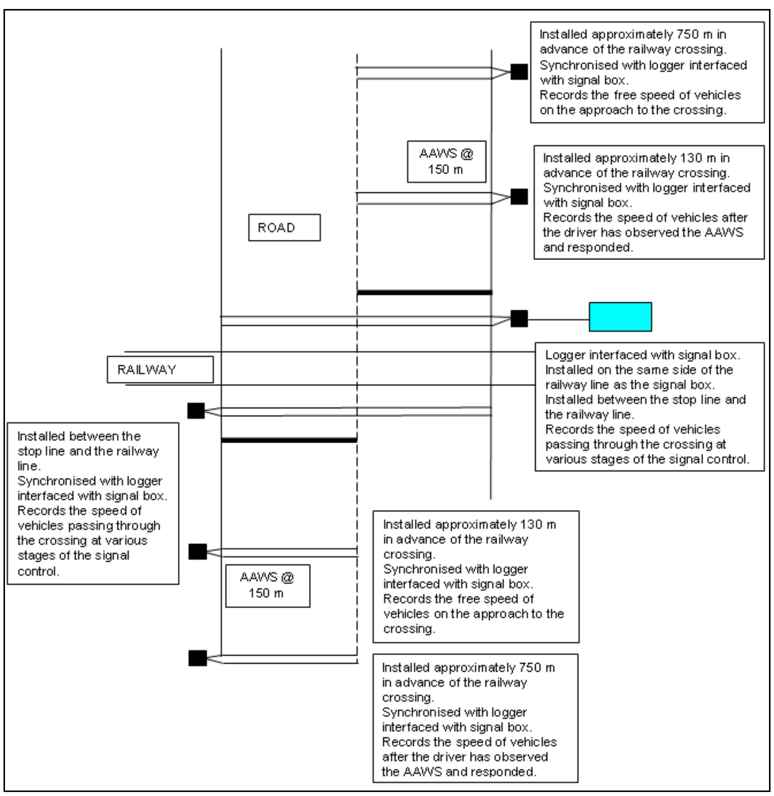


Figure 2.2: Schematic drawing of the layout of the traffic loggers with respect to the railway level crossing

2.3 Data Analysis

A review of the traffic data recorded by the loggers installed on the approach and at the level crossing was undertaken with the aim of determining the following:

- Driver speeds when the AAWS and level crossing controls were active compared to when the AAWS and level crossing control were inactive. This was carried out for the two level crossing locations and the two locations 130 m in advance of the level crossing, four locations in total.
- Driver compliance with the level crossing with AAWS compared to the scenario without AAWS.

Colac-Ballarat Road intersects the Hamilton Highway on the eastbound approach to the Cressy railway level crossing as shown in Figure 2.1. Only through vehicles were used in the analysis of the speed and compliance data.

Vehicles turning right into Colac-Ballarat Road were in the right-turning lane when passing the logger installed 130 m in advance of the level crossing. Vehicles travelling in the right-hand-turn lane were not recorded by the traffic logger and hence not included in this investigation. As a result, right-turning traffic into Colac-Ballarat Road was expected to have negligible impact on this investigation.

For the westbound approach the potential impact of the Colac-Ballarat Road intersection on the opposite side of the railway level crossing was also expected to have negligible impact on this investigation for the following reasons:

- The intersection is located at a sufficient distance from the loggers installed approximately 130 m and 750 m from this intersection to not have an impact on vehicle speeds recorded at these loggers.
- Due to the function of Colac-Ballarat Road, the left-turning vehicles form only a small proportion of all Hamilton Highway traffic.

2.4 Study Limitations

It is worth noting that the robustness of the study results was limited for the following reasons:

1. The sample cannot return a statistically significant result indicative of other sites. Any observed difference in vehicle speeds and compliance level may be influenced by local factors which may potentially be different at different sites (e.g. grades, intersections etc.).
2. The before and after study was undertaken at a site where flashing lights and boom barriers are used as the level crossing control. The impact of AAWS on driver approach speed and compliance may be different at sites with other types of level crossing controls (e.g. at level crossings controlled by flashing lights only).
3. The small amount of data (traffic and train data) able to be obtained within the study timeframes was a limitation in the analysis.
4. Potential for minor synchronisation issues and time drift between individual data loggers.

3 FINDINGS

3.1 Vehicle to Train Interactions

The total number of detected vehicles approaching the crossing at the same time as a train is shown in Table 3.1. Vehicle-to-train interactions were considered to have occurred when vehicles were detected at the 130 m advance logger within a period beginning six seconds prior to the level crossing control's activation and ending when the level crossing control was no longer active.

Table 3.1: Number of vehicle to train interactions per site and approach

Cressy level crossing Before or After	Approach	Number of vehicles in the sample	
		Passenger	Heavy
Before	Eastbound approach	341	53
	Westbound approach	409	62
After	Eastbound approach	221	63
	Westbound approach	273	59

Although the survey duration was sufficient to achieve in excess of 30 heavy vehicle to train interactions, the number of vehicles approaching the level crossing in a specific time window relative to the level crossing operation was low. Time windows of interest include:

- when the AAWS are active but the level crossing is not active
- in the period between when the lights of the level crossing become active to when the boom gate drops down.

3.2 Key Findings from the Before and After AAWS Scenarios

The key findings based on the data analysis for the before and after AAWS scenarios outlined in Appendix B, Appendix C, Appendix D, Appendix E, Appendix F and Appendix G are listed in Table 3.2.

Table 3.2: Key findings from the before and after AAWS study

Measure	Location	Key finding
When the AAWS is active in the six seconds prior to the level crossing becoming active.	130 m in advance of the level crossing.	The results were not clear if active AAWS influences driver approach speeds under these conditions.
When the level crossing is active and AAWS is active.	130 m in advance of the level crossing.	Due to mixed results, the analysis was unable to conclude if AAWS influences driver approach speeds under these conditions.

Measure	Location	Key finding
When the AAWS is active in the three seconds prior to the level crossing becoming active.	At the level crossing.	Data analysis was unable to confirm if the installation of AAWS results in vehicles traversing the level crossing any differently just prior to the activation of the level crossing than without AAWS. It was observed from the data that vehicles traversing the level crossing just prior to the crossing becoming active were doing so at higher speeds than their normal speed when traversing the level crossing when a train was not approaching. A larger sample size would be required to verify this observation.
When the level crossing is active.	At the level crossing.	Data analysis was unable to confirm if the installation of AAWS results in vehicles traversing the level crossing any differently when the level crossing is active than without AAWS. It was observed from the data that vehicles traversing the level crossing during the flashing light phase reduced their speeds more from their normal speeds when traversing the level crossing when a train was not approaching after the installation of the AAWS. A larger vehicle sample size would be required to verify this observation.
Compliance	At the level crossing.	It was observed from the data that the AAWS did not impact on the number or timing of violations at the level crossing. However, a larger violation sample would be needed to verify this observation.
Timing of violations.	At the level crossing.	Refer to Figure 3.1. Most violations occurring at the start of the active crossing control phase occurred within the first four seconds of the level crossing activation for both the 'with' and 'without' AAWS scenarios. While the number of violations in the first two seconds appears lower in the after scenario, the absolute numbers are too low to make the difference statistically significant. Violations during the 'boom up' phase for the before and after AAWS scenarios follow the same pattern (i.e. primarily in the last four seconds).

