Redland Smart Signs and Smart Messages:

A Driver Behaviour Change Project – Year 5

Final Report (2022-2-23)

Report prepared for Redland City Council

July 2023

Report published by Griffith University's Applied Road Ecology Group.

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Additional copies may be obtained from the Centre for Planetary Health and Food Security, Griffith University, Nathan, Qld 4111.

This publication should be cited as: Appleby, R. and Ransome, L., (2023). Redland Smart Signs and Smart Messages: A Driver Change Behaviour Project – Year 5 Final Report. Prepared for Redland City Council. Applied Road Ecology Group, Centre for Planetary Health and Food Security, Griffith University, Nathan, Qld.

Executive Summary

In February 2022, the koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) listing was upgraded from vulnerable to endangered, in reflection of ongoing, rapid population declines across much of their range. Threats such as habitat loss, disease, dog attacks and vehicle strikes remain pervasive. As a part of a wide-ranging koala threat mitigation program, in 2018 the Redland City Council instituted the 'Smart Signs and Smart Messaging' program on several roads in designated Koala Safe Neighbourhoods in the Redlands Coast. Whilst previous research had suggested passive signs were relatively ineffective in encouraging driver behavioural change, new technology in the form of dynamic vehicle messaging signage emerged that offered new opportunities to re-explore efficacy. Different versions of VMS are available, and initial trials involved an examination of which models performed the most consistently and reliably in relation to koala-specific messaging. Now in its fifth year of experimental implementation, with signs being rolled out across the city, the program has demonstrated the benefits of this new sign technology in increasing driver vigilance with drivers consistently slowing down, albeit usually modestly.

In this report, speed and traffic volume data from 13 currently operating signs, including several deployed during 2022, were collated and analysed. Principle points of interest were: (1) detecting any indication of driver habituation to signage over multiple years and (2) conducting a brief pilot study where two different sets of messages were displayed to drivers at different times of the day (standard, koala-related 'smiley' messaging at night and 'bicycle' awareness messaging during the day) on one signed road. As with previous years, most signs demonstrated a reduction in average daily speed when drivers passed by fully operational signs. For the first time however, there was a potential indication of driver habituation, clearest for a single sign which showed an increase in average daily speed compared to an associated pre-treatment period average. Two additional signs showed slight increases in average daily speed compared to a year beforehand, although in both cases averages were still below that of pre-treatment periods. The vast majority of signs however showed no evidence of habituation and actually reported further decreases in average and 85th percentile speeds compared to previous years. These results continue to provide evidence that signs can consistently reduce vehicle speeds, even over relatively long periods of time and with assumed, high rates of repeated driver exposure. The pilot study on mixed messages appeared to show that whilst drivers reduced average daily

speeds below that of a pre-treatment average for both sets of messages, they reduced speeds further in relation to koala-related smiley messaging compared to bicycle messaging.

Unfortunately, for the first time in the project, three koalas were struck and killed on roads outfitted with signs. GPS collar data also showed that three koalas crossed roads outfitted with signs during the study period. One koala (Blake) appeared to make regular crossings on one road (Fitzroy Street), as he has done in previous years. These events, along with the first potential indications of driver habituation on one of the same roads has prompted a recommended shift in experimentation towards reinforcing beneficial driver responses such as increased vigilance and slow, careful driving on those roads where strike risk is deemed high. This will mark a shift in the current research program towards bolstering efforts to further minimise koala strikes through both monitoring driver and koala behaviour simultaneously. These parallel efforts are expected to more comprehensively assess and mitigate koala strike risk and further enhance current warning signage by providing drivers with real time feedback, and information about both their driving behaviour and any koalas that are active near roads. If successful, this approach to mitigation is likely to have much wider, positive ramifications for protecting koalas near roads not just in the Redlands, but throughout their range.

Acknowledgements

The Redland Smart Signs project was commissioned by Redland City Council as part of their koala conservation safe neighbourhoods initiative. Dr Cathryn Dexter, Threatened Species Advisor -Koala Conservation was instrumental as the project lead. Cathryn initiated the Smart Signs project and managed all those involved in implementing the project. We are very grateful to Cathryn for all her support throughout the study. We are also grateful to Ritchie Jones, Stuart Driver and Andrew Drysdale from Jenoptik Traffic Solutions; Mario Conde, Michael Knight, Daniel Thomas and Michael Fahey from ITS/Artcraft; Rudy Budianto from RoadTek; Darren Biles and David Shearman from Queensland Civil Group; and Rex Roebeck and Candy Daunt from Redland City Council.

Romane Cristescu and Kim McLaren from the Detection Dogs For Conservation Research Group at the University of the Sunshine Coast supplied data on koala movements and road crossings in the study areas. Sharyn Rundle-Thiele and collaborators from Social Marketing @ Griffith University conducted community feedback surveys during the public awareness campaigns and when the dynamic signs were displayed.

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1. Introduction

In February 2022, the koala (*Phascolarctos cinereus*) was listed as endangered in Queensland (as well as New South Wales and the Australian Capital Territory), a reflection of their further decline towards extinction (Dept. Env. and Science, 2022). Ten years earlier, the koala was upgraded to the conservation status of vulnerable, suggesting that despite recognition of major threats to koala populations for some time, little has changed to halt their decline. These major threats, which include habitat loss, climate change, disease and vehicle strike (McAlpine et al. 2015), remain pervasive throughout the distribution of koalas. Lunney et al. (2022) noted that wherever koala habitat is dissected by roads, strikes are likely to occur, meaning that urban and semi-urban populations of koalas in particular are at significant risk of being struck on roads.

In recognition of such threats, the Redland City Council (RCC) has initiated a series of koala conservation and management programs aimed at bridging significant knowledge gaps and implementing recovery and mitigation strategies wherever possible. One such strategy was the Smart Signs and Smart Messaging program, the centrepiece of which has been the rollout of variable message signage (VMS) aimed at encouraging drivers to decrease their speed and maintain vigilance in areas known to have local koala populations. In turn, the hope is that by reducing vehicle speeds and improving driver awareness, fewer koalas will be struck. To-date, 13 primary (Jenoptik 'smiley') signs) have been deployed on seven select roads throughout the Redlands and results have consistently and encouragingly demonstrated modest reductions in vehicle speeds in response to signs (Blacker et al. 2019; Appleby et al. 2020-2022). Two additional signs from a different manufacturer have also been deployed, but are not included in this year's results due to differences in data collection methods between manufacturers.

A major concern in relation to the efficacy of signs relates to driver habituation, a (largely assumed) process whereby constant exposure to signs reduces any beneficial responses from drivers. In previous years there has been little evidence of habituation occurring on those roads that had signs deployed over relatively long periods (Appleby et al. 2020-2022). Habituation may take considerable time to develop or become noticeable, and was therefore again explored in the current year. Additionally, this year's experiment also saw a brief, pilot investigation of the use of mixed messaging on one set of signs (Old Cleveland Road East - OCRE). There was interest in exploring whether the signs could serve to reinforce other kinds of safety messaging (e.g. bicycle awareness) along with koala-specific messaging.

The hope was that if successful, sign usage could be expanded to include various safety messages without compromising their original purpose.

Despite encouraging results generally in relation to drivers' responses, the previous year's results demonstrated that there is a persistent minority of drivers exhibiting excessive speeding. For the purposes of the investigation, excessive speeding was defined as vehicles traveling at or above 100 km/hr where designated speed limits ranged from 50 km to 60 km. Although vehicles travelling at such speeds represented a fraction of the overall population of drivers, such speeds are arguably dangerous, and certainly put drivers at a major disadvantage in terms of safely avoiding strikes of koalas or accidents more generally. This phenomenon was again explored in the current year.

This report marks the fifth in a series of annual reports on experiments exploring the utility of VMS in the Redlands. It is, to the best of our knowledge, one of the longest and most comprehensive experimental investigations of wildlife signage conducted anywhere in the world, producing an exceptional, ongoing dataset on vehicle speeds in response to signs. Yet the link between the sign program and any potential, associated reduction in koala strike is very challenging to ascertain in the absence of associated koala abundance, distribution and road crossing information. Two koala strikes resulting in three fatalities as a dependent joey also died, have occurred on roads outfitted with signs since the project began in 2018. Both occurred during the latest round of experimentation (2022-2023): one on Old Cleveland Road East (OCRE) and one on Sturgeon Street. What is unknown however is whether there are cases of strikes being avoided that might have otherwise occurred had signs not been present. As highlighted in previous reports, VMS signs have shown a demonstrable ability to consistently and reliably encourage drivers to lower their speed, and as a result, improve the potential to reduce strikes. Ideally though, information directly related to koala 'availability' (i.e. koalas attempting to or actually crossing roads) needs to be integrated into the smart sign program, in order for evaluations to be more robust.

The three recorded koala fatalities highlight the fact that whilst signs may help reduce the risk of strikes by encouraging drivers to slow down and be more vigilant for koalas entering the road, they cannot prevent strikes altogether. However, there are emerging technologies that may further reduce strike risk, encourage safer driving and help to assess koala availability that are likely to become crucial elements of the Redlands Smart Signs and Smart Messaging program in the near future. These are outlined further in the discussion section of this report. Exploration of these new approaches are set to mark a new phase of research aimed at better understanding and subsequently reducing road strike risk to koalas

in the Redlands, and has potentially beneficial ramifications for koalas across their distribution.

2. Methodology

2.1 Wildlife warning signs

Two models of Sierzega dynamic message signs (supplied by Jenoptik Traffic Solutions) that reported tailorable messages to drivers via an LED display panel were tested during this year's experiment. In each case, the display panel was the same, with the primary variation between the two types being the passive messaging displayed on each. A generic version of the sign (named 'generic smiley') featured a high visibility border and the words: "DRIVE SAFELY", whilst a koala-specific version (named 'koala smiley') featured the image of a koala with the words: "KOALA CROSSING".

Figure 1 shows each version of the Jenoptik signs side-by-side for comparison.

Figure 1. Sierzega brand models of dynamic (variable) message signage, named for this project as Jenoptik 'generic smiley' (left) and 'koala smiley' (right).

The Jenoptik signs were capable of recording the speed of a vehicle both before and as it passed the sign, allowing for a direct comparison of these speeds. These signs recorded vehicles individually, such that one row of the data output pertained to one vehicle, including a time/date stamp accurate down to the second. Since 2020, only Jenoptik ‘koala smiley’ signs have been purchased and deployed in the Redlands, because they were the most consistent and reliable in terms of performance.

2.2 Dynamic (variable) messaging

Both types of Jenoptik sign types (‘generic smiley’ and ‘koala smiley’) were capable of dynamically changing (often referred to as ‘variable’) messaging conveyed to drivers depending on their speed. Figure 2 provides an example of the different messages drivers received at different speeds. Note that at the lowest speed threshold, drivers receive a digital koala smiley message.

Figure 2. An example of the dynamic, variable sign messaging that greeted drivers given certain measured vehicle speed thresholds, capable with the Jenoptik models. In this example, messaging was tailored to a 50 km/hr posted speed limit zone. For a 60 km/hr posted speed limit zone, each threshold was increased by 10 km/hr. The green koala symbol

greeted drivers if they were recorded to be driving under 45 km/hr (or under 55 km/hr in a 60 km/hr zone).

In 2022, a new ‘mixed’ message was trialled on OCRE signs in an effort to expand the utility of signs. Instead of being greeted with the usual messages shown in Figure 2, drivers instead were greeted with images of bicycles (i.e. meant to prompt added awareness of cyclists in the area). Depending on the speed they were travelling, drivers would either receive a green bicycle for driving at least 5 km or more below the posted speed limit), an yellow or amber bicycle for driving 5 km/hr less than or equal to the posted speed limit or else a red bicycle warning them they were driving over the speed limit. These images were displayed between the hours of 5 am to 7 pm each day. Outside of these hours, the sign reverted to the standard koala/smiley face images shown in Figure 2.

Figure 3. Bicycle-style messaging trialled at OCRE during most of February 2023, showing the various speed thresholds and associated images that a driver would see as they pass by.

2.3 Sign operation dates, locations and treatments

Eight Jenoptik signs were installed, covered and became operational from 1 October 2020. These signs were covered during the 2020-2021 pre-treatment period and then uncovered during the 2020-2021 treatment period, remaining uncovered for the 2021-2022 and 2022-2023 treatment periods (17/04/2021 - 28/02/2023). The location of each sign and data collection periods are detailed in Table 1.

Five additional Jenoptik signs were installed, covered and became operational from 23-25 May 2022. These signs were covered during the 2022 pre-treatment period (ending on 4 September 2022) and then uncovered during their 2022-2023 treatment period (6/09/2022 – 28/02/2023). The location of each sign and data collection periods are detailed in Table 3.

In an effort to determine whether driver habituation would occur (a lessening of driver responses to the signs over time), each sign remained in place at its allocated site until data collection concluded (Table 1). All roads had ‘Wildlife Zone’ painted thresholds installed near each sign in previous years, and these were still clearly visible on the roads. It should be noted that the installation of the painted thresholds had no discernible impact on vehicle speeds at the Ormiston sites during Year 1 (Blacker et al. 2019), but may serve a broader role of helping to remind drivers about the presence of wildlife near roads and demarcate areas where drivers are required to be more vigilant.

Finally, a pilot experiment of varied messaging was conducted, with a view to exploring how drivers responded to signs displaying different messages at different times of the day. Starting Thursday 2/02/2023 until the end of the data collection period (28/02/2023) a new set of messages were displayed on both Old Cleveland Road East signs (see Figure 3) from 5:00 AM to 6:59 PM daily, which then reverted back to the normal koala/smiley faces for the rest of the night.

Table 1. The sign allocation to each site for the previously installed Jenoptik signs, with the dates of operation for data collection during the 2020/21, 2021/22 and 2022/23 treatment periods.

Site	Sign	2020/21 Treatment start date	2020/21 Treatment end date	2021/22 Treatment start date	2021/22 Treatment end date	2022/23 Treatment start date	2022/23 Treatment end date
Sturgeon Street west	Koala smiley 16720	16/12/2020	16/04/2021	17/04/2021	24/02/2022	1/03/2022	28/02/2023
Sturgeon Street east	Koala smiley 19543	16/12/2020	16/04/2021	17/04/2021	24/02/2022	7/03/2022	28/02/2023
Wellington Street north	Koala smiley 19541	16/12/2020	16/04/2021	17/04/2021	24/02/2022	13/06/2022	28/02/2023
Wellington Street south	Koala smiley 19540	16/12/2020	16/04/2021	17/04/2021	24/02/2022	1/03/2022	28/02/2023
Old Cleveland Road East east	Generic smiley 14370	6/11/2020	16/04/2021	17/04/2021	24/02/2022	1/03/2022	23/01/2023
Old Cleveland Road East west	Generic smiley 14361	16/12/2020	16/04/2021	17/04/2021	24/02/2022	1/03/2022	23/01/2023
Fitzroy Street north	Koala smiley 16718	28/11/2020	16/04/2021	17/04/2021	24/02/2022	1/03/2022	28/02/2023
Fitzroy Street south	Koala smiley 18935	29/11/2020	16/04/2021	17/04/2021	24/02/2022	1/03/2022	28/02/2023

Table 2. The length of the 2020/21 pre-treatment period and the 2020/21, 2021/22 and 2022/23 treatment period datasets for each previously installed Jenoptik sign and site (after the removal of any anomalous data).

Site	Sign	2020/21 Pre-treatment period (days)	2020/21 Treatment period (days)	2021/22 Treatment period (days)	2022/23 Treatment period (days)
Sturgeon Street west	Koala smiley 16720	56	111	304	241
Sturgeon Street east	Koala smiley 19543	56	122	291	352
Wellington Street north	Koala smiley 19541	66	30	244	247
Wellington Street south	Koala smiley 19540	70	118	289	358
Old Cleveland Road East east	Generic smiley 14370	22	140	312	329
Old Cleveland Road East west	Generic smiley 14361	73	122	272	329
Fitzroy Street north	Koala smiley 16718	54	139	311	365
Fitzroy Street south	Koala smiley 18935	57	126	307	362

Table 3. The sign allocation to each site for the new Jenoptik signs installed in 2022, with the dates of operation for data collection during the 2022/23 pre-treatment and treatment periods, as well as the length of the datasets (after the removal of any anomalous data).

Site	Sign	2022/23 Pre-treatment start date	2022/23 Pre-treatment end date	2022/23 Pre-treatment period (days)	2022/23 Treatment start date	2022/23 Treatment end date	2022/23 Treatment period (days)
Nelson Road	Koala smiley 26978	24/05/2022	4/09/2022	104	6/09/2022	28/02/2023	176
Wellington Street north_2	Koala smiley 26981	24/05/2022	4/09/2022	97	6/09/2022	28/02/2023	176
Collingwood Road	Koala smiley 26986	24/05/2022	4/09/2022	90	6/09/2022	28/02/2023	176
South Street east	Koala smiley 26987	23/05/2022	4/09/2022	98	6/09/2022	28/02/2023	176
South Street west	Koala smiley 27633	25/05/2022	4/09/2022	103	6/09/2022	28/02/2023	176

2.4 Technical and data issues

Signs operated as expected for the majority of the time and enough data were collected during each study period (pre-treatment and treatment periods) in order to make reasonable comparisons. There were times when one or more signs malfunctioned, or where other issues arose, resulting in compromised or lost data. These issues are detailed in Appendix 1 and data losses are summarised in Appendix 2.

2.5 Data processing and quality checks

Throughout the study period the online web portals were checked regularly, including radar outputs and summary data, to ensure signs were operational. Data files were then downloaded at the end of the pre-treatment and treatment periods.

For all Jenoptik signs, raw data in the form of .GRS files were downloaded from the Sierzega GR.net online web portal then exported from the Sierzega GRS 5.2 software program as .txt files, which were then compiled by sign and treatment period in R (R Core Team, 2023). Data cleaning was then conducted in both R and Excel, with graphing conducted in Excel.