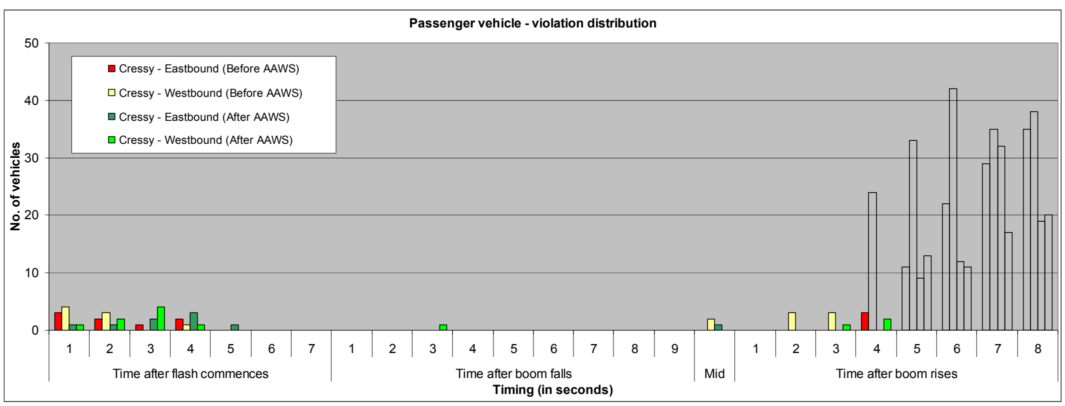


Figure 3.1: With AAWS scenario versus without AAWS scenario – violation distribution for passenger vehicles

Lack of consistency in observed speeds between the before and the after scenarios suggests that AAWS may have not affected driver behaviour at the Cressy level crossing (already controlled by boom gates and flashing lights).

Compliance with the level crossing controls, in particular at the start of the phase (i.e. during the flashing lights only or boom down phase) is more likely to be dependent on the attitude of the drivers towards the level crossing controls rather than to their reaction to the activation of the AAWS.

It is suggested that the greatest benefit of the AAWS would be for scenarios where there is poor sight distance to the level crossing controls. Where sight distance is satisfactory, the AAWS may assist in providing further warning to those drivers that may not be fully alert or complacent when approaching the level crossing. Unfortunately the impact of the AAWS on this type of driver is difficult to measure.

4 DISCUSSION

The key limitation of the study was a small sample size during the critical time windows (e.g. six seconds prior to level crossing activation but after AAWS have been activated).

To establish more robust results a larger sample would be needed, preferably from a number of test and control sites. For many rural level crossing locations (i.e. where AAWS are typically used) this would require permanent data collection stations to enable the collection of data over an extended period until sufficient samples are collected (i.e. well in excess of four weeks).

The permanent data stations would need to utilise vehicle detection equipment embedded in the pavement both to prevent the detection equipment from being vandalised and to avoid the visual presence of the detection equipment influencing driver behaviour. Ideally vehicles and level crossing operation detection should be fed into one logger to avoid synchronisation and time drift issues with the data being able to be remotely downloaded for analysis.

It is noted that a study undertaken at level crossings controlled by other means (e.g. flashing lights only) or a study undertaken at different level crossing sites may report different findings to those outlined in this study.

5 CONCLUSIONS

The study was not able to conclude if there was an appreciable difference in the approach speeds of vehicles and in driver compliance with the crossing controls as a result of the installation of the AAWS at the Cressy level crossing.

There were mixed results with respect to the change in speeds in advance of and at the level crossing. Violations prior to the boom up phase of the level crossing operation were small in both the before and after study and therefore it was difficult to determine if violations were different with AAWS compared to without AAWS.

To be able to establish more robust results a larger sample would be needed, preferably from many test and control sites. For many rural level crossing locations, permanent data collection stations would be needed to enable the collection of data over an extended period.

It is noted that a study undertaken at level crossings controlled by other controls (e.g. flashing lights only) or a study undertaken at different level crossing sites may report different findings.

REFERENCES

Green, D 2009, 'Evaluation of Active Advance Warning Signs (AAWS) using existing installations', contract report VC74957, ARRB Group, Vermont South, Vic.

Standards Australia 2007, *Manual of uniform traffic control devices, part 7, railway crossings*, AS 1742.7-2007, SA, North Sydney.

Whereis 2009, whereis, viewed 18 December 2009, <http://www.whereis.com>.

APPENDIX A PHOTOS AND PLANS OF CRESSY LEVEL CROSSING

Photos and plans of the Cressy level crossing are shown in Figure A 1 through to Figure A 8.

Figure A 1: Eastbound - approx 700 m from the level crossing

Figure A 2: Eastbound - approx 200 m from the level crossing

Figure A 3: Eastbound - at the level crossing

Figure A 4: Westbound - approx 800 m from the level crossing

Figure A 5: Westbound - approx 200 m from level crossing

Figure A 6: Westbound - at the level crossing

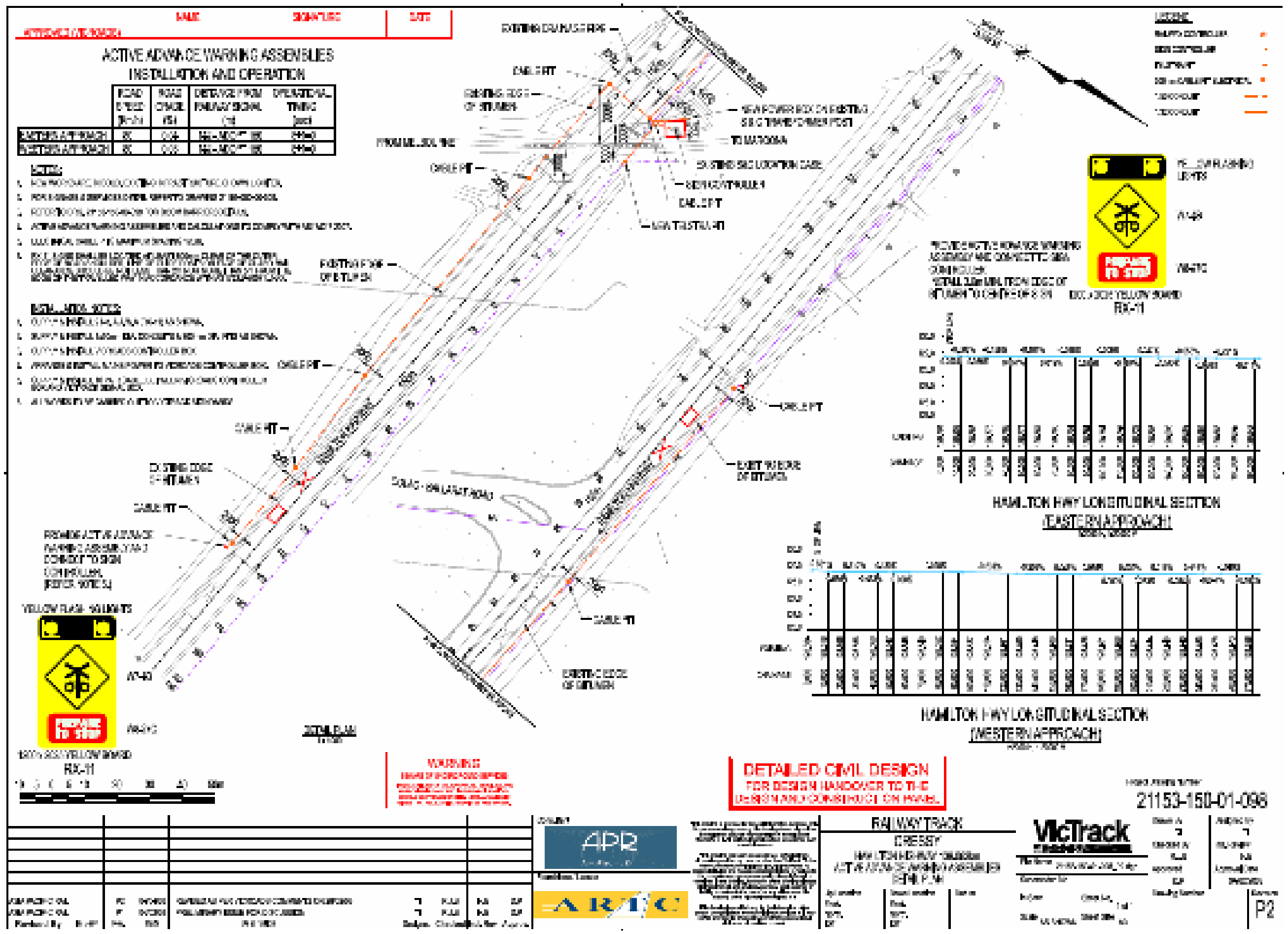


Figure A 7: To be constructed drawings for the AAWS installation at the Cressy level crossing – plan 1

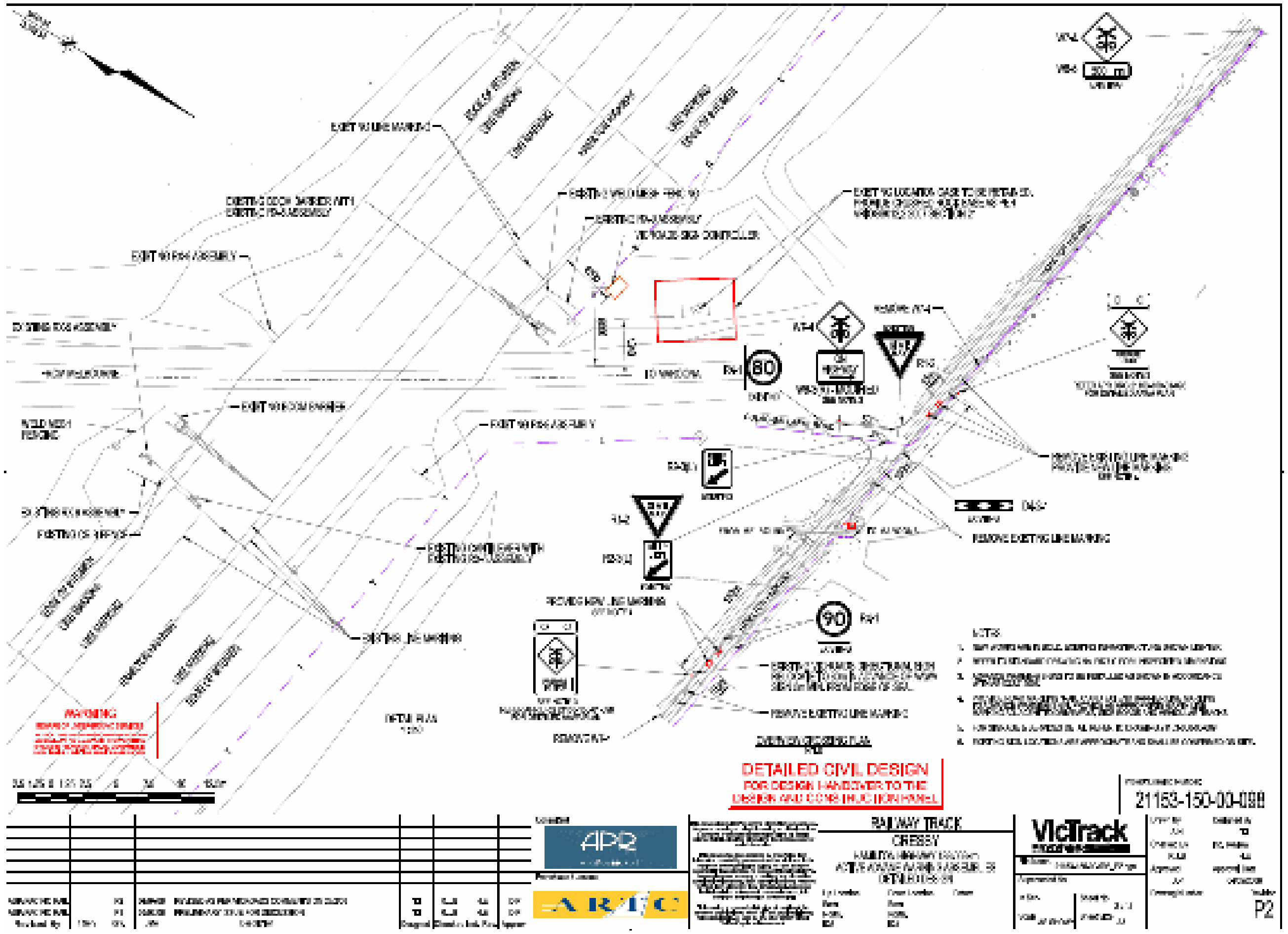


Figure A 8: **To be constructed drawings for the AAWS installation at the Cressy level crossing – plan 2**