Graphs of average daily car speeds from all signs were created in order to check for anomalies in the form of large spikes or dips in speed. Such anomalous data were investigated and removed from datasets where appropriate (see anomalies detailed in Appendix 1: Technical and data issues).

2.6 Data analyses

As with the previous three reports (Appleby et al. 2020; Appleby et al. 2021; Appleby et al. 2022) we chose to present results in descriptive and graphical formats, rather than undertaking specific hypothesis tests or modelling approaches, due to limitations of the available data. A major limitation for instance is that it is entirely unclear whether and to what degree the same drivers drove on more than one experimental road, but given the proximity of some of these roads to one another, some overlap would be expected. These limitations lead to inevitable caveats, and caution is therefore required in interpreting results. At the same time, the descriptive approaches we favoured still offer useful insights regarding overall sign performance.

As with previous years of this project, the Jenoptik signs again recorded two speeds per vehicle. The 'V1' speed was recorded as the driver approached the sign and the 'V2' speed was recorded as the driver passed the sign, with the V2 speeds from the pre-treatment period being compared with the V2 speeds from the treatment period for analyses. R and Excel were used to produce summary statistical analyses for these signs, including average vehicle speeds and 85th percentile vehicle speeds (the speed at or below which 85% of all cars were recorded) for the 2022/23 pre-treatment and treatment periods. From these, changes in average and 85th percentile speeds were calculated between the pre-treatment periods in 2020/21 and 2022/23 and the 2022/23 treatment periods.

GPS collar data were kindly provided by the University of the Sunshine Coast researchers and were collated in Microsoft Excel (2018) and mapped in GPS Visualizer (https://www.gpsvisualizer.com/).

3. Results

3.1 Exploration of habituation

In contrast to previous years' results, this year saw the first potential evidence for driver habituation. As Table 4 suggests, it was, albeit, modest evidence, as it involved a single sign on Sturgeon Street (eastbound), and represented a slight increase in average speed of 0.87km/hr (equivalent to 1.79%) compared to the pre-treatment average. No changes in 85th percentile speeds were observed. All other signs exhibited modest reductions in average speeds over the same period. All average V2 speeds, including that for Sturgeon Street east remained below the posted speed limit for a given road.

Table 4. Comparison of the change in average and 85th percentile V2 vehicle speeds for Jenoptik 'koala smiley' and ‘generic smiley’ signs, between the 2020/21, 2021/22, and 2022/23 study periods. Numbers in red represent increases in speed, or no change in speed, between the pre-treatment and treatment periods of the relevant year.

			2020/21				2021/22				2022/23			
			Speed changes from Pre-treatment to Treatment period				Speed changes from 2020/21 Pre-treatment period to 2021/22 Treatment period				Speed changes from 2020/21 Pre-treatment period to 2022/23 Treatment period			
Site	Speed limit (km/hr)	Sign	Change in average speed (km/hr)	Change in average speed (%)	Change in 85th percentile speed (km/hr)	Change in 85th percentile speed (%)	Change in average speed (km/hr)	Change in average speed (%)	Change in 85th percentile speed (km/hr)	Change in 85th percentile speed (%)	Change in average speed (km/hr)	Change in average speed (%)	Change in 85th percentile speed (km/hr)	Change in 85th percentile speed (%)
Sturgeon St east	60	Koala smiley 19543	-0.03	-0.05	0.00	0.00	-0.10	-0.20	0.00	0.00	0.87	1.79	0.00	0.00
Sturgeon St west	60	Koala smiley 16720	-1.46	-2.65	-1.00	-1.64	-1.68	-3.06	-1.00	-1.64	-1.45	-2.65	-1.00	-1.64
Wellington St north	50	Koala smiley 19541	-1.49	-3.15	-1.00	-1.82	-0.98	-2.07	-1.00	-1.82	-1.36	-2.87	-1.00	-1.82
Wellington St south	50	Koala smiley 19540	-2.37	-4.98	-2.00	-3.57	-2.25	-4.73	-2.00	-3.57	-2.83	-5.95	-3.00	-5.36
Fitzroy St north	50	Koala smiley 16718	-2.64	-5.42	-3.00	-5.17	-2.24	-4.59	-3.00	-5.17	-2.94	-6.03	-4.00	-6.90
Fitzroy St south	50	Koala smiley 18935	-2.10	-4.90	-3.00	-5.77	-1.70	-3.96	-2.00	-3.85	-1.58	-3.68	-2.00	-3.85
Old Cleveland Rd East east	60	Generic smiley 14370	-1.71	-3.14	-2.00	-3.28	-1.66	-3.05	-1.00	-1.64	-1.94	-3.55	-2.00	-3.28
Old Cleveland Rd East west	60	Generic smiley 14361	-2.11	-3.57	-2.00	-3.03	-2.01	-3.40	-2.00	-3.03	-3.53	-5.98	-3.00	-4.55

In an effort to further explore any changes in average vehicle speed that might be indicative of driver habituation, Figure 4 shows any observed difference in average V2 speeds between the pre-treatment period and subsequent treatment periods (2020/23) for each given sign. The pre-

treatment average (not explicitly shown) is represented by the ‘zero’ line in the figure. Thus, as also suggested by Table 4, only the sign at Sturgeon Street east showed an increase in average speed above this zero mark, and only for the current year. There were, however, slight upticks in average speed for two additional signs (Sturgeon Street west and Fitzroy Street south) in comparison to previous treatment years, whilst the remaining signs all show slight decreases in average speed for the current year of measurement.

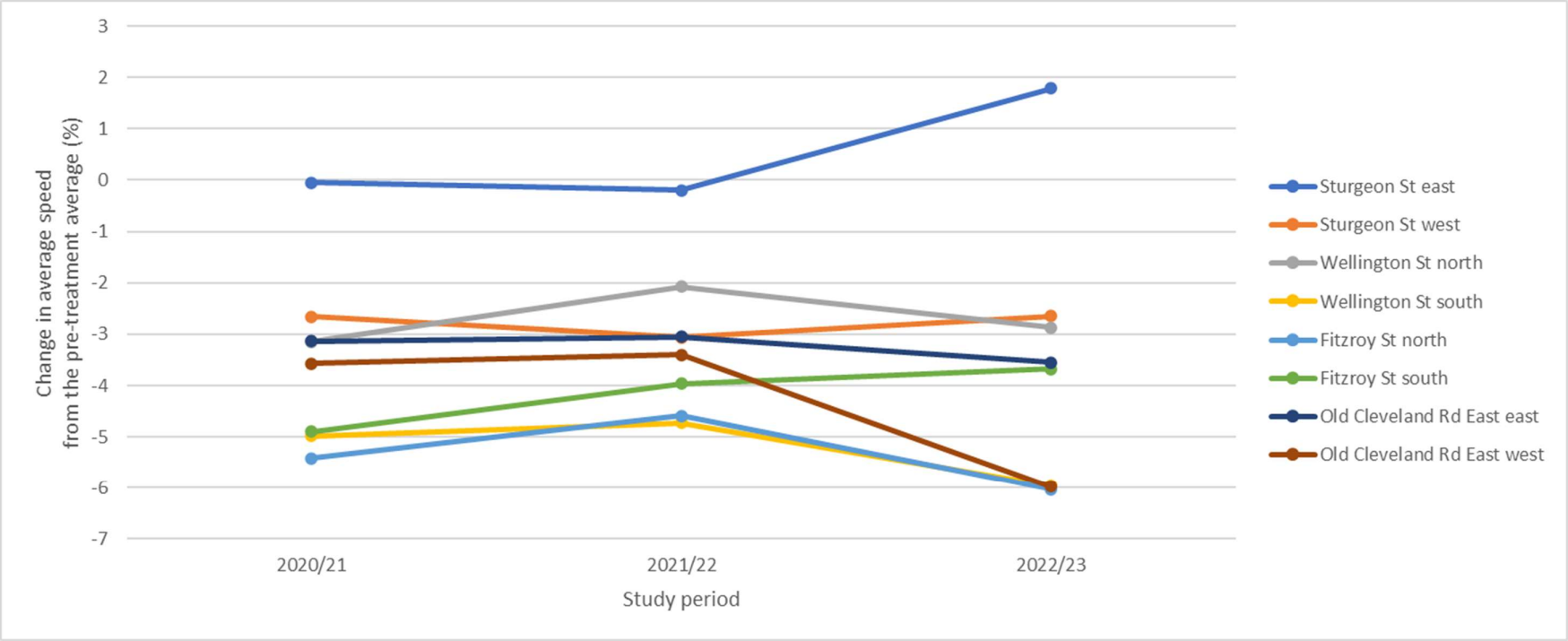

Figure 4. Comparison of changes in average V2 speeds between the pre-treatment (signs covered) average and the 2020/21, 2021/22, and 2022/23 study periods (signs uncovered) for all of the previously installed signs. The ‘0’ point line represents the pre-treatment average for all signs, while the data points for the signs represent the change from that pre-treatment average as a percentage e.g. a datapoint at '-5' represents a 5% decrease in average V2 speeds after the cover was removed, while a data point at ‘2’ represents a 2% increase in average V2 speeds after the cover was removed.

Next, individual habituation plots were made for each road and sign using average daily speeds across the entire study period. Figure 5 is for the Old Cleveland Road East west sign and shows considerably more variation in average daily speeds was experienced from approximately April to August 2022 (possibly relating to road works) in both V1 and V2 speeds.

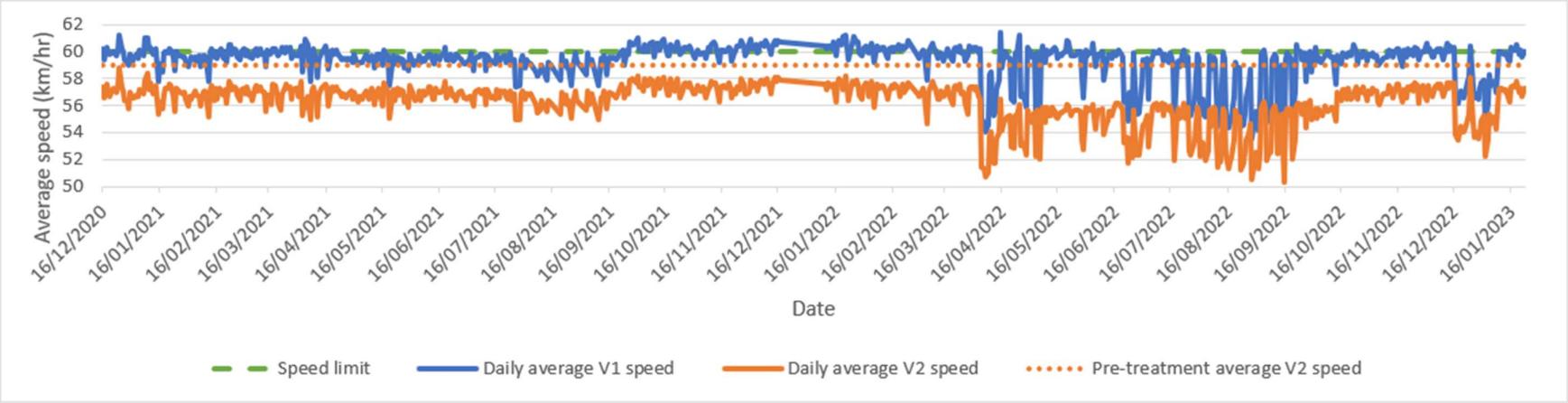

Figure 5. Old Cleveland Road East west daily average vehicle speeds during the 2020/21, 2021/22, and 2022/23 treatment periods when Jenoptik 'generic smiley' sign 14361 was displayed to drivers. The speed limit and average pre-treatment speed are also shown. Note: the pre-treatment line represents the overall average V2 speed from the data collected during the period when the sign was covered in 2020. The linear section at around 16/12/2021 to 16/01/2022 represents a period of roadworks that resulted in anomalous data that were removed.

Figure 6 shows daily average speeds for the Old Cleveland Road East east sign and shows little overall variation across the entire study period.

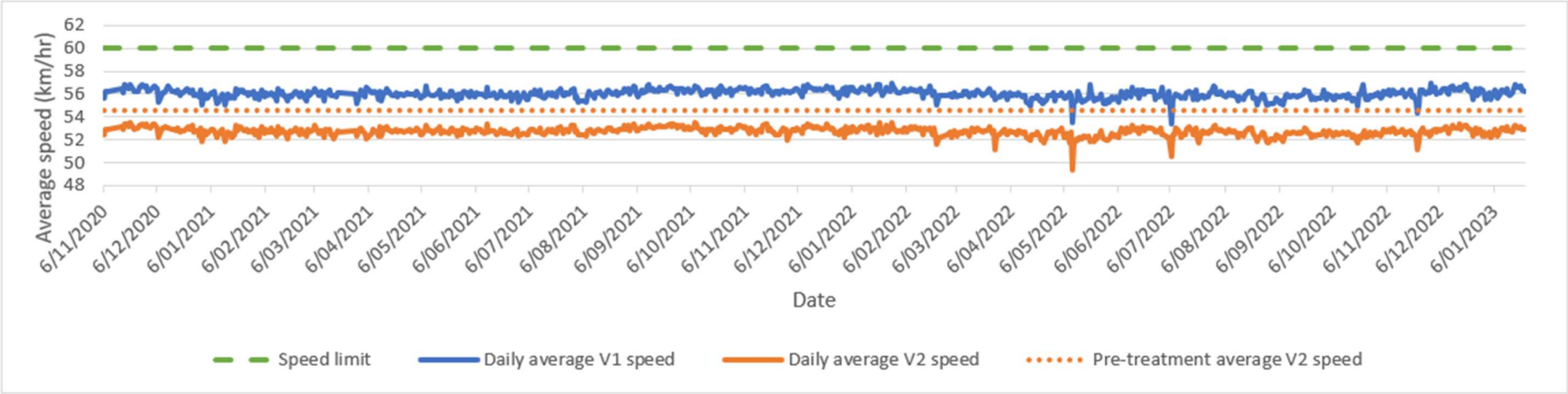

Figure 6. Old Cleveland Road East east daily average vehicle speeds during the 2020/21, 2021/22, and 2022/23 treatment periods when Jenoptik 'generic smiley' sign 14370 was displayed to drivers. The speed limit and average pre-treatment speed are also shown. Note: the pre-treatment line represents the overall average V2 speed from the data collected during the period when the sign was covered in 2020.

Figure 7 shows daily average speeds for Fitzroy Street north and from approximately May 2022 onwards there was a notable decrease in both V1 and V2 average daily speeds.

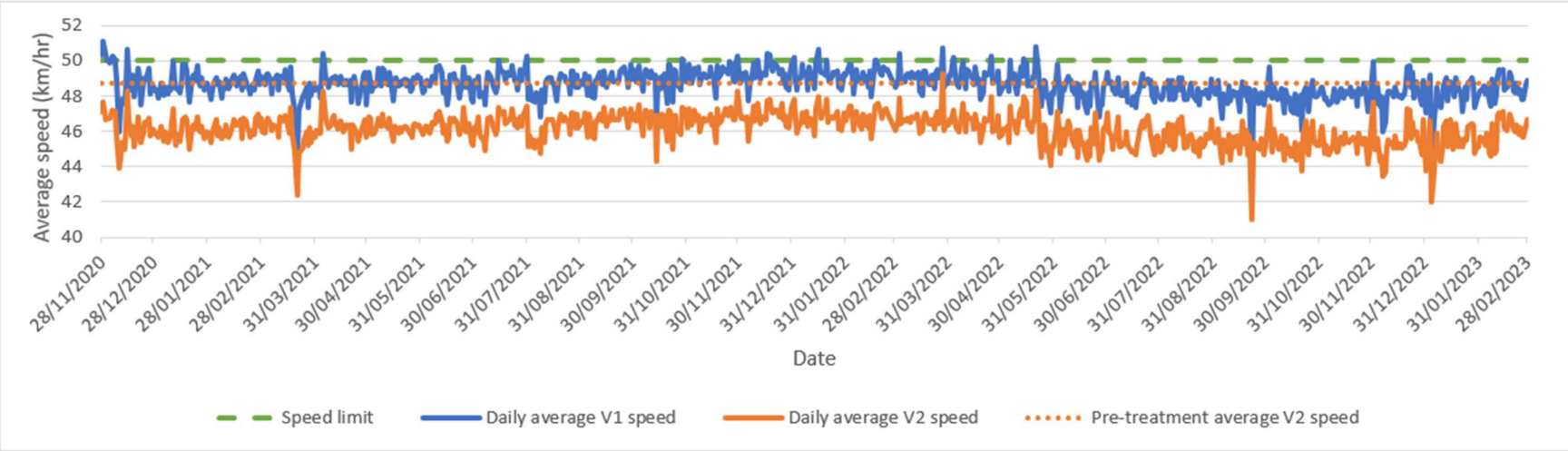

Figure 7. Fitzroy Street north daily average vehicle speeds during the 2020/21, 2021/22, and 2022/23 treatment periods when Jenoptik 'koala smiley' sign 19718 was displayed to drivers. The speed limit and average pre-treatment speed are also shown. Note: the pre-treatment line represents the overall average V2 speed from the data collected during the period when the sign was covered in 2020.

The sign at Fitzroy Street south (Figure 8) showed some minor variation across the study period including some potentially anomalous dips in V2 speeds towards the latter third of the period, but overall, there was no major, observable change in average daily speed.