APPENDIX B MEAN AND 85TH PERCENTILE SPEED OF VEHICLES BEFORE AND AFTER THE INSTALLATION OF AAWS

Table B 1: Mean speeds of passenger vehicles when crossing control was active / not active

Measure		Cressy level crossing			
		Before scenario		After scenario	
		Eastbound approach[1]	Westbound approach	Eastbound approach[1]	Westbound approach
Free speed on the approach to the railway level crossing	Approximately 750 m in advance of the railway level crossing.	84.3 km/h	92.5 km/h	83.4 km/h	95.2 km/h
Mean speed: When train not present (i.e. level crossing and AAWS not active)	Approximately 130 m in advance of the railway level crossing.	75.8 km/h	75.1 km/h	81.0 km/h	80.4 km/h
	At the railway level crossing.	75.7 km/h	67.5 km/h	75.9 km/h	76.5 km/h
Mean speed: When trains are present or approaching	Approximately 130 m in advance of the railway level crossing. Vehicles only detected at this logger when the AAWS is operating in advance of the level crossing control (i.e. 6 seconds prior to the level crossing control becoming active)[2].	75.2 km/h 11 vehicles	66.6 km/h 20 vehicles	72.0 km/h 13 vehicles	61.5 km/h 12 vehicles
	Approximately 130 m in advance of the railway level crossing. Vehicles only detected at this logger when the level crossing control is active (i.e. level crossing control lights are flashing and AAWS is on).	43.2 km/h 330 vehicles	50.5 km/h 389 vehicles	46.9 km/h 208 vehicles	48.1 km/h 261 vehicles
	At the railway level crossing. Vehicles only detected at this logger when the AAWS is active in advance of the level crossing control (i.e. 3 seconds prior to the level crossing becoming active)[3].	78.3 km/h 22 vehicles	66.7 km/h 14 vehicles	78.9 km/h 8 vehicles	68.5 km/h 8 vehicles
	At the railway level crossing. Vehicles only detected at this logger between when the lights start flashing and the boom gate comes down.	79.3 km/h 8 vehicles	69.0 km/h 8 vehicles	73.2 km/h 6 vehicles	67.5 km/h 8 vehicles

Notes:

1. Due to the presence of the Ballarat-Colac Road (Route C146) intersection, only those vehicles detected in isolation at the detector located 130 m in advance of the level crossing within 12 seconds of being detected at the stop line were included. Other detected vehicles were assumed to have come from Ballarat-Colac Road.
2. It is noted that AAWS activates nine seconds prior to the level crossing control.
3. A three seconds time window was chosen to compare the mean speed of vehicles passing through the site just prior to the level crossing becoming active in response to observing the status of the AAWS.

Table B 2: Mean speed of heavy vehicles when crossing control was active / not active

Measure		Cressy level crossing			
		Before scenario		After scenario	
		Eastbound approach[1]	Westbound approach	Eastbound approach[1]	Westbound approach
Free speed on the approach to the railway level crossing	Approximately 750 m in advance of the railway level crossing.	84.1 km/h	83.3 km/h	84 km/h	90.2 km/h
Mean speed: When train not present (i.e. level crossing and AAWS not active)	Approximately 130 m in advance of the railway level crossing.	78.8 km/h	72.7 km/h	85.0 km/h	80.4 km/h
	At the railway level crossing.	80.5 km/h	63.1 km/h	81.0 km/h	78.2 km/h
Mean speed: When trains are present or approaching	Approximately 130 m in advance of the railway level crossing. Vehicles only detected at this logger when the AAWS is active in advance of the level crossing control (i.e. 6 seconds prior to the level crossing control becoming active)[2].	75.4 km/h 3 vehicles	58.5 km/h 3 vehicles	81.3 km/h 8 vehicles	81.4 km/h 1 vehicle
	Approximately 130 m in advance of the railway level crossing. Vehicles only detected at this logger when the level crossing control is active (i.e. level crossing control lights are flashing).	39.0 km/h 50 vehicles	39.9 km/h 58 vehicles	42.5 km/h 55 vehicles	40.7 km/h 58 vehicles
	At the railway level crossing. Vehicles only detected at this logger when the AAWS is active in advance of the level crossing control (i.e. 3 seconds prior to the level crossing becoming active)[3].	76.6 km/h 1 vehicle	71.0 km/h 1 vehicle	77.2 km/h 2 vehicles	84.5 km/h 2 vehicles
	At the railway level crossing. Vehicles only detected at this logger between when the lights start flashing and the boom gate comes down.	74.0 km/h 3 vehicles	53.7 km/h 3 vehicles	78.9 km/h 1 vehicles	87.6 km/h 1 vehicle

Notes:

1. Due to the presence of the Ballarat-Colac Road (Route C146) intersection, only those vehicles detected in isolation at the detector located 130 m in advance of the level crossing within 12 seconds of being detected at the stop line were included. Other detected vehicles were assumed to have come from Ballarat-Colac Road.
2. It is noted that AAWS activates nine seconds prior to the level crossing control.
3. A three seconds time window was chosen to compare the mean speed of vehicles passing through the site just prior to the level crossing becoming active in response to observing the status of the AAWS.

Table B 3: 85th percentile speeds of passenger vehicles when crossing control was active / not active

Measure		Cressy level crossing			
		Before scenario		After scenario	
		Eastbound approach[1]	Westbound approach	Eastbound approach[1]	Westbound approach
Free speed on the approach to the railway level crossing	Approximately 750 m in advance of the railway level crossing.	94.6 km/h	102.7 km/h	92.9 km/h	103.9 km/h
85th percentile speed: When train not present (i.e. level crossing and AAWS not active)	Approximately 130 m in advance of the railway level crossing.	83.3 km/h	85.3 km/h	89.1 km/h	89.6 km/h
	At the railway level crossing.	84.9 km/h	80.7 km/h	85.8 km/h	88.8 km/h
85th percentile speed: When trains are present or approaching	Approximately 130 m in advance of the railway level crossing. Vehicles only detected at this logger when the AAWS is active in advance of the level crossing control (i.e. 6 seconds prior to the level crossing control becoming active)[2].	89.8 km/h 11 vehicles	77.9 km/h 20 vehicles	87.8 km/h 13 vehicles	81.1 km/h 12 vehicles
	Approximately 130 m in advance of the railway level crossing. Vehicles only detected at this logger when the level crossing control is active (i.e. level crossing control lights are flashing).	55.0 km/h 330 vehicles	63.5 km/h 389 vehicles	60.8 km/h 208 vehicles	60.9 km/h 261 vehicles
	At the railway level crossing. Vehicles only detected at this logger when the AAWS is active in advance of the level crossing control (i.e. 3 seconds prior to the level crossing becoming active)[3].	84.7 km/h 22 vehicles	75.7 km/h 14 vehicles	84.3 km/h 8 vehicles	107 km/h 8 vehicles
	At the railway level crossing. Vehicles only detected at this logger between when the lights start flashing and the boom gate comes down.	98.1 km/h 8 vehicles	80.9 km/h 8 vehicles	87.3 km/h 6 vehicles	97.0 km/h 8 vehicles