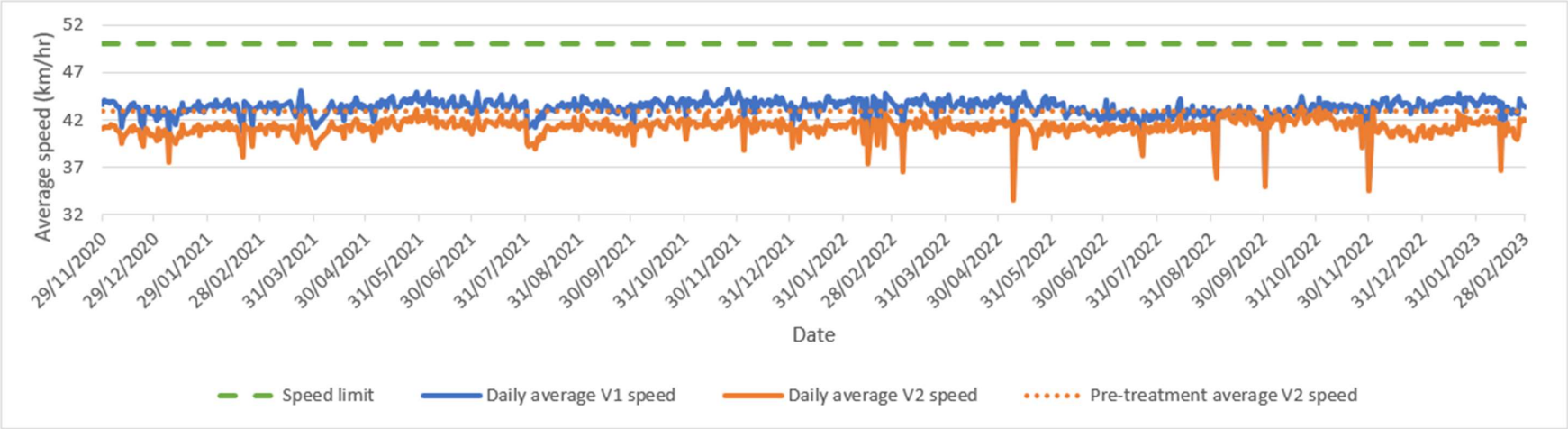

Figure 8. Fitzroy Street south daily average vehicle speeds during the 2020/21, 2021/22, and 2022/23 treatment periods when Jenoptik 'koala smiley' sign 18935 was displayed to drivers. The speed limit and average pre-treatment speed are also shown. Note: the pre-treatment line represents the overall average V2 speed from the data collected during the period when the sign was covered in 2020.

The Sturgeon Street west sign (Figure 9) exhibited considerable variation in average daily speeds across the study period, particularly in the beginning half of the period. V2 speeds occasionally went above the pre-treatment average but most often were observed at least 1km/hr below.

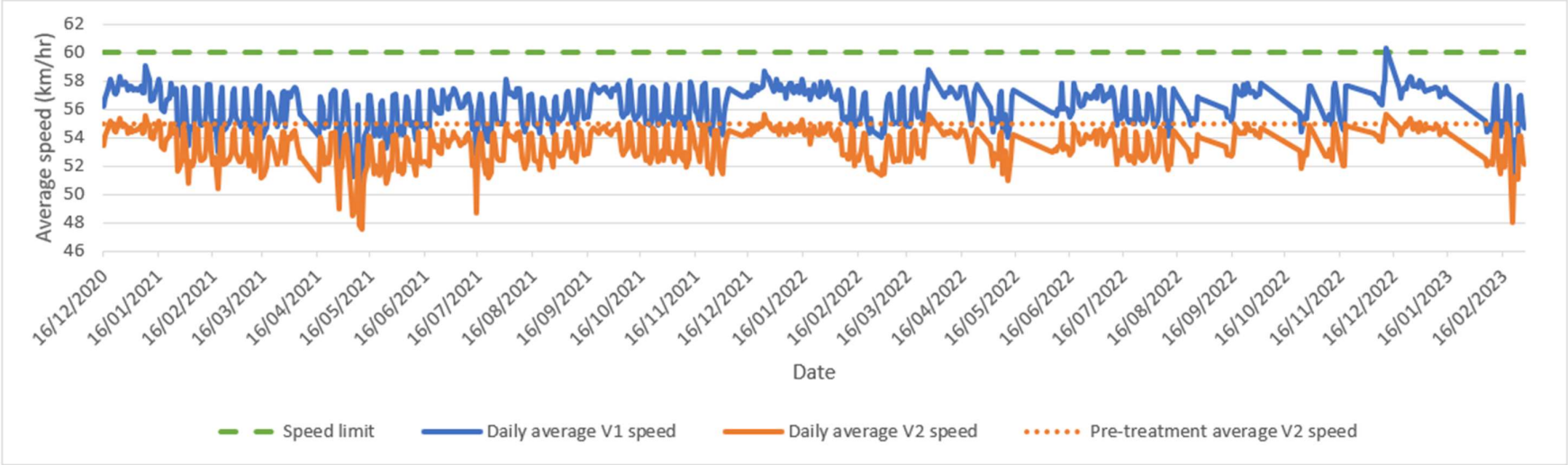

Figure 9. Sturgeon Street west daily average vehicle speeds during the 2020/21, 2021/22, and 2022/23 treatment periods when Jenoptik 'koala smiley' sign 16720 was displayed to drivers. The speed limit and average pre-treatment speed are shown. Note: the pre-treatment line represents the overall average V2 speed from the data collected during the period when the sign was covered in 2020.

The sign at Sturgeon St east (Figure 10) was the only sign for which driver habituation may be apparent, with a consistent daily average speed observed above the pre-treatment average speed in the most recent year of data recording. The observed daily average speed from approximately December 2021 through to February 2023 is consistently just above the pre-treatment average, although it occasionally dips below.

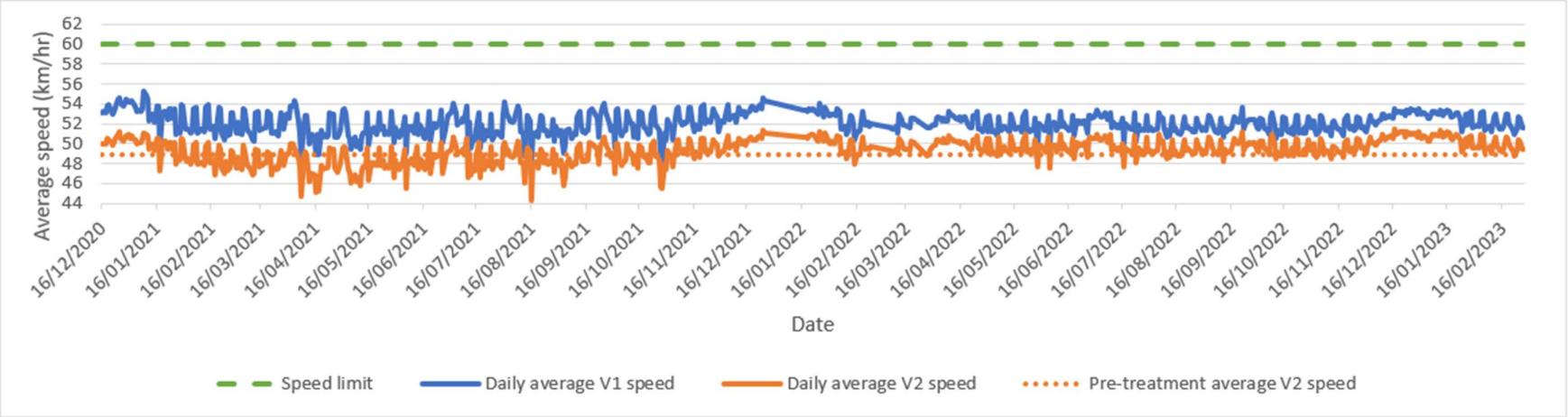

Figure 10. Sturgeon Street east daily average vehicle speeds during the 2020/21, 2021/22, and 2022/23 treatment periods when Jenoptik 'koala smiley' sign 19543 was displayed to drivers. The speed limit and average pre-treatment speed are also shown. Note: the pre-treatment line represents the overall average V2 speed from the data collected during the period when the sign was covered in 2020. The linear section at around 25/12/2021 to 17/01/2022 represents a period of anomalous data that was removed.

Finally the two signs at Wellington Street (south: Figure 11 and north: Figure 12) both show V2 average daily speeds consistently below the pre-treatment average. It is worth noting the period of missing and anomalous data for the Wellington Street north sign from about December 2021 through to June 2022, which may have skewed results. In the most recent year an additional sign was placed to the north of this sign but was not included in the habituation analysis as it has not been deployed long enough for comparison.

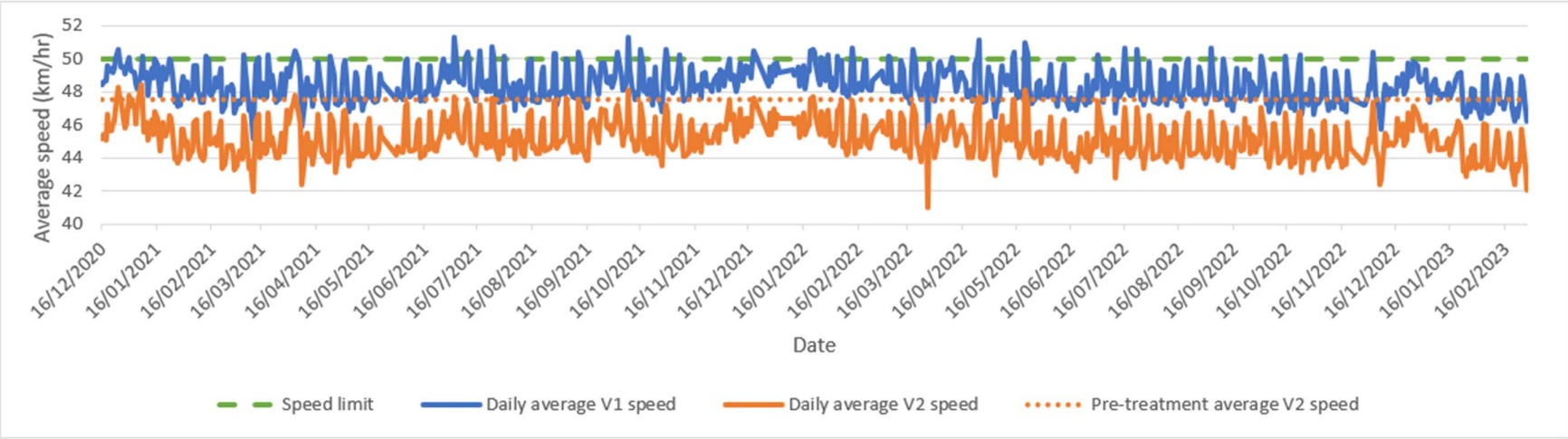

Figure 11. Wellington Street south daily average vehicle speeds during the 2020/21, 2021/22, and 2022/23 treatment periods when Jenoptik 'koala smiley' sign 19540 was displayed to drivers. The speed limit and average pre-treatment speed are also shown. Note: the pre-treatment line represents the overall average V2 speed from the data collected during the period when the sign was covered in 2020.

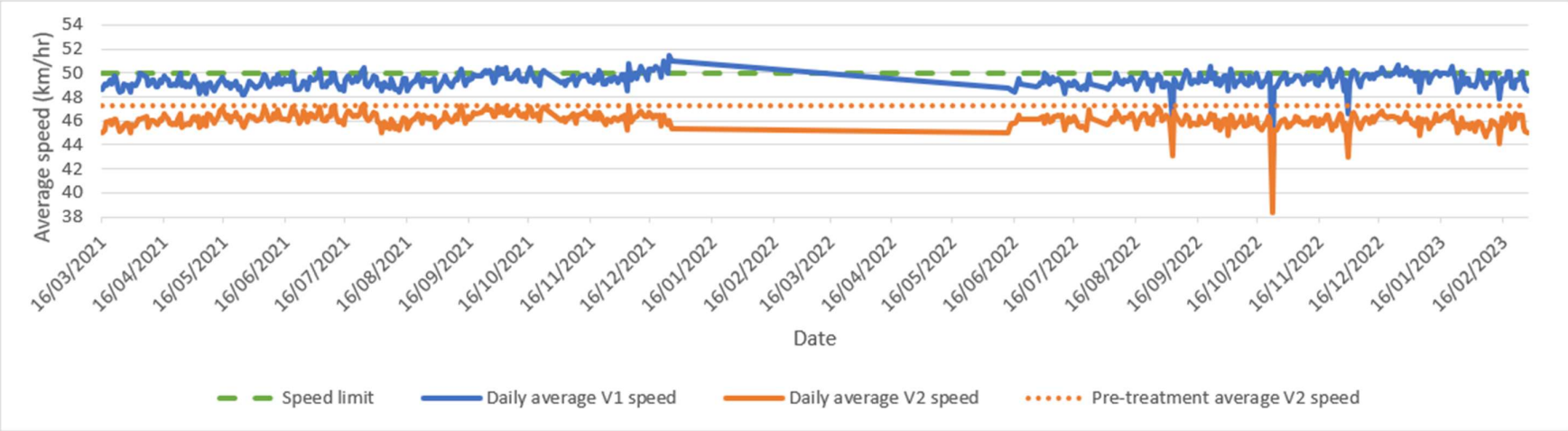

Figure 12. Wellington Street north daily average vehicle speeds during the 2020/21, 2021/22, and 2022/23 treatment periods when Jenoptik 'koala smiley' sign 19541 was displayed to drivers. The speed limit and average pre-treatment speed are also shown. Note: the pre-treatment line represents the overall average V2 speed from the data collected during the period when the sign was covered in 2020. The linear section from 26/12/2021 to 13/06/2022 represents a period of both missing data and anomalous data that was removed.

3.2 Newly-installed signs

Table 5 provides an overview of average and 85th percentile V2 speeds for both the pre-treatment and treatment periods for all new signs deployed in the most recent monitoring period. Only the sign at Collingwood Street did not show a decrease in average or 85th percentile V2 speeds. Some possible reasons for this are explored in the discussion.

Table 5. Comparison of the change in average and 85th percentile V2 vehicle speeds for five newly-installed Jenoptik 'koala smiley' signs during the 2022/23 study period. Numbers in red represent increases in speed, or no change in speed, between the pre-treatment and treatment periods.

			2022/23															
			Pre-treatment period						Treatment period						Speed changes from Pre-treatment to Treatment period			
Site	Speed limit (km/hr)	Sign	Average V2 speed (km/hr)	Standard deviation	Minimum daily average speed (km/hr)	Maximum daily average speed (km/hr)	85th percentile V2 speed (km/hr)	Sample size (number of cars)	Average V2 speed (km/hr)	Standard deviation	Minimum daily average speed (km/hr)	Maximum daily average speed (km/hr)	85th percentile V2 speed (km/hr)	Sample size (number of cars)	Change in average V2 speed	Change in average V2 speed	Change In 85th percentile V2 speed (km/hr)	Change In 85th percentile V2 speed (%)
Collingwood Rd	60	Koala smiley 26986	47.91	7.54	45.43	49.40	55	295072	47.93	7.67	45.34	49.40	55	604956	0.02	0.05	0	0.00
Nelson Rd	60	Koala smiley 26978	51.36	9.26	49.81	52.73	58	152277	50.50	9.30	46.98	51.68	57	262919	-0.86	-1.68	-1	-1.72
South St east	50	Koala smiley 26987	48.76	7.50	46.19	50.22	55	151972	47.46	7.35	46.39	48.56	54	281335	-1.30	-2.66	-1	-1.82
South St west	50	Koala smiley 27633	45.31	7.50	42.06	46.87	51	225207	44.16	7.22	43.28	45.03	50	389271	-1.15	-2.54	-1	-1.96
Wellington St north2	50	Koala smiley 26981	51.08	7.30	49.39	52.72	57	231749	49.56	7.22	48.23	52.72	56	428075	-1.53	-2.99	-1	-1.75

Plots for each individual sign, showing daily average V2 speeds for both the pre-treatment (sign covered) and treatment (sign uncovered) periods are provided below. Figure 13 shows the daily average speeds for Collingwood Street, which appeared to exhibit more variation in daily averages during the pre-treatment period, although there was very little overall difference in average speeds between the two periods.

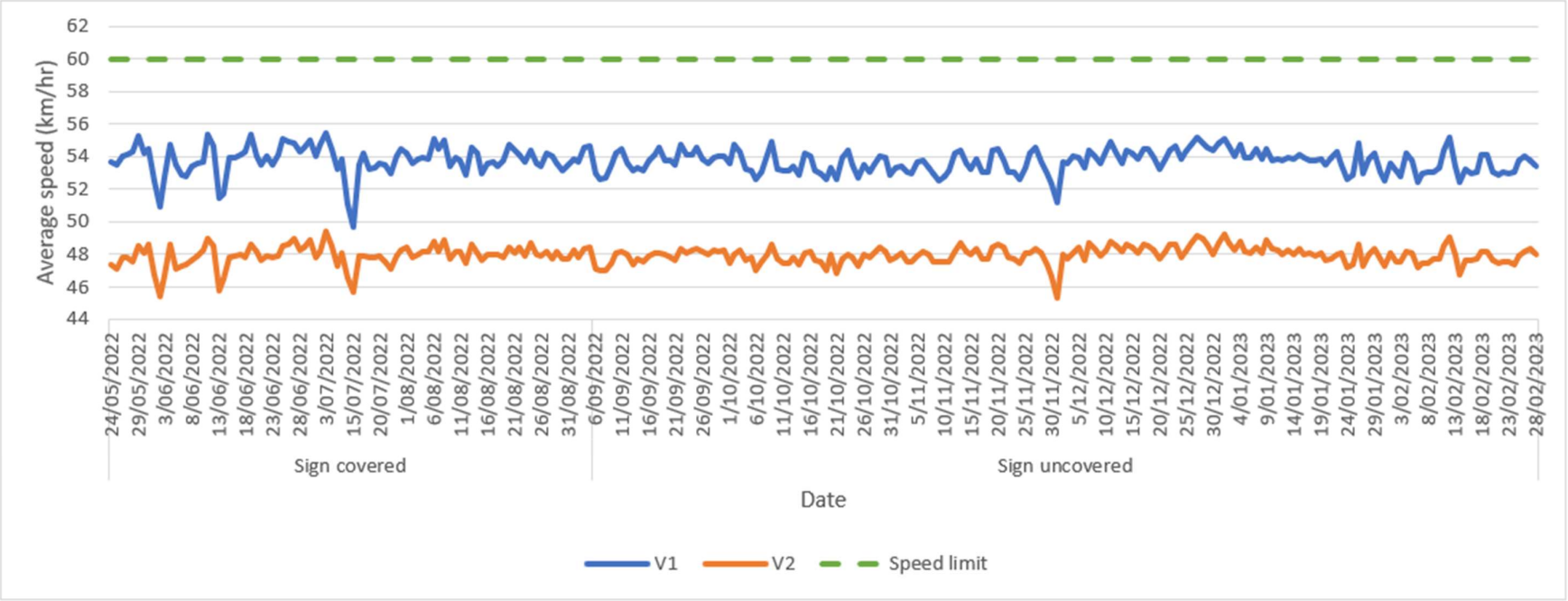

Figure 13. Collingwood Road daily average vehicle speeds during the pre-treatment period when Jenoptik 'koala smiley' sign 26986 was present but covered, and during the treatment period when the sign was uncovered. Note the pre-treatment plot shows two separate lines for V1 and V2 speeds, possibly due to vehicles slowing in response to pre-existing road infrastructure or conditions, or to the presence of the covered sign. Changes in vehicle speeds between the pre-treatment and treatment periods were therefore calculated using the V2 speeds from each period.