Notes:

1. Due to the presence of the Ballarat-Colac Road (Route C146) intersection, only those vehicles detected in isolation at the detector located 130 m in advance of the level crossing within 12 seconds of being detected at the stop line were included. Other detected vehicles were assumed to have come from Ballarat-Colac Road.
2. It is noted that AAWS activates nine seconds prior to the level crossing control.
3. A three seconds time window was chosen to compare the mean speed of vehicles passing through the site just prior to the level crossing becoming active in response to observing the status of the AAWS.

Table B 4: 85th percentile speed of heavy vehicles when crossing control was active / not active

Measure		Cressy level crossing			
		Before scenario		After scenario	
		Eastbound approach[1]	Westbound approach	Eastbound approach[1]	Westbound approach
Free speed on the approach to the railway level crossing	Approximately 750 m in advance of the railway level crossing.	95.4 km/h	99.3 km/h	94.4 km/h	102.0 km/h
85th percentile speed: When train not present (i.e. level crossing and AAWS not active)	Approximately 130 m in advance of the railway level crossing.	89.4 km/h	85.8 km/h	96.0 km/h	91.3 km/h
	At the railway level crossing.	91.6 km/h	82.1 km/h	92.5 km/h	92.4 lm/h
85th percentile speed: When trains are present or approaching	Approximately 130 m in advance of the railway level crossing. Vehicles only detected at this logger when the AAWS is active in advance of the level crossing control (i.e. 6 seconds prior to the level crossing control becoming active)[2].	77.9 km/h 3 vehicles	68.6 km/h 3 vehicles	100.4 km/h 8 vehicles	81.4 km/h 1 vehicle
	Approximately 130 m in advance of the railway level crossing. Vehicles only detected at this logger when the level crossing control is active (i.e. level crossing control lights are flashing).	48.7 km/h 50 vehicles	54.7 km/h 58 vehicles	62.1 km/h 55 vehicles	52.8 km/h 58 vehicles
	At the railway level crossing. Vehicles only detected at this logger when the AAWS is active in advance of the level crossing control (i.e. 3 seconds prior to the level crossing becoming active)[3].	76.6 km/h 1 vehicle	71.0 km/h 1 vehicle	78.9 km/h 2 vehicles	92.0 km/h 2 vehicles
	At the railway level crossing. Vehicles only detected at this logger between when the lights start flashing and the boom gate comes down.	83.7 km/h 1 vehicle	68.5 km/h 1 vehicle	78.9 km/h 1 vehicle	87.6 km/h 1 vehicle

Notes:

1. Due to the presence of the Ballarat-Colac Road (Route C146) intersection, only those vehicles detected in isolation at the detector located 130 m in advance of the level crossing within 12 seconds of being detected at the stop line were included. Other detected vehicles were assumed to have come from Ballarat-Colac Road.
2. It is noted that AAWS activates nine seconds prior to the level crossing control.
3. A three seconds time window was chosen to compare the mean speed of vehicles passing through the site just prior to the level crossing becoming active in response to observing the status of the AAWS.

APPENDIX C MEAN SPEED STATISTICAL ANALYSIS

Table C 1: Eastbound passenger vehicles: statistical analysis of mean speed before and after the installation of AAWS

Approximate location	Before Treatment				After Treatment				% difference in mean	Group t-test p-value	Is the difference significant at 90% confidence level (CI)
	Number of samples	Mean	Standard deviation	Coefficient of variation (CoV)	Number of samples	Mean	Standard deviation	Coefficient of variation (CoV)			
130 m – six seconds prior to lv X activation	11	75.2	13.7	0.18	13	72.0	22.1	0.31	-4%	0.67	No
130 m – when lv X is active	330	43.2	12.9	0.30	208	46.9	14.2	0.30	9%	0.00	Yes
Stop line – three seconds prior to lv X activation	22	78.3	7.2	0.09	5	78.9	6.8	0.09	1%	0.84	No
Stop line – when lv X is active	8	79.3	21.5	0.27	6	73.2	21.9	0.30	-8%	0.61	No

Table C 2: Westbound passenger vehicles: statistical analysis of mean speed before and after the installation of AAWS

Approximate location	Before Treatment				After Treatment				% difference in mean	Group t-test p-value	Is the difference significant at 90% confidence level (CI)
	Number of samples	Mean	Standard deviation	Coefficient of variation (CoV)	Number of samples	Mean	Standard deviation	Coefficient of variation (CoV)			
130 m – six seconds prior to lv X activation	20	66.6	13.2	0.20	12	61.5	19.7	0.32	-8%	0.43	No
130 m – when lv X is active	389	50.5	12.4	0.24	261	48.1	13.3	0.28	-5%	0.02	Yes
Stop line – three seconds prior to lv X activation	14	66.7	9.5	0.14	8	68.5	32.8	0.48	3%	0.89	No
Stop line – when lv X is active	8	69.0	11.3	0.16	8	67.5	29.1	0.43	-2%	0.89	No

Table C 3: Eastbound heavy vehicles: statistical analysis of mean speed before and after the installation of AAWS

Approximate location	Before Treatment				After Treatment				% difference in mean	Group t-test p-value	Is the difference significant at 90% confidence level (CI)
	Number of samples	Mean	Standard deviation	Coefficient of variation (CoV)	Number of samples	Mean	Standard deviation	Coefficient of variation (CoV)			
130 m – six seconds prior to lv X activation	3	75.4	3.7	0.05	8	81.3	16.8	0.21	8%	0.38	No
130 m – when lv X is active	50	39.0	12.9	0.33	55	42.7	16.8	0.39	10%	0.39	No
Stop line – three seconds prior to lv X activation	1	76.6	-	-	2	77.3	3.3	0.04	1%	-	-
Stop line – when lv X is active	3	74.0	14.0	0.19	1	78.9	-	-	7%	-	-