Figure 14 provides the daily average speeds for the Nelson Rd sign, with an observable, modest drop in the treatment versus pre-treatment period.

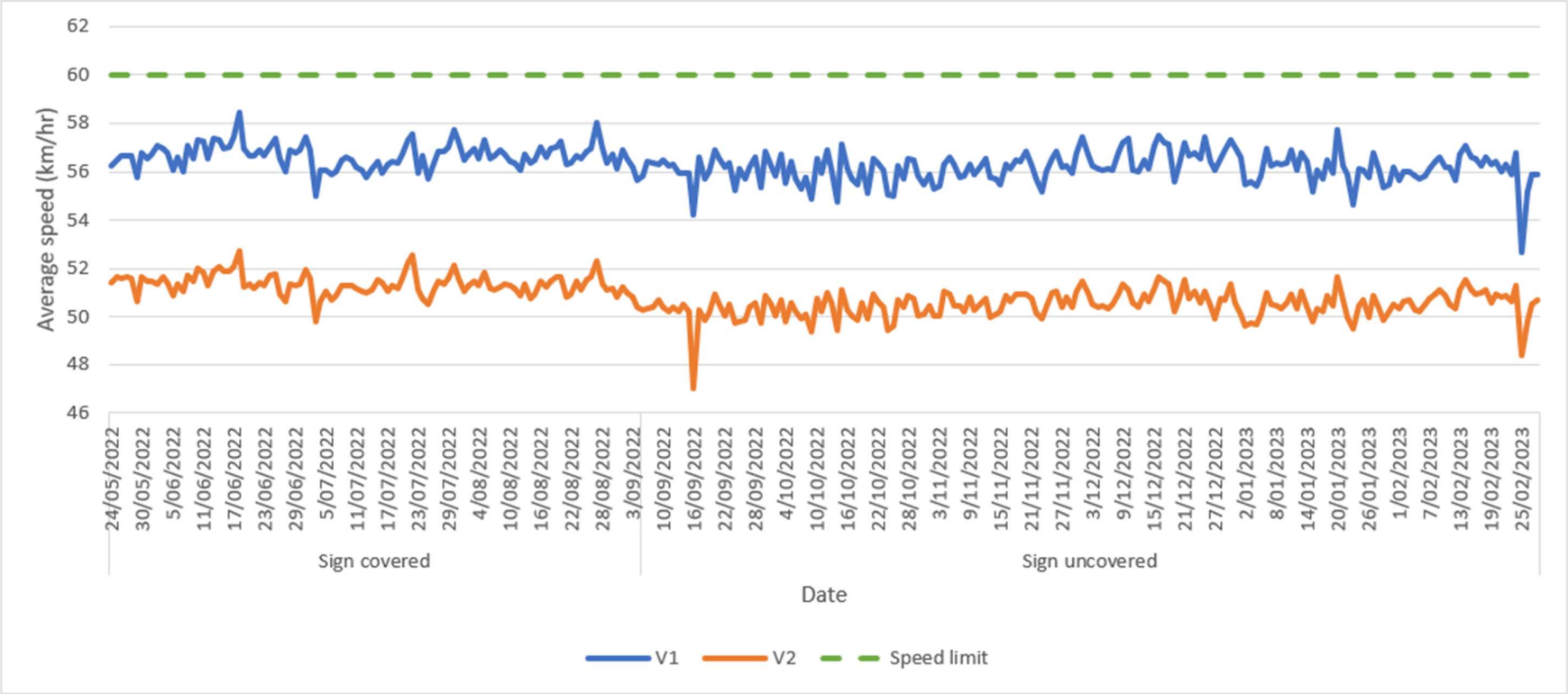

Figure 14. Nelson Road daily average vehicle speeds during the pre-treatment period when Jenoptik 'koala smiley' sign 26978 was present but covered, and during the treatment period when the sign was uncovered. Note the pre-treatment plot shows two separate lines for V1 and V2 speeds, possibly due to vehicles slowing in response to pre-existing road infrastructure or conditions, or to the presence of the covered sign. Changes in vehicle speeds between the pre-treatment and treatment periods were therefore calculated using the V2 speeds from each period.

For the first time in the study, a sign recorded consistently higher V2 average daily speeds in comparison to V1 daily speeds (Figure 15), at South Street east. Note however that there is still a marked drop in both averages after sign covers were removed, suggesting that drivers were still responding to sign messaging. There is a relatively clear, decreasing trend in daily average speeds across the treatment period.

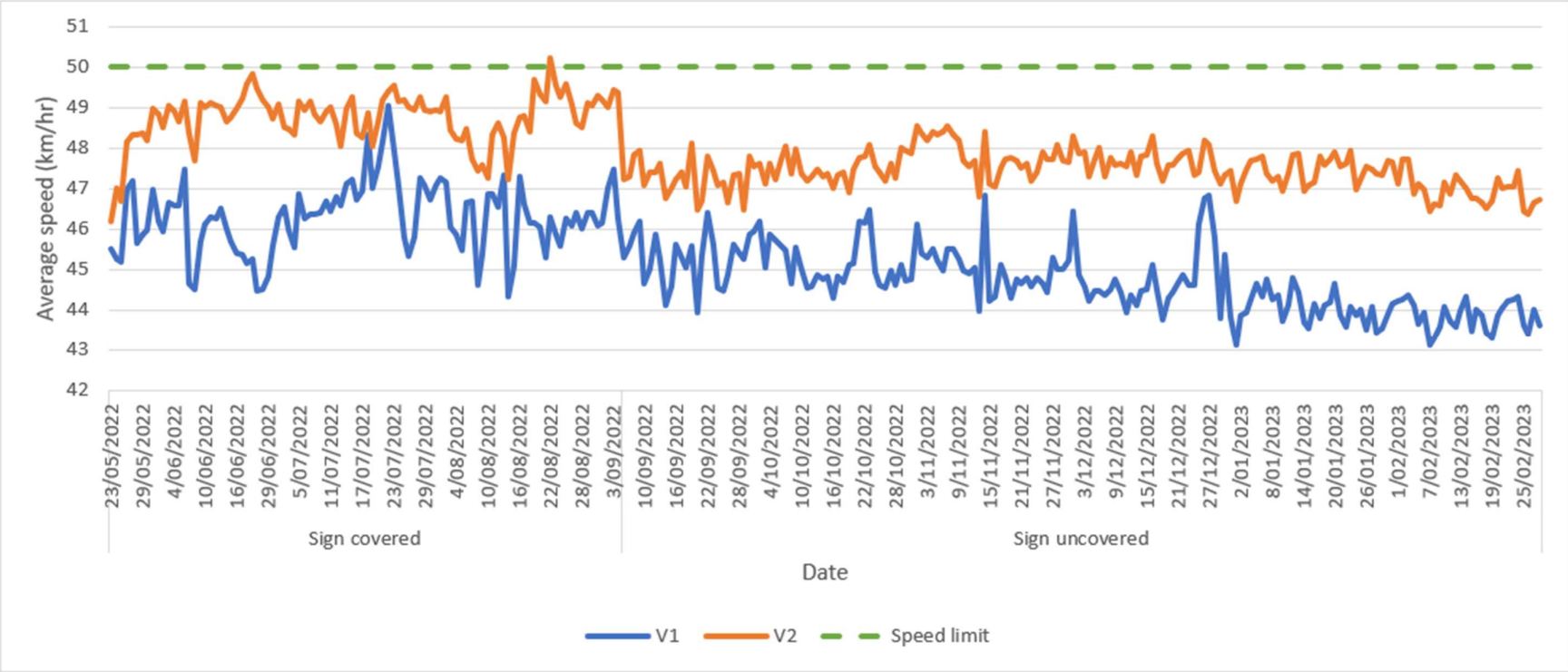

Figure 15. South Street east daily average vehicle speeds during the pre-treatment period when Jenoptik 'koala smiley' sign 26987 was present but covered, and during the treatment period when the sign was uncovered. Note that, unlike the data from the other signs, V2 speeds are greater than V1 speeds, indicating that drivers were speeding up as they passed the sign, possibly due to pre-existing road infrastructure or

conditions. However, there was still a drop in average V2 speeds after the sign cover was removed. As with the other signs, changes in vehicle speeds between the pre-treatment and treatment periods were calculated using the V2 speeds from each period.

The sign at South Street west (Figure 16) also recorded a drop in daily average V1 and V2 speeds when comparing the pre-treatment and treatment periods, with V1 speeds being closer to the posted speed limit. The drop in these two averages for both signs on South Street is quite noticeable at the beginning of the treatment period.

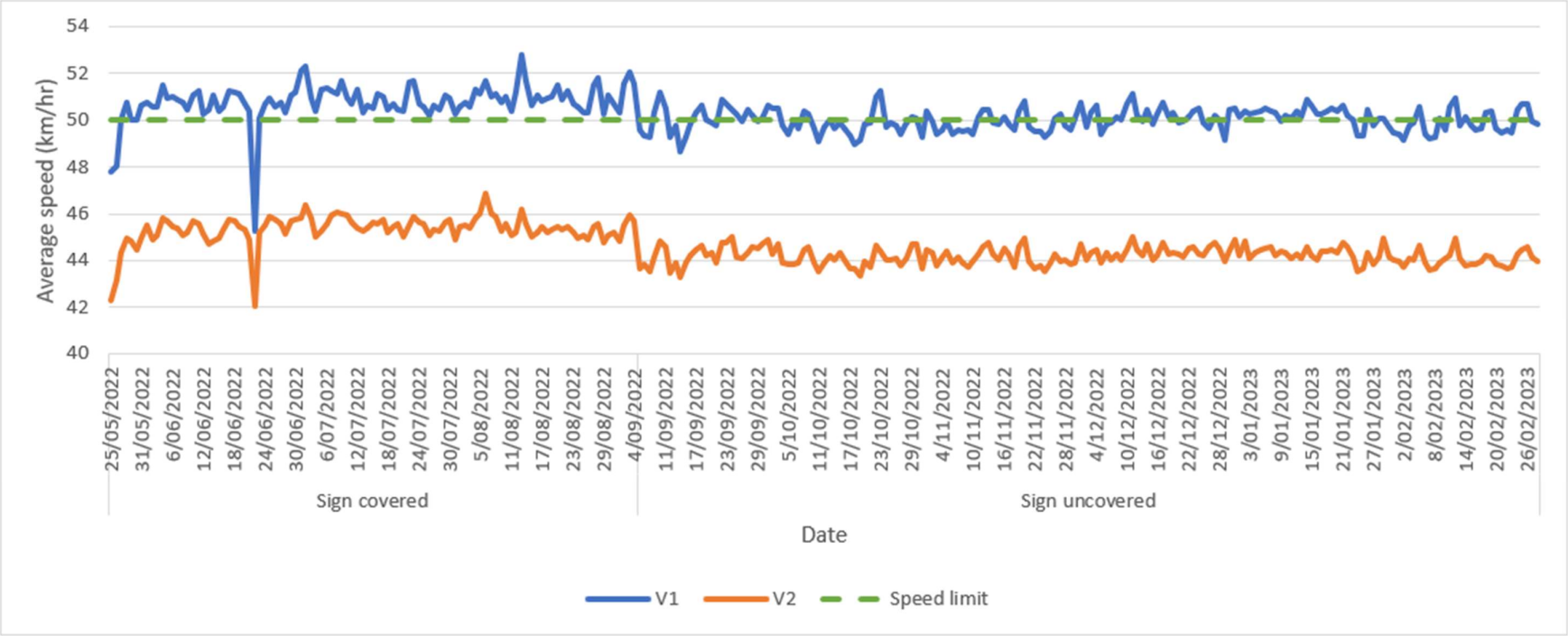

Figure 16. South Street west daily average vehicle speeds during the pre-treatment period when Jenoptik 'koala smiley' sign 27633 was present but covered, and during the treatment period when the sign was uncovered. Note the pre-treatment plot shows two separate lines for V1 and V2 speeds, possibly due to vehicles slowing in response to pre-existing road infrastructure or conditions, or to the presence of the covered sign. Changes in vehicle speeds between the pre-treatment and treatment periods were therefore calculated using the V2 speeds from each period.

Finally, the new sign on Wellington Street ('north2', Figure 17) shows a notable drop in V1 and V2 daily average speeds as soon as the treatment period began. Encouragingly, whilst V1 and V2 daily average speeds were both above the posted speed limit almost throughout the pre-treatment period, V2 speeds in particular often crept below the posted speed limit throughout the treatment period, and occasionally, so did the V1 average daily speeds.

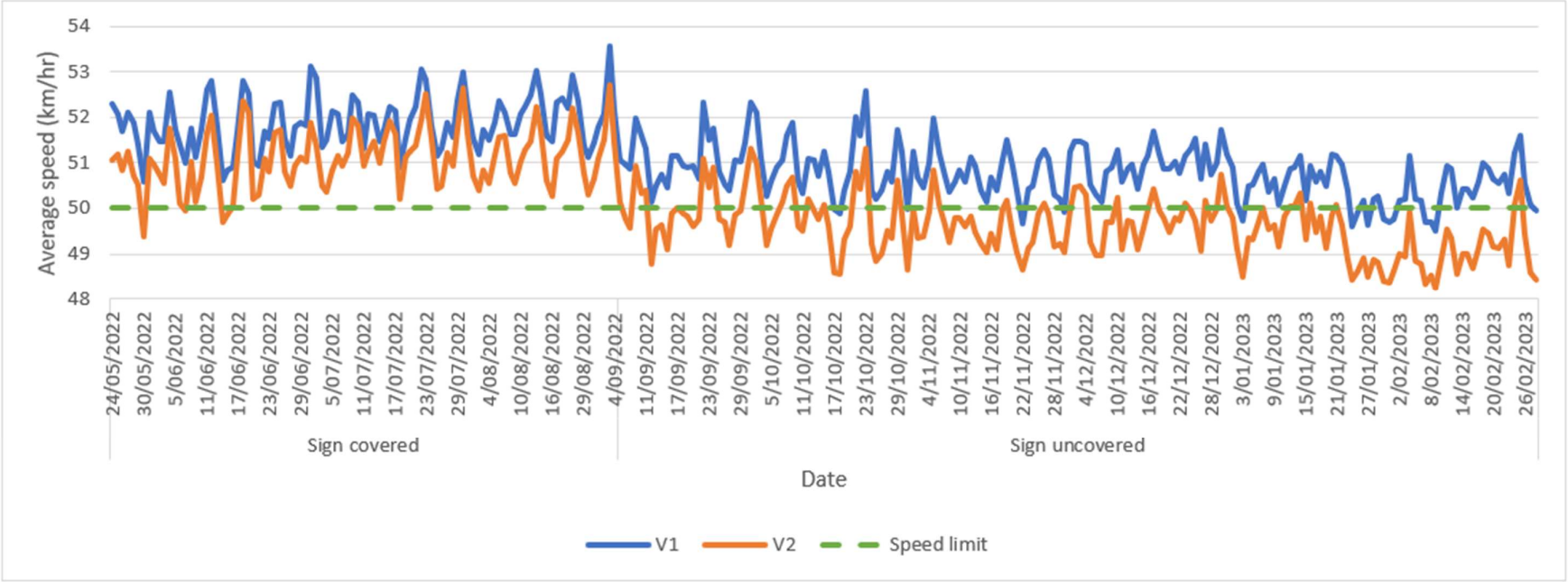

Figure 17. Wellington Street north_2 daily average vehicle speeds during the pre-treatment period when Jenoptik 'koala smiley' sign 26981 was present but covered, and during the treatment period when the sign was uncovered. Note the pre-treatment plot shows two separate lines for V1 and V2 speeds, possibly due to vehicles slowing in response to pre-existing road infrastructure or conditions, or to the presence of the covered sign. Changes in vehicle speeds between the pre-treatment and treatment periods were therefore calculated using the V2 speeds from each period.

3.3 OCRE ‘bicycle messaging’ experiment

A pilot assessment was conducted to explore driver responses to ‘mixed’ messages emanating from signs. Two distinct message types were assessed: standard koala-specific messaging as well as bicycle-specific messaging, on both signs located on Old Cleveland Road East. Table 6 provides the overall results for both signs comparing the average, minimum and maximum daily averages, and 85th percentile V2 speeds for the standard koala treatment period with the bicycle treatment period. While both signs showed a decrease in average speed in comparison to pre-treatment averages during the bicycle treatment period, these decreases were not as pronounced as those observed during the standard koala treatment period. The OCRE west sign recorded a larger decrease than the OCRE east sign for both the standard koala and bicycle treatment periods.

Table 6. Comparison of the change in average and 85th percentile V2 vehicle speeds for two Jenoptik 'generic smiley' signs on Old Cleveland Road East (eastbound and westbound), for both the 2022/23 treatment period (when koala/smiley faces were shown on the signs) and 2023 bicycle messaging period (when images of bicycles was shown on the signs). Numbers in red represent increases in speed, or no change in speed, between the 2020/21 pre-treatment period (when the signs were covered) and the treatment periods (signs uncovered).

			2022/23																	
			Treatment period						Speed changes from 2020/21 Pre-treatment period to 2022/23 Treatment period				Bicycle treatment period						Speed changes from 2020/21 Pre-treatment period to 2022/23 Bicycle treatment period			
Site	Speed limit (km/hr)	Sign	Average speed (km/hr)	Standard deviation	Minimum daily average speed (km/hr)	Maximum daily average speed (km/hr)	85th percentile speed (km/hr)	Sample size (number of cars)	Change in average speed (km/hr)	Change in average speed (%)	Change In 85th percentile speed (km/hr)	Change In 85th percentile speed (%)	Average speed (km/hr)	Standard deviation	Minimum daily average speed (km/hr)	Maximum daily average speed (km/hr)	85th percentile speed (km/hr)	Sample size (number of cars)	Change in average speed (km/hr)	Change in average speed (%)	Change in 85th percentile speed (km/hr)	Change in 85th percentile speed (%)
Old Cleveland Rd East east	60	Generic smiley 14370	52.58	7.19	49.34	53.35	59	2956995	-1.94	-3.55	-2	-3.28	54.29	7.02	53.80	54.72	61	165216	-0.23	-0.42	0	0
Old Cleveland Rd East west	60	Generic smiley 14361	55.50	8.62	50.28	58.11	63	2387535	-3.53	-5.98	-3	-4.55	57.37	8.09	56.49	57.89	64	152116	-1.66	-2.81	-2	-3.03

Looking at the individual sign plots for daily average speeds for both the standard koala and bicycle messaging periods, Figure 18 highlights the relatively high levels of speed variation observed for the OCRE west sign, particularly during the koala messaging period. In contrast, the OCRE east sign (Figure 19) showed far less variation over the entire measurement period. Note though, that there is a very clear uptick in daily average V2 speed as soon as the bicycle messaging period begins for the OCRE east sign.

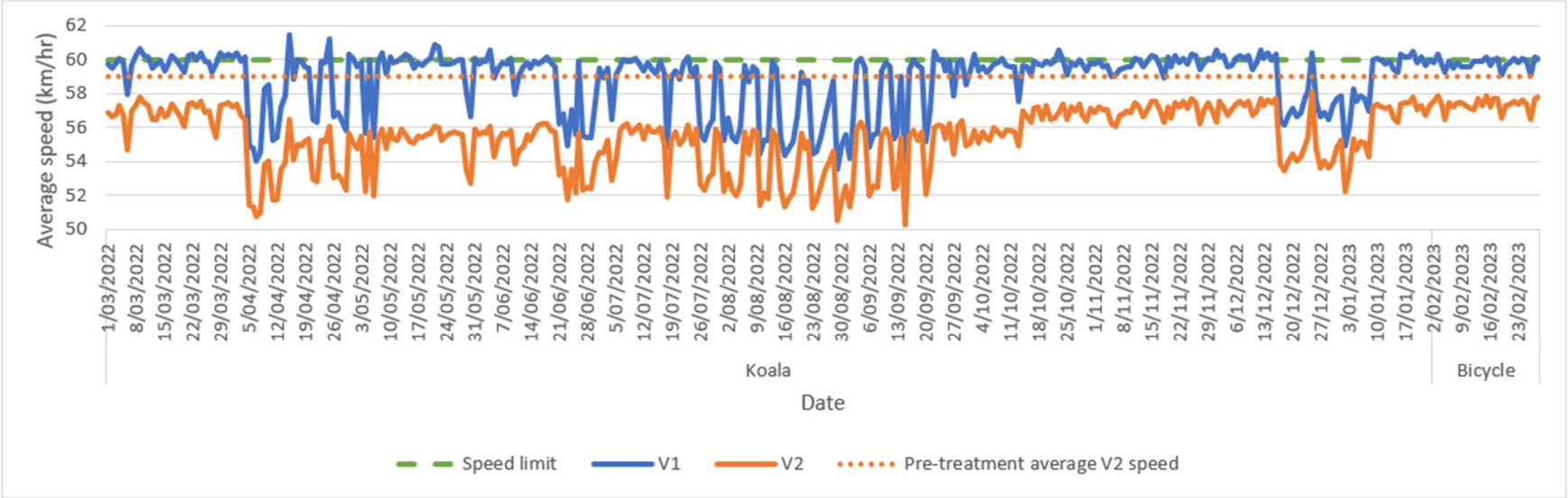

Figure 18. Old Cleveland Road East west daily average vehicle speeds during the 2022/23 treatment period ('Koala') when Jenoptik 'generic smiley' sign 14361 was present and uncovered (1/03/2022-23/01/2023), and during the 'bicycle messaging' treatment period ('Bicycle') when the sign was uncovered but changed to display the bicycle images shown in Figure 3 (from 5AM-6:59 PM), rather than the koala/smiley faces shown in Figure 2 (2-28/02/2023). Changes in vehicle speeds between the two treatment periods were calculated using the V2 speeds from each period.

Figure 19 shows the daily average speeds for the OCRE east sign and whilst both V1 and V2 daily averages remained well below the posted speed limit throughout the period, note the observable uptick in daily average V2 speeds corresponding to the introduction of the bicycle messaging experiment.

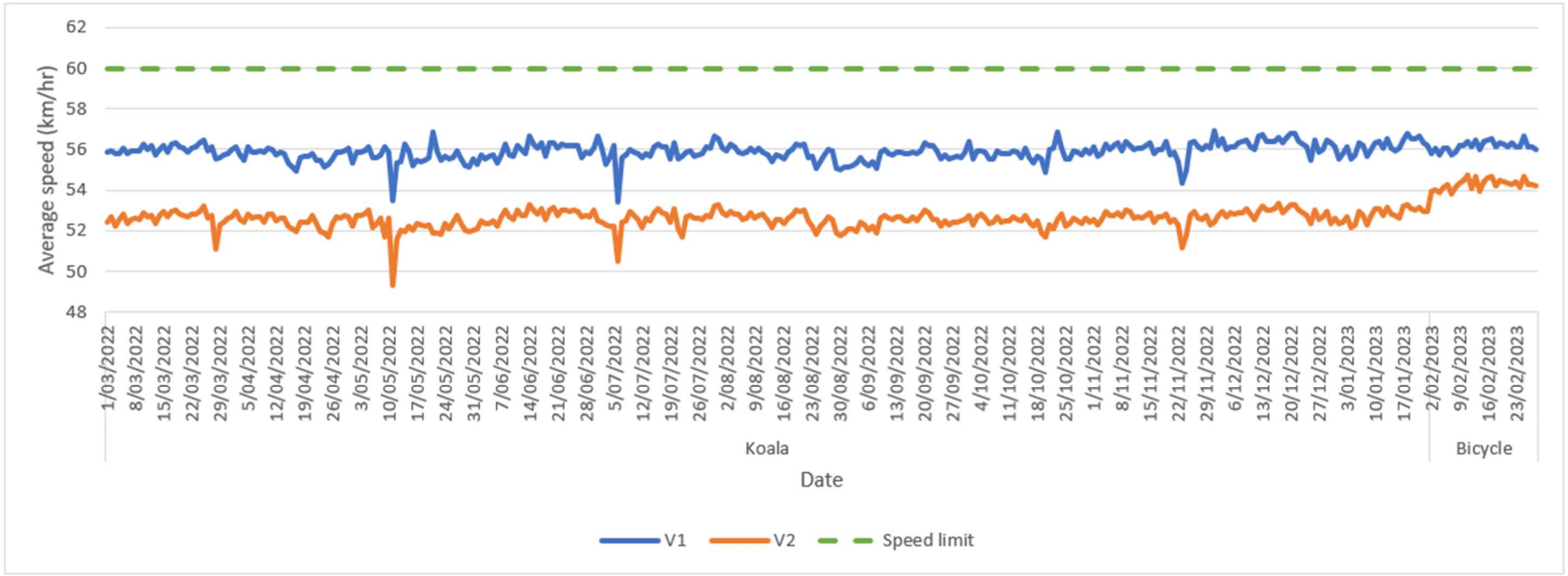

Figure 19. Old Cleveland Road East east average daily vehicle speeds during the 2022/23 treatment period ('Koala') when Jenoptik 'generic smiley' sign 14370 was present and uncovered (1/03/2022-23/01/2023), and during the 'bicycle messaging' treatment period ('Bicycle') when the sign was uncovered but changed to display the bicycle images shown in Figure 3 (from 5AM-6:59 PM), rather than the koala/smiley faces shown in Figure 2 (2-28/02/2023). Changes in vehicle speeds between the two treatment periods were calculated using the V2 speeds from each period.

As the OCRE signs displayed different sets of messages at different times of the day, datasets were compiled to match these time periods and summary data from these are presented in Table 7. In an effort to ensure a fair comparison, average, minimum and maximum, and 85th

percentile V2 speeds for both the koala/smiley message-only treatment period ('Koala') and the mixed bicycle and koala/smiley message period ('Bicycle') were split up into 'Night' and 'Day'. During the 'Koala' treatment period, only koala/smiley messages were conveyed both day and night. During the 'Bicycle' treatment period, koala/smiley messages were conveyed at night and bicycle messages during the day. Results were somewhat complicated in that average night time speeds were lower than day time speeds for OCRE east in both treatment periods, whilst the opposite was true for OCRE west. Direct time-of-day comparisons between the two treatment periods showed that average and 85th percentile speeds were, largely lower during the 'Koala' treatment compared to the 'Bicycle' treatment periods, albeit modestly. An exception was for OCRE west, where night time 85th percentile speeds were lower.

Table 7. Comparison of the change in average and 85th percentile V2 vehicle speeds for two Jenoptik 'generic smiley' signs on Old Cleveland Rd East (eastbound and westbound), between night time ('Night': 7pm - 5am) and day time ('Day': 5am - 7pm) periods for both the 2022/23 treatment period ('Koala treatment period') when koala/smiley faces were exclusively shown on the signs, and the 2023 bicycle messaging period ('Bicycle treatment period') when images of bicycles were shown on the signs between the hours of 5am and 7pm (reverting to koala/smiley faces during the night). Numbers in red represent increases in speed, or no change in speed.

				2022/23														
				Koala treatment period						Bicycle treatment period						Speed changes from Koala treatment period to Bicycle treatment period			
Site	Speed limit (km/hr)	Sign	Time period	Average speed (km/hr)	Standard deviation	Minimum daily average speed (km/hr)	Maximum daily average speed (km/hr)	85th percentile speed (km/hr)	Sample size (number of cars)	Average speed (km/hr)	Standard deviation	Minimum daily average speed (km/hr)	Maximum daily average speed (km/hr)	85th percentile speed (km/hr)	Sample size (number of cars)	Change in average speed (km/hr)	Change in average speed (%)	Change in 85th percentile speed (km/hr)	Change in 85th percentile speed (%)
Old Cleveland Rd East east	60	Generic smiley 14370	Night	51.93	8.15	44.92	54.01	59	472967	53.42	7.71	52.52	54.08	60	25726	1.49	2.87	1	1.69
			Day	52.71	6.98	49.57	53.74	59	2484028	54.45	6.87	53.91	55.10	61	139490	1.74	3.31	2	3.39
Old Cleveland Rd East west	60	Generic smiley 14361	Night	57.29	8.13	52.08	58.84	65	438965	57.84	7.68	57.18	58.79	64	28801	0.56	0.97	-1	-1.54
			Day	55.10	8.68	48.59	58.60	63	1948570	57.26	8.18	56.00	57.88	64	123315	2.16	3.93	1	1.59

Figures 20 and 21 show a visual representation of the difference in average speeds between the two messaging treatment periods ('Koala' and 'Bicycle'), again broken up into 'Day' and 'Night' groupings. Regardless of whether it was night or day time, the koala/smiley messaging resulted in slower average speeds, albeit only modestly, compared to the bicycle-specific messaging time periods. Note that this was true for night time speed comparisons when bicycle messaging was never displayed (i.e. there was no difference in messaging being compared, regardless of treatment period). Despite this, there was a modest difference in average night time speed most clearly demonstrated for OCRE east at night during the bicycle treatment, and much less so for OCRE west during the same treatment. The point of comparison that arguably matters most however, was between daytime averages across treatment periods, when bicycle-specific messaging was displayed during the bicycle treatment period. Here, as was suggested in Table 7, the differences are notable (increases in average speeds of 1.74km/hr and 2.16km/hr during the bicycle-specific messaging compared to koala/smiley messaging). The smallest difference was for the OCRE west sign at night time (when the signs were displaying koala/smiley messaging across both treatment periods). Average speeds for bicycle-specific messaging periods were still below the posted speed limit of OCRE (60km/hr).

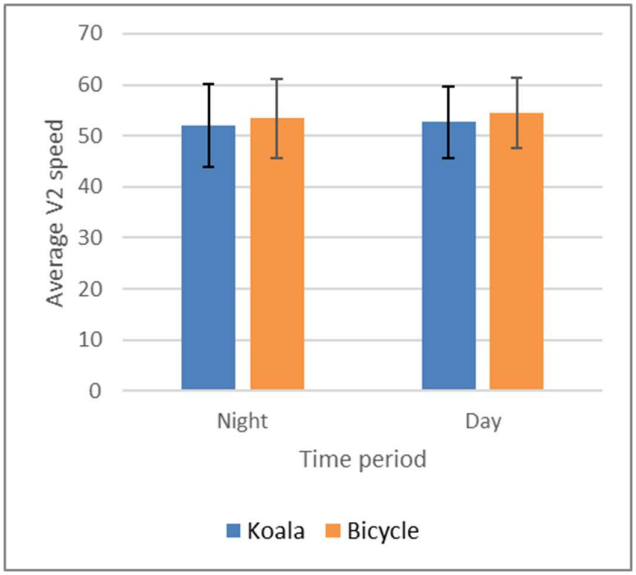

Figure 20. Comparison of average V2 vehicle speeds for Jenoptik 'generic smiley' sign (14370) on Old Cleveland Rd East east, between night time ('Night': 7pm - 5am) and day time ('Day': 5am - 7pm) periods for both the 2022/23 treatment period ('Koala') when koala/smiley faces were exclusively shown on the signs, and the 2023 bicycle messaging period ('Bicycle') when images of bicycles were shown on the signs between the hours of 5am and 7pm (reverting to koala/smiley faces during the night).

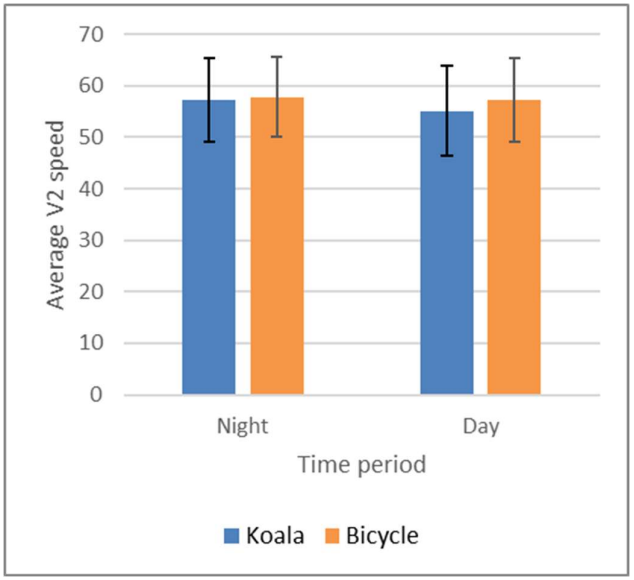

Figure 21. Comparison of average V2 vehicle speeds for Jenoptik 'generic smiley' sign (14361) on Old Cleveland Rd East west, between night time ('Night': 7pm - 5am) and day time ('Day': 5am - 7pm) periods for both the 2022/23 treatment period ('Koala') when koala/smiley faces were exclusively shown on the signs, and the 2023 bicycle messaging period ('Bicycle') when images of bicycles were shown on the signs between the hours of 5am and 7pm (reverting to koala/smiley faces during the night).

3.4 Excessive speeding

As with the previous year, numerous records of people driving at excessive speeds were again observed for all signs and on all roads. Figures 22 to 35 provide the frequencies (counts) of all vehicles traveling at or above 100 km/hr on each day of the week and for time of day (in hourly blocks) recorded by each sign. The sign at Old Cleveland Road East west (Figure 30) had the highest overall number of excessive speeders, with over 2400 offending records taken over the sampling period. The sign at Old Cleveland Road East east had approximately half as many offending vehicles, but this still equated to over 1000 instances. Frequency appeared to peak in the early evening and early morning each day for some signs, although this was not consistent across all signs. In contrast to most other signs, the sign at South Street west (Figure 26) had comparatively few excessive speeders.