Table C 4: Westbound heavy vehicles: statistical analysis of mean speed before and after the installation of AAWS

Approximate location	Before Treatment				After Treatment				% difference in mean	Group t-test p-value	Is the difference significant at 90% confidence level (CI)
	Number of samples	Mean	Standard deviation	Coefficient of variation (CoV)	Number of samples	Mean	Standard deviation	Coefficient of variation (CoV)			
130 m – six seconds prior to lv X activation	3	58.5	14.3	0.24	1	81.4	-	-	39%	-	-
130 m – when lv X is active	58	39.9	13.6	0.34	58	40.7	13.1	0.32	2%	0.73	-
Stop line – three seconds prior to lv X activation	1	71.0	-	-	2	84.5	15.1	0.18	19%	-	-
Stop line – when lv X is active	3	53.7	21.5	0.40	1	87.6	-	-	63%	-	-

Table C 5: Eastbound passenger vehicles: statistical analysis of mean speed when AAWS and/or level crossing is not active and when it is

Approximate location and period relative to level crossing activation	When AAWS and/or level crossing is not activated				When AAWS and/or level crossing is activated				% difference in mean	Group t-test p-value	Is the difference significant at 90% confidence level (CI)
	Number of samples	Mean	Standard deviation	Coefficient of variation (CoV)	Number of samples	Mean	Standard deviation	Coefficient of variation (CoV)			
Before AAWS 130 m – 6 sec prior	18,382	75.8	9.2	0.12	11	75.2	13.7	0.18	-1%	0.89	No
Before AAWS 130 m – Lv X active	18,382	75.8	9.2	0.12	330	43.2	12.9	0.30	-43%	0.00	Yes
Before AAWS Stop line – 3 sec prior	11,997	75.7	10.9	0.14	22	78.3	7.2	0.09	3%	0.11	No
Before AAWS Stop line – Lv X active	11,997	75.7	10.9	0.14	8	79.3	21.5	0.27	5%	0.65	No
After AAWS 130 m – 6 sec prior	19,542	81.0	9.8	0.12	13	72.0	22.1	0.31	-11%	0.17	Yes
After AAWS 130 m – Lv X active	19,542	81.0	9.8	0.12	208	46.9	14.2	0.30	-42%	0.00	Yes
After AAWS Stop line – 3 sec prior	9,822	75.4	11.6	0.15	5	78.9	6.8	0.09	4%	0.38	No
After AAWS Stop line – Lv X active	9,822	75.4	11.6	0.15	6	73.2	21.9	0.30	-4%	0.77	No

Table C 6: Westbound passenger vehicles: statistical analysis of mean speed when AAWS and/or level crossing is not active and when it is

Approximate location and period relative to level crossing activation	When AAWS and/or level crossing is not activated				When AAWS and/or level crossing is activated				% difference in mean	Group t-test p-value	Is the difference significant at 90% confidence level (CI)
	Number of samples	Mean	Standard deviation	Coefficient of variation (CoV)	Number of samples	Mean	Standard deviation	Coefficient of variation (CoV)			
Before AAWS 130 m – 6 sec prior	25,210	75.1	13.2	0.18	20	66.6	13.2	0.20	-11%	0.01	Yes
Before AAWS 130 m – Lv X active	25,210	75.1	13.2	0.18	389	50.5	12.4	0.24	-33%	0.00	Yes
Before AAWS Stop line – 3 sec prior	25,693	67.5	16.3	0.24	14	66.7	9.5	0.14	-1%	0.77	No
Before AAWS Stop line – Lv X active	25,693	67.5	16.3	0.24	8	69.0	11.3	0.16	2%	0.71	No
After AAWS 130 m – 6 sec prior	25,321	80.4	10.0	0.12	12	61.5	19.7	0.32	-24%	0.01	Yes
After AAWS 130 m – Lv X active	25,321	80.4	10.0	0.12	261	48.1	13.3	0.28	-40%	0.00	Yes
After AAWS Stop line – 3 sec prior	24,065	76.5	14.6	0.19	8	68.5	32.8	0.48	-11%	0.50	No
After AAWS Stop line – Lv X active	24,065	76.5	14.6	0.19	8	67.5	29.1	0.43	-12%	0.41	No

Table C 7: Eastbound heavy vehicles: statistical analysis of mean speed when AAWS and/or level crossing is not active and when it is

Approximate location and period relative to level crossing activation	When AAWS and/or level crossing is not activated				When AAWS and/or level crossing is activated				% difference in mean	Group t-test p-value	Is the difference significant at 90% confidence level (CI)
	Number of samples	Mean	Standard deviation	Coefficient of variation (CoV)	Number of samples	Mean	Standard deviation	Coefficient of variation (CoV)			
Before AAWS 130 m – 6 sec prior	2,913	78.8	10.8	0.14	3	75.4	3.7	0.05	-4%	0.26	No
Before AAWS 130 m – Lv X active	2,913	78.8	10.8	0.14	50	39.0	12.9	0.33	-51%	0.00	Yes
Before AAWS Stop line – 3 sec prior	1,979	80.5	10.2	0.13	1	76.6	-	-	-	-	-
Before AAWS Stop line – Lv X active	1,979	80.5	10.2	0.13	3	74.0	14.0	0.19	-8%	0.51	No
After AAWS 130 m – 6 sec prior	4,573	85.2	11.1	0.13	8	81.3	16.8	0.21	-5%	0.53	No
After AAWS 130 m – Lv X active	4,573	85.2	11.1	0.13	55	42.7	16.8	0.39	-50%	0.00	Yes
After AAWS Stop line – 3 sec prior	1,741	81.0	10.9	0.13	2	77.3	3.3	0.04	-5%	0.35	No
After AAWS Stop line – Lv X active	1,741	81.0	10.9	0.13	1	78.9	-	-	-	-	-

Table C 8: Westbound heavy vehicles: statistical analysis of mean speed when AAWS and/or level crossing is not active and when it is

Approximate location and period relative to level crossing activation	When AAWS and/or level crossing is not activated				When AAWS and/or level crossing is activated				% difference in mean	Group t-test p-value	Is the difference significant at 90% confidence level (CI)
	Number of samples	Mean	Standard deviation	Coefficient of variation (CoV)	Number of samples	Mean	Standard deviation	Coefficient of variation (CoV)			
Before AAWS 130 m – 6 sec prior	5,378	80.4	11.5	0.14	1	81.4	-	-	-	-	-
Before AAWS 130 m – Lv X active	5,378	80.4	11.5	0.14	58	40.7	13.1	0.32	-49%	0.00	Yes
Before AAWS Stop line – 3 sec prior	4,637	63.1	21.8	0.35	1	71	-	-	-	-	-
Before AAWS Stop line – Lv X active	4,637	63.1	21.8	0.35	3	53.7	21.5	0.40	-15%	0.53	No
After AAWS 130 m – 6 sec prior	4,480	72.7	16.5	0.23	3	58.5	14.3	0.24	-19%	0.23	No
After AAWS 130 m – Lv X active	4,480	72.7	16.5	0.23	58	39.9	13.6	0.34	-45%	0.00	Yes
After AAWS Stop line – 3 sec prior	8,054	78.2	16.8	0.21	2	84.5	15.1	0.18	8%	0.66	No
After AAWS Stop line – Lv X active	8,054	78.2	16.8	0.21	1	87.6	-	-	12%	-	-

APPENDIX D COMMENTARY ON MEAN AND 85TH PERCENTILE SPEEDS BEFORE AND AFTER AAWS

D.1 When a Train was not Present (i.e. when the AAWS and the level crossing are not active)

The following observations were noted with respect to the mean and 85th percentile speeds on the approach to the level crossing when a train was not present (i.e. when the AAWS and the level crossing are not active).

Prior to and after the installation of the AAWS, the mean and 85th percentile speeds of vehicles 750 m in advance of the level crossing were noted to be generally comparable to one another.

Prior to and after the installation of the AAWS, the mean and 85th percentile speeds of vehicles approximately 130 m in advance of the level crossing were:

- slightly higher in the after survey than the before survey period
- generally lower than the mean and 85th percentile vehicle speed 750 m in advance of the level crossing.

Prior to and after the installation of the AAWS, the mean and 85th percentile speeds of vehicles traversing the level crossing when a train was not present were noted to be:

- comparable for the eastbound approach
- higher in the after survey for the westbound approach
- comparable or lower than the mean and 85th percentile vehicle speeds approximately 130 m in advance of the level crossing.

Point speeds of approaching vehicles when the level crossing was not active showed that most of these vehicles slowed slightly when approaching the crossing. It was assumed that this is in response to both:

- the reduced speed limit of 80 km/h just prior to the level crossing for the westbound approach but approximately 700 m prior to the level crossing of the eastbound approach
- the driver comfort level when traversing the level crossing
- driver caution when approaching the level crossing.

D.2 When a Train is Present – Vehicles Approximately 130 m in Advance of the Level Crossing

D.2.1 When the AAWS is Active for the Six Seconds Prior to the Level Crossing Becoming Active

The findings, at a 90% confidence level, are that the mean speed of westbound passenger vehicles was 24% lower than the mean speed of the vehicles when the AAWS was not active during the after survey period. This is compared to an 11% reduction in the mean speed for westbound passenger vehicles in the before survey period. Due to the small sample size it was not possible to determine with any confidence whether this was an isolated occurrence for the vehicle type and approach or whether this also applied to the eastbound approach and to heavy vehicles.

Changes in 85th percentile speeds for passenger vehicles were mixed, with a decrease noted for the eastbound approach but an increase noted for the westbound approach. These observations are based on low sample size and therefore could be random.

Heavy vehicle numbers during this period were too low to make any meaningful observations.

D.2.2 When the Level Crossing is Active

The findings at a 90% confidence level are as follows:

- The mean speed of passenger vehicles was 9% higher in the eastbound direction and 5% lower in the westbound direction after the installation of the AAWS compared to prior to the installation of AAWS. This indicates that the impact of AAWS during this period may be different for individual approaches.
- The mean speed of the eastbound and westbound passenger vehicles is 42% and 40% less respectively, than the mean speed of the vehicles when the AAWS is not active in the after AAWS scenario. This compares with a 43% and 33% reduction in the mean speed for the eastbound and westbound passenger vehicles respectively in the before AAWS scenario. This indicates that there is mixed results with respect to the potential for the AAWS to result in further slowing of passenger vehicles 130 m in advance of the level crossing when the level crossing is active.
- The mean speed of the eastbound and westbound heavy vehicles was 50% and 45% less respectively than the mean speed of the heavy vehicles when the AAWS was not active in the after AAWS scenario. This compares with a 51% and 49% reduction in the mean speed for the eastbound and westbound direction respectively in the before AAWS scenario. This indicates that there is potential for the AAWS to result in further slowing of heavy vehicles 130 m in advance of the level crossing when the level crossing is active.

The 85th percentile speeds for both the passenger and heavy vehicles during this period were both well below the speed limit and well below the 85th percentile speeds during the period when the level crossing is not active. However, the difference in the 85th percentile speed before and after the AAWS was mixed with one approach observing an increase and another approach observing a decrease.

D.3 When a Train is Present – Vehicles at the Level Crossing

D.3.1 Three Seconds Prior to the Level Crossing Becoming Active

Due to the small sample size in this short window of time, no conclusive comments could be made with respect to the approach speeds of these vehicles.

The study was unable to confirm if the installation of AAWS results in vehicles traversing the level crossing any differently just prior to the activation of the level crossing than without AAWS.

The study suggests that vehicles traversing the level crossing just prior to the crossing becoming active, compared to when crossing without an approaching train, are doing so at a higher speed and accelerating more after the installation of the AAWS compared to before. However, a larger sample size would be required to demonstrate this effect with any confidence. This impact may be as a result of vehicles speeding up in response to observing the status of the AAWS in order to get through the level crossing before the level crossing comes down.

Changes in 85th percentile speed during this period were mixed.

D.3.2 When the Level Crossing is Active

Due to the small sample size in this time window no conclusive comments could be made with respect to driver approach speeds during this time period.

The study was unable to confirm if the installation of AAWS results in vehicles illegally traversing the level crossing any differently when the level crossing is active compared to without AAWS. Details of vehicle compliance are outlined in the body of the report with further commentary and raw data outlined in Appendix E, Appendix F and Appendix G.

The study suggests that it may be possible that vehicles traversing the level crossing during the flashing light phase may reduce their speed more and traverse the level crossing at a slower speed after the installation of the AAWS. However, a larger sample size would be required to demonstrate this effect with any confidence.

Changes in 85th percentile speeds during this period were mixed.