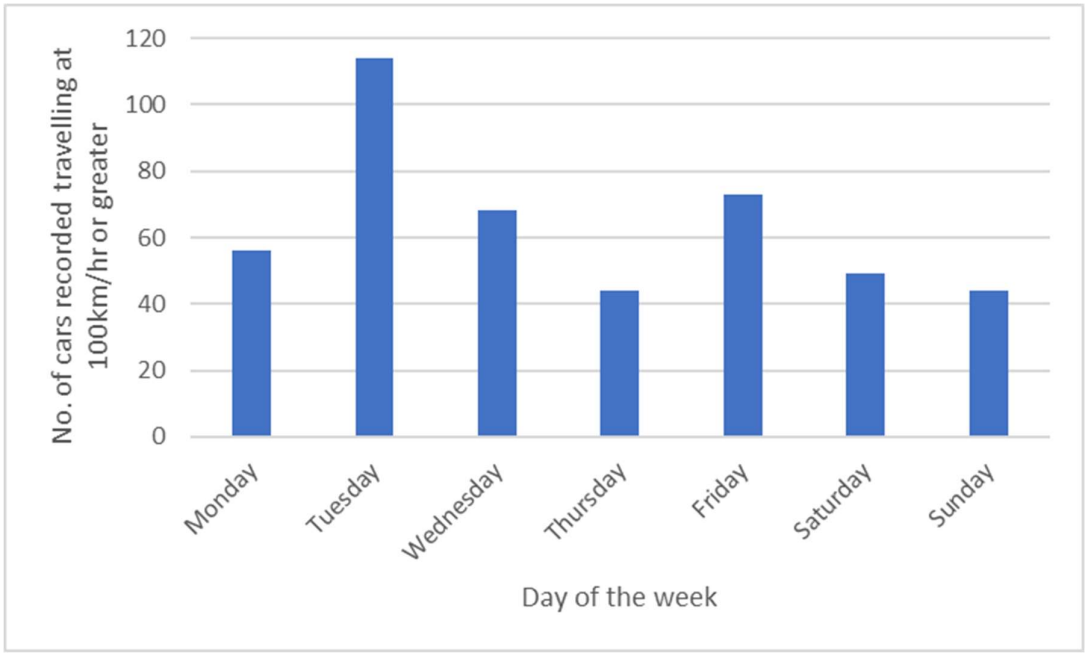

Figure 22. Counts of the number of cars travelling at 100km/hr or greater on Collingwood Road (speed limit 60km/hr) during each day of the week for the period 24/05/2022 - 28/02/2023. Speeds were recorded by Jenoptik sign 26986.

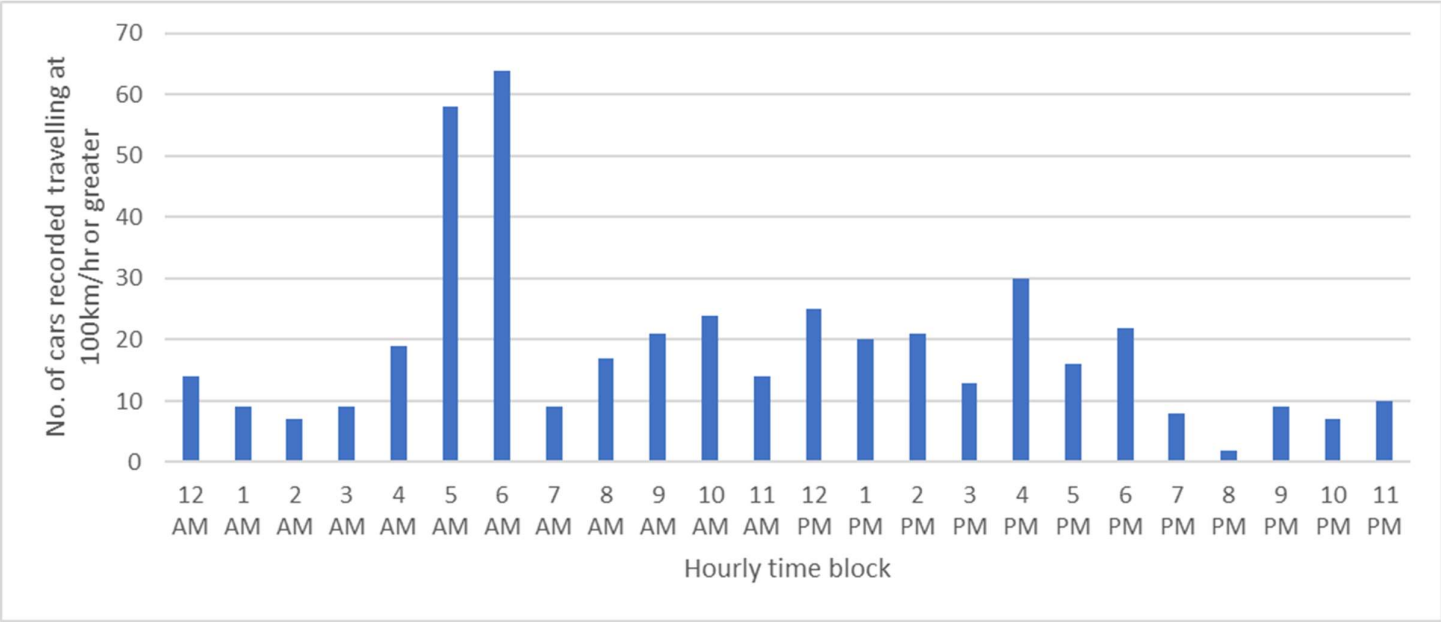

Figure 23. Counts of the number of cars travelling at 100km/hr or greater on Collingwood Road (speed limit 60km/hr) during each hourly time block for the period 24/05/2022 - 28/02/2023. Speeds were recorded by Jenoptik sign 26986.

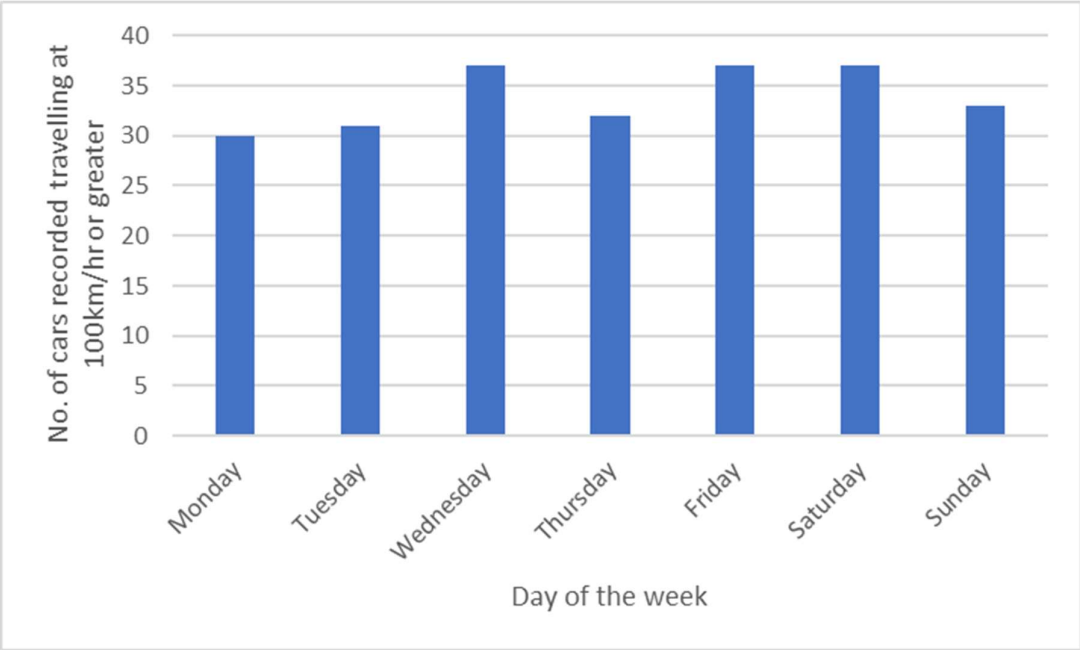

Figure 24. Counts of the number of cars travelling at 100km/hr or greater on Nelson Road (speed limit 60km/hr) during each day of the week for the period 24/05/2022 - 28/02/2023. Speeds were recorded by Jenoptik sign 26978.

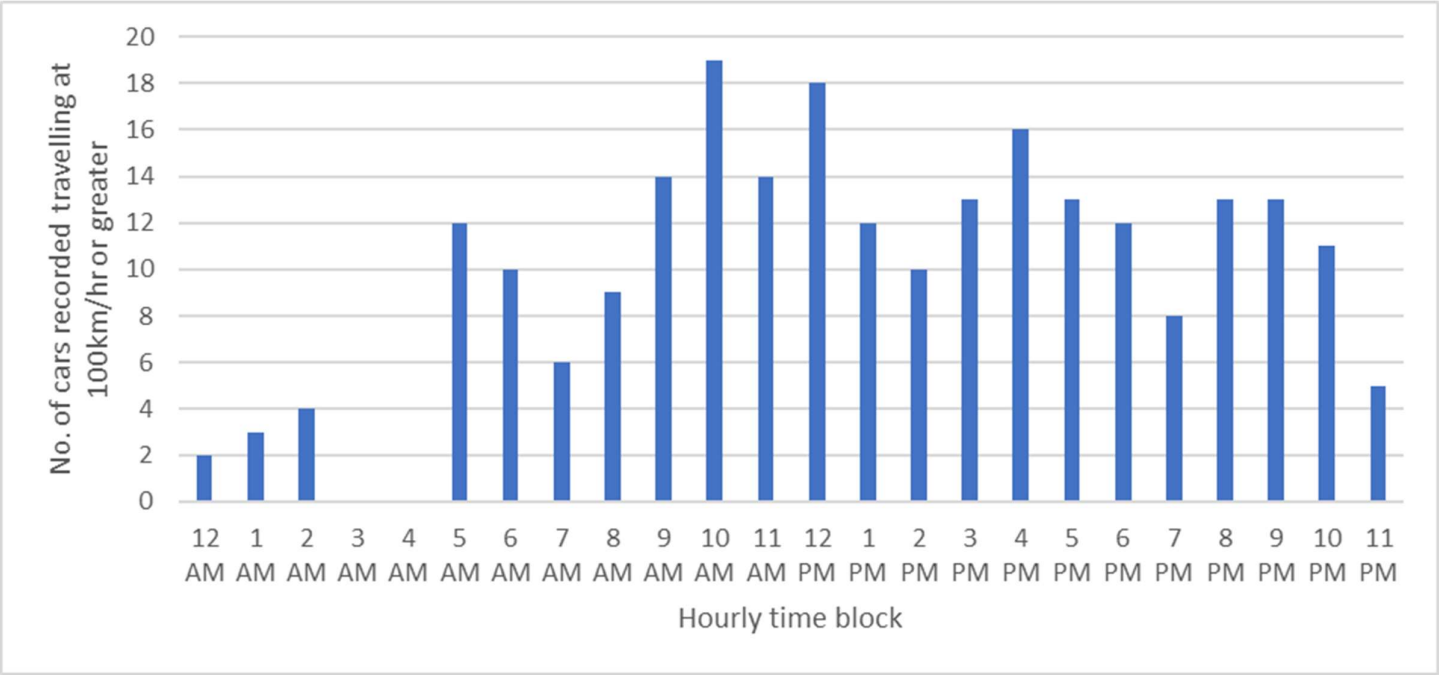

Figure 25. Counts of the number of cars travelling at 100km/hr or greater on Nelson Road (speed limit 60km/hr) during each hourly time block for the period 24/05/2022 - 28/02/2023. Speeds were recorded by Jenoptik sign 26978.

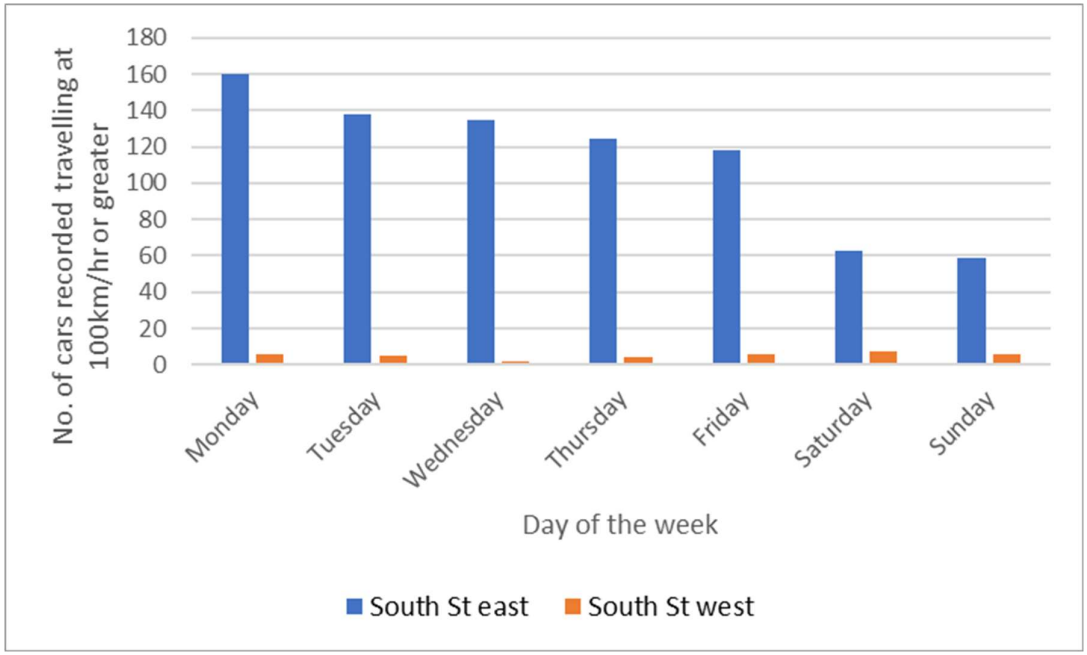

Figure 26. Counts of the number of cars travelling at 100km/hr or greater on South Street (speed limit 50km/hr) during each day of the week for the period 24/05/2022 - 28/02/2023. Speeds were recorded at two sites by Jenoptik signs 26987 (South Street east) and 27633 (South Street west).

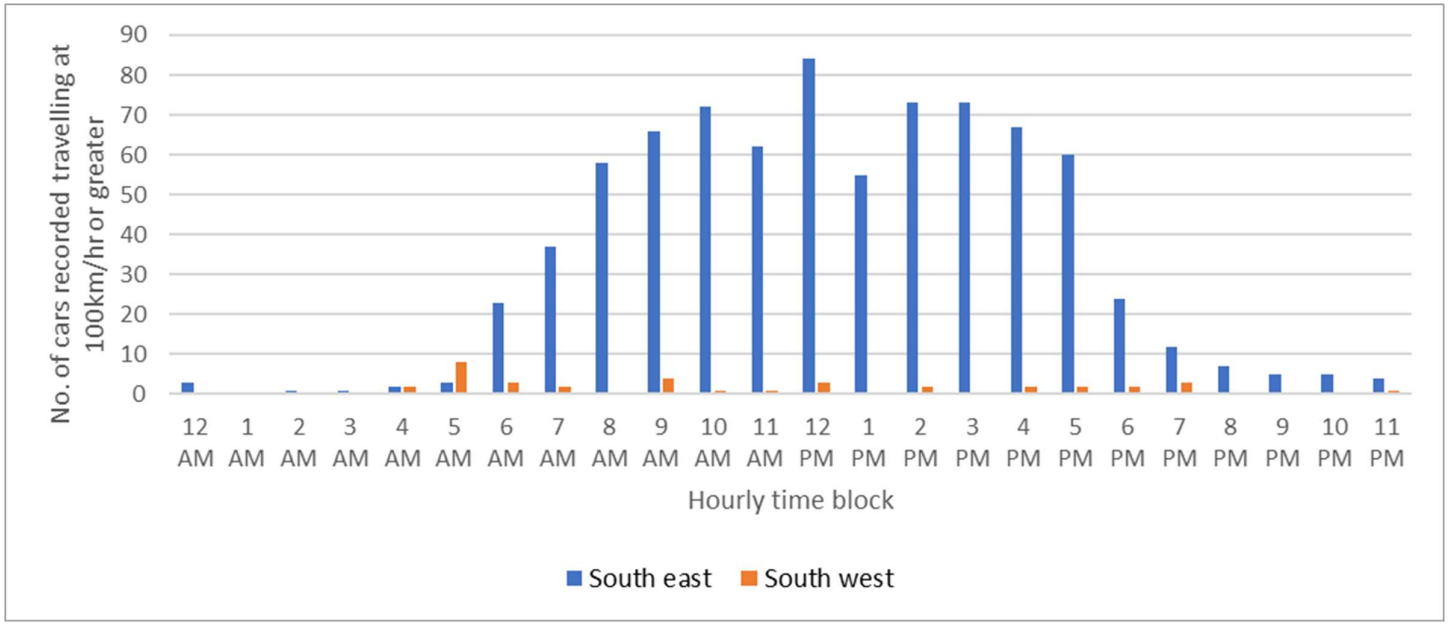

Figure 27. Counts of the number of cars travelling at 100km/hr or greater on South Street (speed limit 50km/hr) during each hourly time block for the period 24/05/2022 - 28/02/2023. Speeds were recorded at two sites by Jenoptik signs 26987 (South Street east) and 27633 (South Street west).

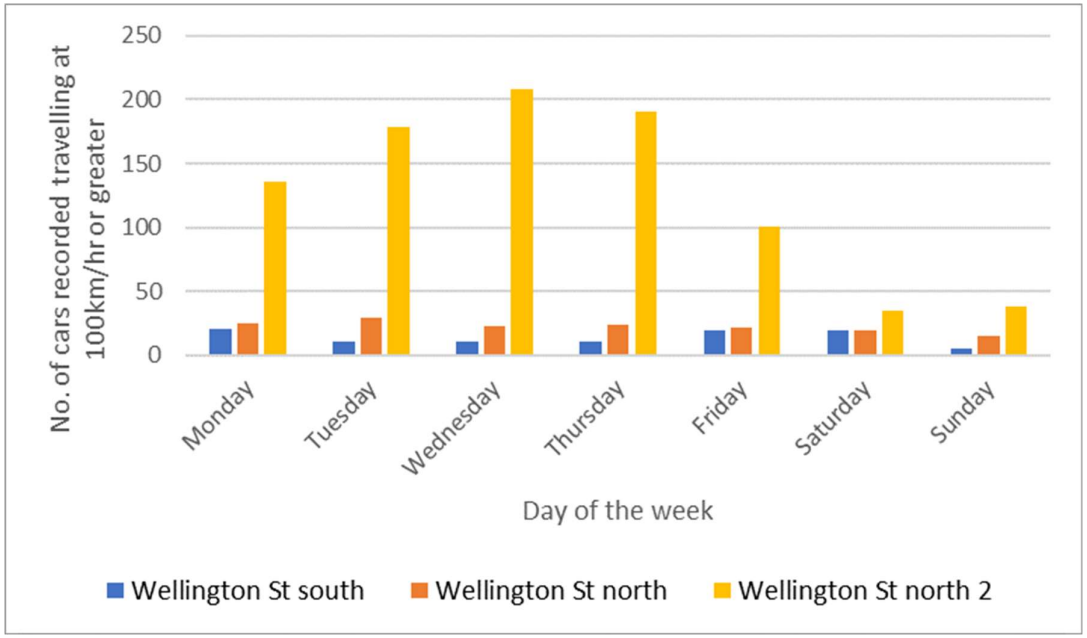

Figure 28. Counts of the number of cars travelling at 100km/hr or greater on Wellington Street (speed limit 50km/hr) during each day of the week for the period 1/03/2022 - 28/02/2023. Speeds were recorded at three sites by Jenoptik signs 19540 (Wellington Street south), 19541 (Wellington Street north), and 26981 (Wellington Street north 2).