APPENDIX E VEHICLE COMPLIANCE WITH THE LEVEL CROSSING CONTROL

Table E 1: Passenger vehicle compliance with controls at both crossings

Measure		Cressy level crossing			
		Before scenario		After scenario	
		Eastbound approach[1]	Westbound approach	Eastbound approach[1]	Westbound approach
The number of vehicles detected approximately 130 m in advance on the level crossing six seconds prior to the level crossing becoming active. This number is used to compare flashing light and boom down violations.		11	20	13	12
The number of vehicles detected approximately 130 m in advance on the level crossing while the level crossing is active. This number is used to compare boom up violations.		330	389	208	261
Number of level crossing control operations during the survey		385	385	341	341
The total number of vehicles driving over the level crossing per violation type.	Flashing lights only	8	8	8	8
	Boom down	0	2	1	1
	Boom up	100	178	72	64
Violation rate per 100 level crossing operations.	Flashing lights only	2.1	2.1	2.3	2.3
	Boom down	0.0	0.5	0.3	0.3
	Boom up	26.0	46.2	21.1	18.8
Violation rate per vehicle approaching the level crossing within six seconds of the level crossing becoming active (i.e. detected approximately 130 m in advance of the level crossing within six seconds prior to the level crossing control is active).	Flashing lights only	0.7	0.4	0.6	0.7
	Boom down	0.0	0.1	0.1	0.1
Violation rate per 100 vehicles approaching while the level crossing is active (i.e. detected approximately 130 m in advance of the level crossing while the level crossing control is active).	Boom up	30.3	45.8	34.6	24.5

Notes:

1. Due to the presence of the Ballarat-Colac Road (Route C146) intersection, only those vehicles detected in isolation at the detector located 130 m in advance of the level crossing within 12 seconds of being detected at the stop line were included. Other detected vehicles were assumed to have come from Ballarat-Colac Road.

Table E 2: Heavy vehicle compliance with controls at both crossings

Measure		Cressy level crossing			
		Before scenario		After scenario	
		Eastbound approach[1]	Westbound approach	Eastbound approach[1]	Westbound approach
The number of vehicles detected approximately 130 m in advance on the level crossing six seconds prior to the level crossing becoming active. This number is used to compare flashing light and boom down violations.		3	3	8	1
The number of vehicles detected approximately 130 m in advance on the level crossing while the level crossing is active. This number is used to compare boom up violations.		50	58	55	58
Number of operations during the survey		385	385	341	341
The total number of vehicles driving over the level crossing per violation type.	Flashing lights only	3	3	2	1
	Boom down	0	0	0	0
	Boom up	7	15	3	3
Violation rate per 100 level crossing operations.	Flashing lights only	0.8	0.8	0.6	0.3
	Boom down	0.0	0.0	0.0	0.0
	Boom up	1.8	3.9	0.9	0.9
Violation rate per vehicle approaching the level crossing within six seconds of the level crossing becoming active (i.e. detected approximately 130 m in advance of the level crossing within six seconds prior to the level crossing control is active).	Flashing lights only	1	1	0.25	1
	Boom down	0.0	0.0	0.0	0.0
Violation rate per 100 vehicles approaching while the level crossing is active (i.e. detected approximately 130 m in advance of the level crossing while the level crossing control is active).	Boom up	14	25.9	5.5	5.2

Notes:

1. Due to the presence of the Ballarat-Colac Road (Route C146) intersection, only those vehicles detected in isolation at the detector located 130 m in advance of the level crossing within 12 seconds of being detected at the stop line were included. Other detected vehicles were assumed to have come from Ballarat-Colac Road.

APPENDIX F COMMENTARY ON VEHICLE COMPLIANCE WITH THE LEVEL CROSSING CONTROL BEFORE AND AFTER AAWS

Table E 1 and Table E 2 show the level of driver compliance with the level crossing control for the before and after scenario. In these tables, the violation rate refers to the number of violations per:

- 100 level crossing operations
- vehicles detected approximately 130 m in advance of the level crossing six seconds prior to the level crossing becoming active (this is applicable for flashing light and boom down violations only)
- 100 vehicles detected approximately 130 m in advance of the level crossing while the level crossing is active (this is applicable to boom up violations only).

Due to the low number of violations and the method with which the study was undertaken (logging of vehicles past single points rather than tracking vehicles) no statistical analysis was undertaken; however, the study suggests the following:

- The number of violations per passenger vehicle occurring during the flashing light phase of the level crossing activation is comparatively the same with and without AAWS. The number of heavy vehicles violating during the flashing light and boom down phase remained very low after the installation of the AAWS.
- The number of heavy vehicle and passenger vehicle violations per 100 level crossing operations occurring during the flashing light and boom down phase of the level crossing activation is comparatively the same with and without AAWS.
- Violations occurring during the boom up phase were not a focus of this study. However, it is noted that the study reported mixed results with the westbound approach showing a large reduction while the eastbound showed an increase. This violation is associated with driver reaction to the actual level crossing control rather than the AAWS.

It is noted that no vehicles were considered to have gone around the boom gate either before or after the installation of the AAWS.

APPENDIX G VIOLATION DISTRIBUTION

The violation distribution for the two sites for passenger vehicles is outlined in Table G 1 and Table G 2.

Table G 1: Passenger vehicle violation distribution

		Before scenario		After scenario	
	Seconds	**Cressy - Eastbound**	**Cressy - Westbound**	**Cressy - Eastbound**	**Cressy - Westbound**
Time after flash commences	1	3	4	1	1
	2	2	3	1	2
	3	1	0	2	4
	4	2	1	3	1
	5	0	0	1	0
	6	0	0	0	0
	7	0	0	0	0
Time after boom falls	1	0	0	0	0
	2	0	0	0	0
	3	0	0	0	1
	4	0	0	0	0
	5	0	0	0	0
	6	0	0	0	0
	7	0	0	0	0
	8	0	0	0	0
	9	0	0	0	0
Mid	-	0	2	1	0
Time after boom rises	1	0	0	0	0
	2	0	3	0	0
	3	0	3	0	1
	4	3	24	0	2
	5	11	33	9	13
	6	22	42	12	11
	7	29	35	32	17
	8	35	38	19	20

Table G 2: Heavy vehicle violation distribution

		Before scenario		After scenario	
	seconds	Cressy - Eastbound	Cressy - Westbound	Cressy - Eastbound	Cressy - Westbound
Time after flash commences	1	0	0	0	0
	2	1	1	0	0
	3	0	1	0	0
	4	2	1	1	0
	5	0	0	0	1
	6	0	0	0	0
	7	0	0	1	0
Time after boom falls	1	0	0	0	0
	2	0	0	0	0
	3	0	0	0	0
	4	0	0	0	0
	5	0	0	0	0
	6	0	0	0	0
	7	0	0	0	0
	8	0	0	0	0
	9	0	0	0	0
Mid	-	0	0	0	0
Time after boom rises	1	0	0	0	0
	2	0	0	0	0
	3	0	0	0	0
	4	0	1	0	1
	5	0	2	0	0
	6	4	2	1	0
	7	1	3	0	0
	8	2	7	2	2