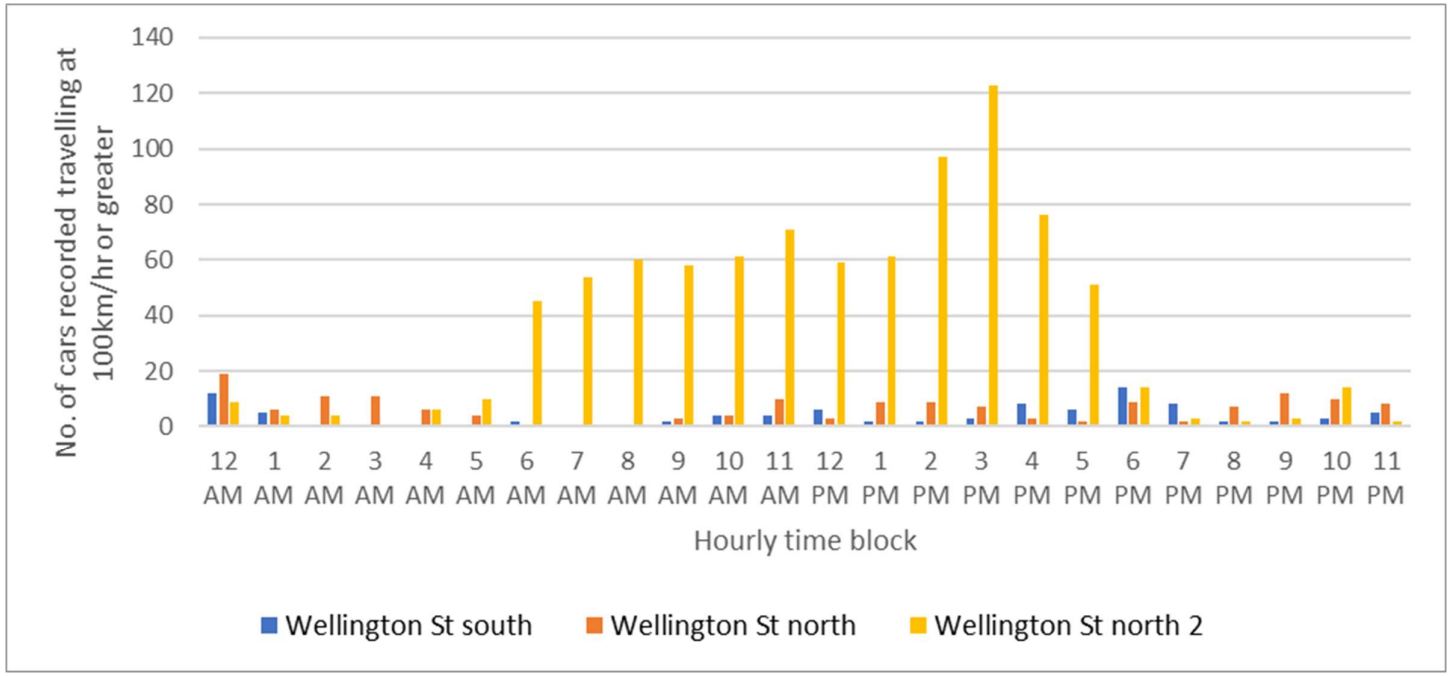

Figure 29. Counts of the number of cars travelling at 100km/hr or greater on Wellington Street (speed limit 50km/hr) during each hourly time block for the period 24/05/2022 - 28/02/2023. Speeds were recorded at three sites by Jenoptik signs 19540 (Wellington Street south), 19541 (Wellington Street north), and 26981 (Wellington Street north 2).

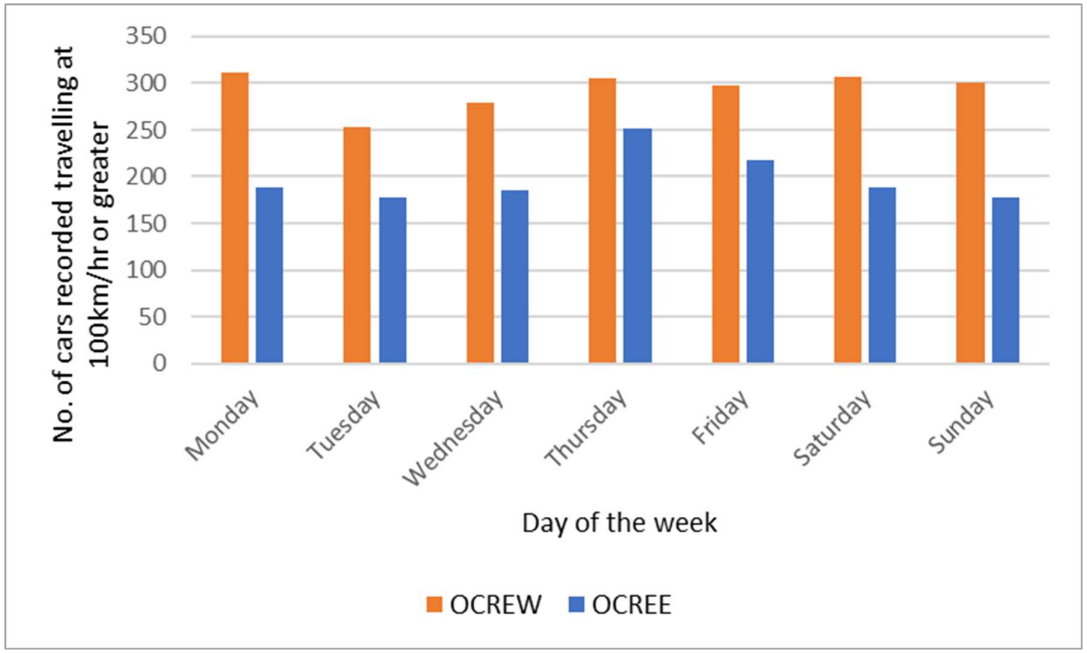

Figure 30. Counts of the number of cars travelling at 100km/hr or greater on Old Cleveland Road East (speed limit 60km/hr) during each day of the week for the period 1/03/2022 - 28/02/2023. Speeds were recorded at two sites by Jenoptik signs 14361 (Old Cleveland Road East west/ OCREW) and 14370 (Old Cleveland Road East east/OCREE).

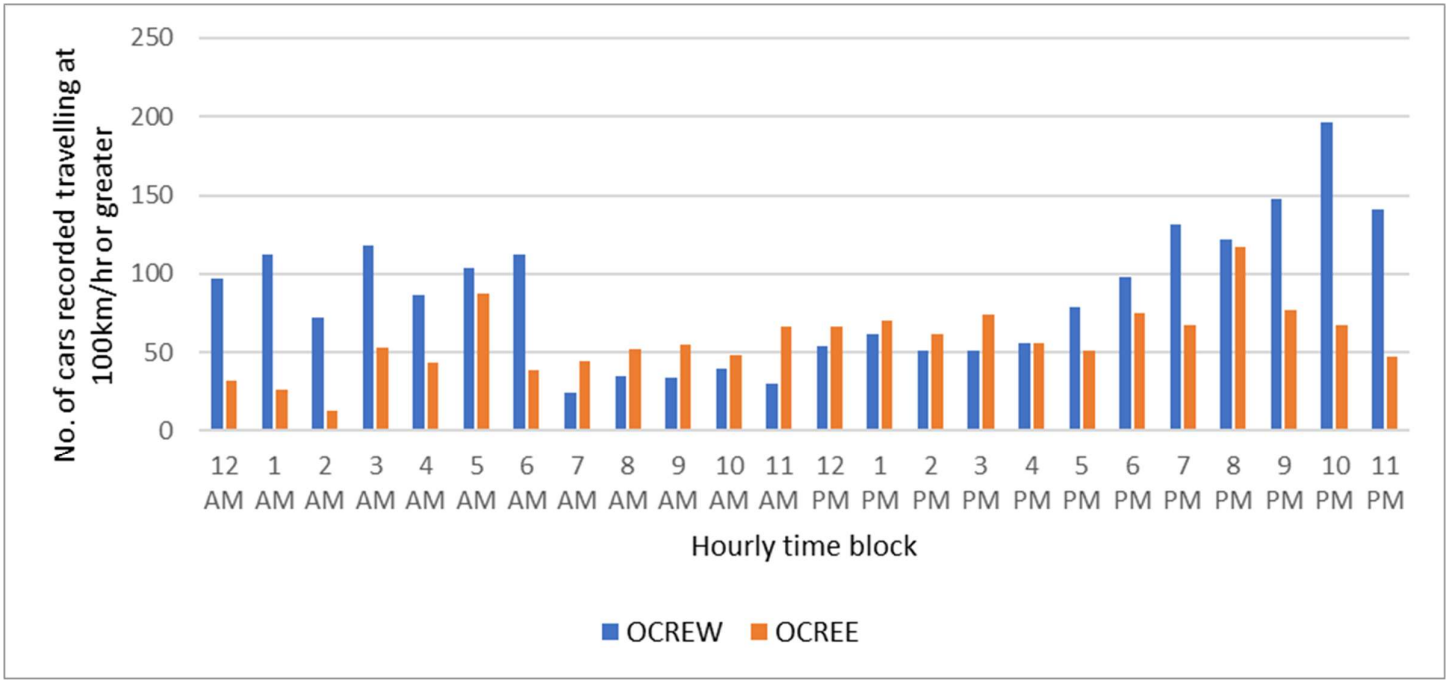

Figure 31. Counts of the number of cars travelling at 100km/hr or greater on Old Cleveland Road East (speed limit 60km/hr) during each hourly time block for the period 1/03/2022 - 28/02/2023. Speeds were recorded at two sites by Jenoptik signs 14361 (Old Cleveland Road East west) and 14370 (Old Cleveland Road East east).

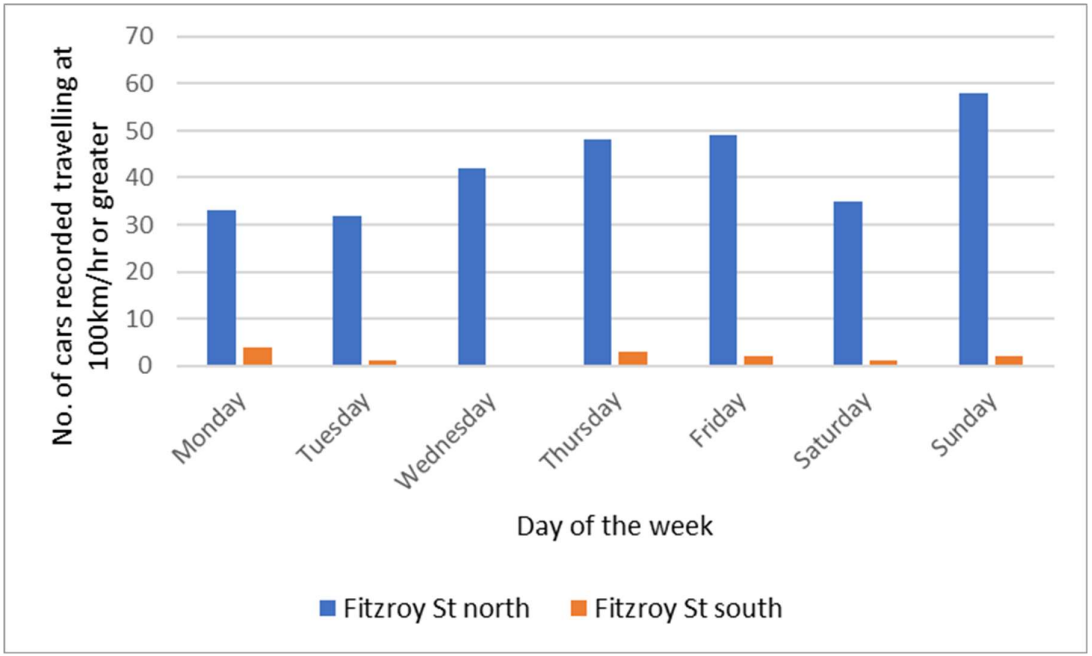

Figure 32. Counts of the number of cars travelling at 100km/hr or greater on Fitzroy Street (speed limit 50km/hr) during each day of the week for the period 1/03/2022 - 28/02/2023. Speeds were recorded at two sites by Jenoptik signs 16718 (Fitzroy Street north) and 18935 (Fitzroy Street south).

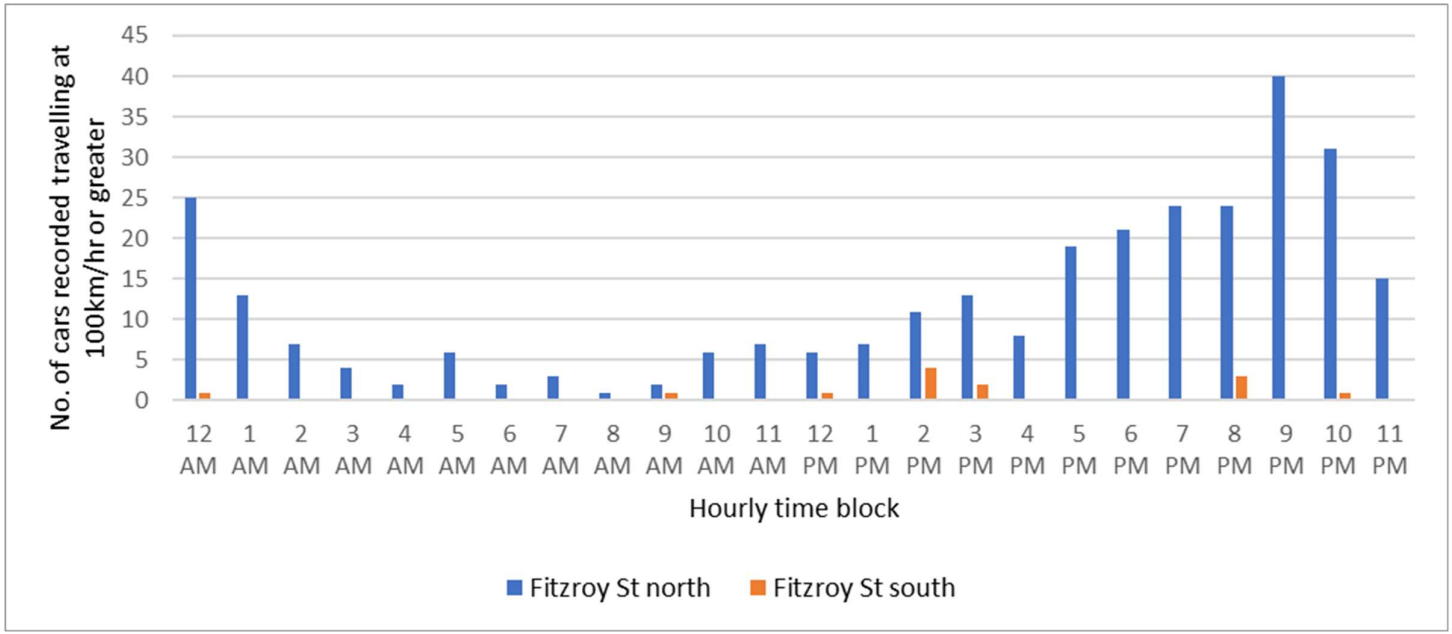

Figure 33. Counts of the number of cars travelling at 100km/hr or greater on Fitzroy Street (speed limit 50km/hr) during each hourly time block for the period 1/03/2022 - 28/02/2023. Speeds were recorded at two sites by Jenoptik signs 16718 (Fitzroy Street north) and 18935 (Fitzroy Street south).

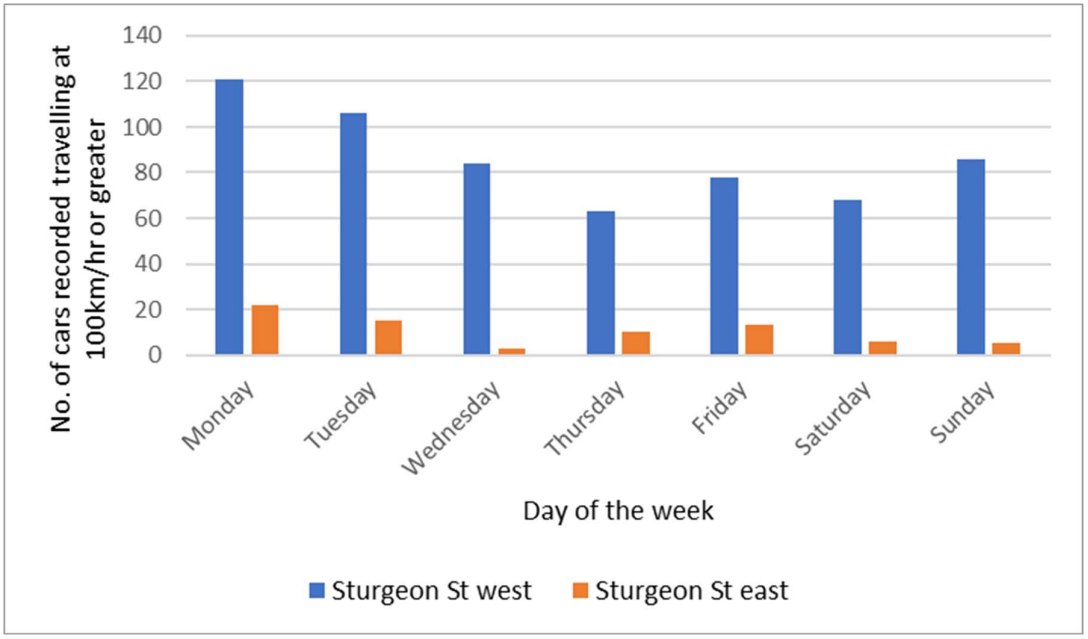

Figure 34. Counts of the number of cars travelling at 100km/hr or greater on Sturgeon Street (speed limit 60km/hr) during each day of the week for the period 1/03/2022 - 28/02/2023. Speeds were recorded at two sites by Jenoptik signs 16720 (Sturgeon Street west) and 19543 (Sturgeon Street east).

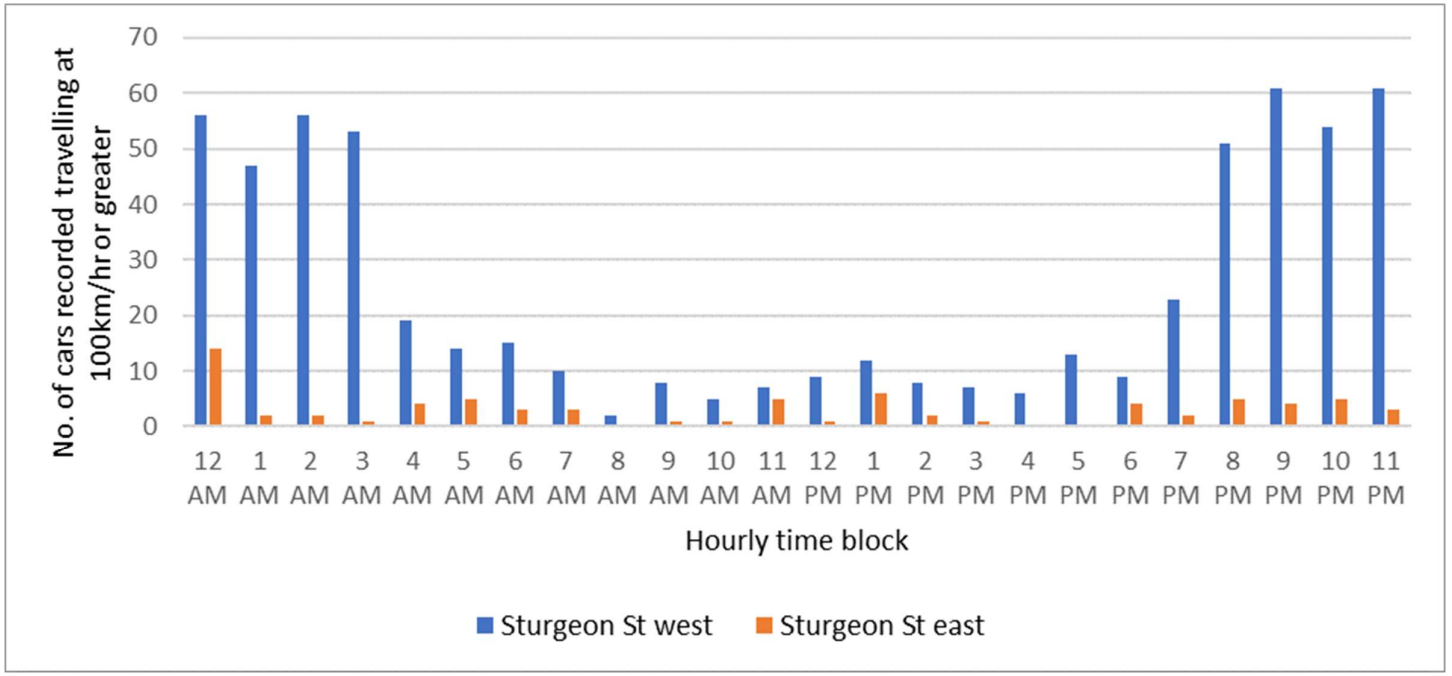

Figure 35. Counts of the number of cars travelling at 100km/hr or greater on Sturgeon Street (speed limit 60km/hr) during each hourly time block for the period 1/03/2022 - 28/02/2023. Speeds were recorded at two sites by Jenoptik signs 16720 (Sturgeon Street west) and 19543 (Sturgeon Street east).

3.5 Koala strike events

This year saw the first koala strikes on signed roads in the Redlands. Both strike events were fatal. One occurred on OCRE (most likely on the evening of Monday, April 11 2022) involving an adult female, and the other at Sturgeon Street (at approximately 7:30PM on Friday, September 9 2022) involving an adult female. The female also had a joey that later died in hospital.

3.6 Road crossing events

Based upon GPS collar data, three koalas (Axle, Benson and Blake) appeared to cross roads outfitted with signs during the study period. Figures 36, 37 and 38 show GPS waypoints and 'tracks' between waypoints. Axle's crossings (Figure 36) of Collingwood Road (and nearby Pitt Road) appeared limited to several occasions, whilst Benson (Figure 37) and Blake (Figure 38) both crossed Fitzroy Street (and several other nearby roads/streets) regularly, particularly Blake. Benson appears to have crossed South Street at least once, another road outfitted with signs during 2022.

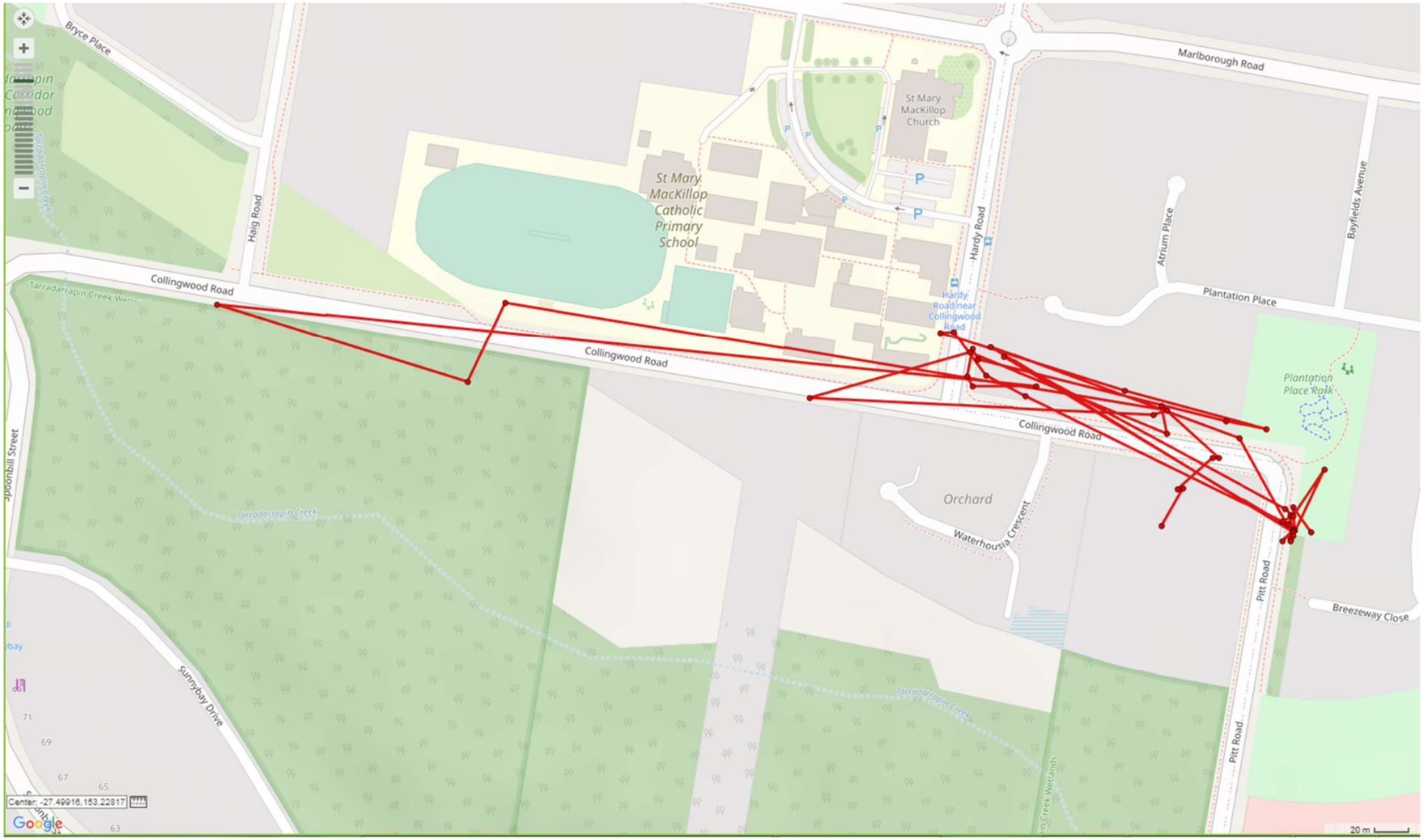

Figure 36. A map of GPS collar waypoints and tracks of the koala Axle crossing Collingwood Road and nearby Pitt Road.

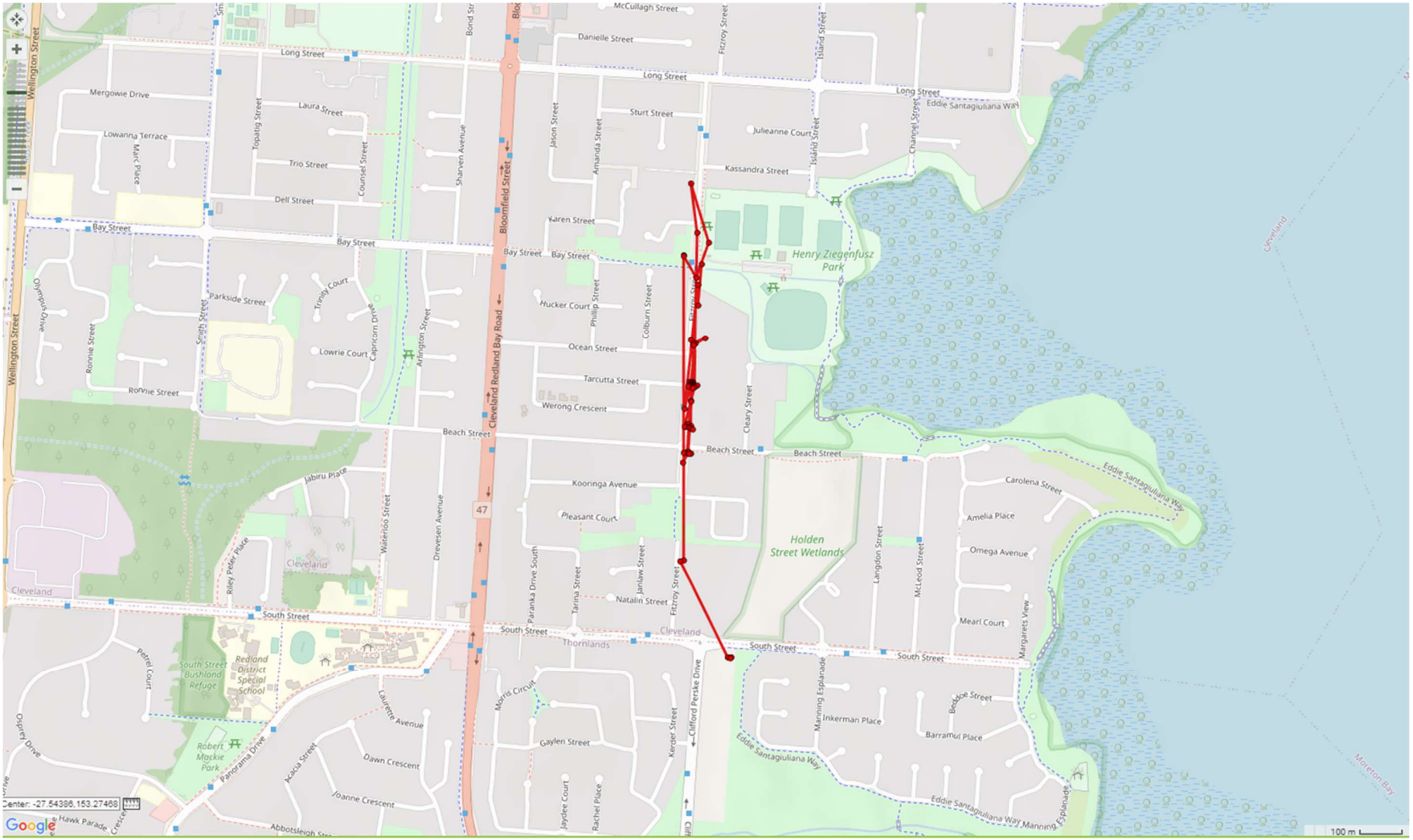

Figure 37. A map of GPS collar waypoints and tracks of the koala Benson crossing Fitzroy Street and other nearby roads.

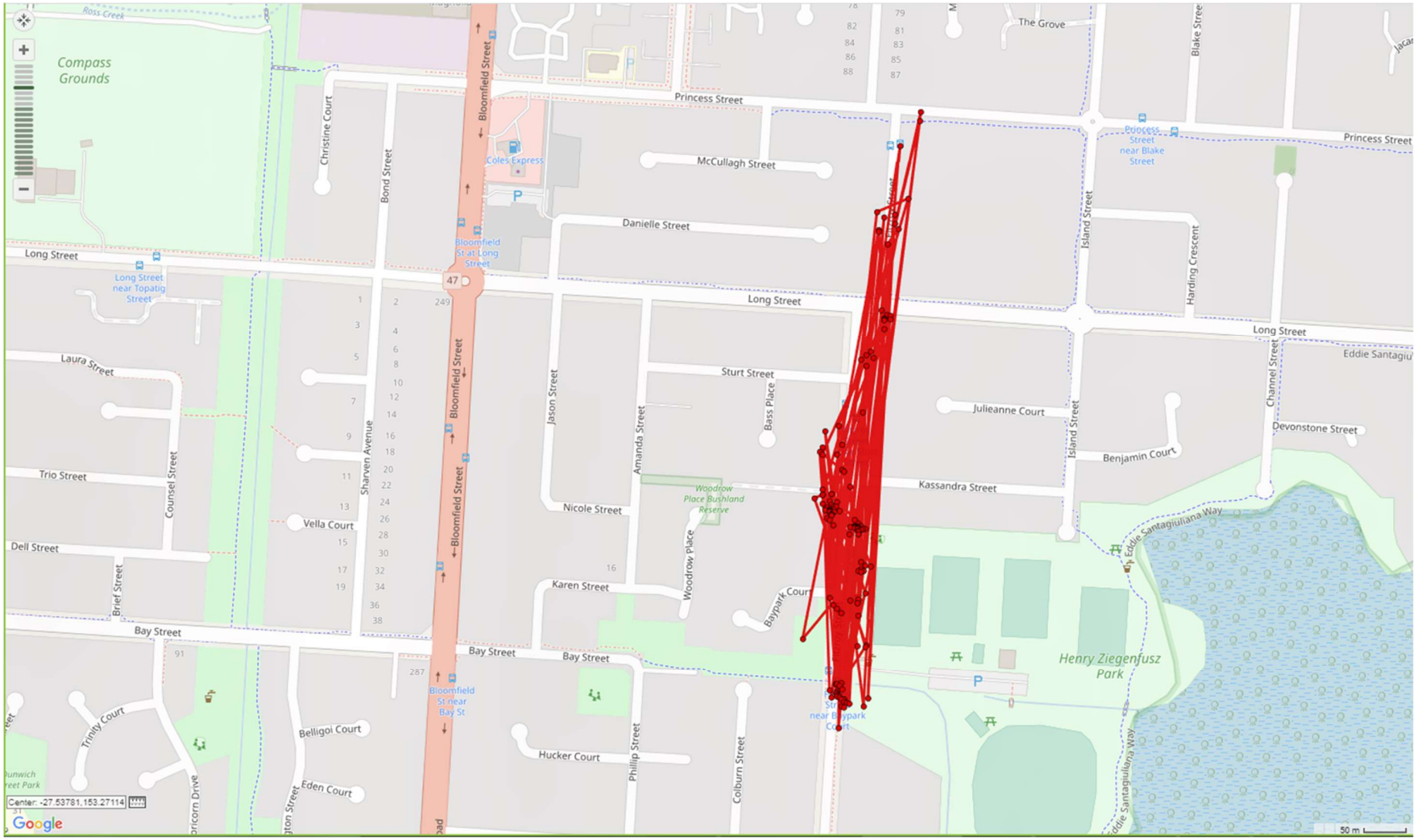

Figure 38. A map of GPS collar waypoints and tracks of the koala Blake crossing Fitzroy Street and nearby roads.

4. Discussion

4.1 Habituation

Data from several signs showed further drops in speed in their third year of investigation, suggesting that drivers were potentially becoming increasingly aware of signs and responding to messaging by further reducing speed.This year's results however, saw the first, potential indication of driver habituation observed during the study, albeit largely for one sign on Sturgeon Street east, where average speed increased by 0.87km per hour (1.79%) in comparison to pre-treatment average speed. Additionally, two signs (Sturgeon Street west and Fitzroy Street south) showed slight increases in average speed in comparison to the previous treatment year. These two signs still had average speeds that were below pre-treatment average speeds.

It is difficult, particularly with relatively small changes in averages, to confidently ascribe habituation as the cause. This may particularly be the case for Sturgeon Street west and Fitzroy Street, where, for example, the so-called regression to the mean phenomenon could have resulted in initial sampling being anomalous, and 'correcting' in subsequent years. There is a degree of error (or unexplained variation) in any set of measurements that occurs during experimentation (e.g. road works, weather/traffic anomalies or even undetected variation in sensor measurements may all contribute to unexplained variation/error), especially given that pre-treatment periods are often relatively short in comparison to treatment periods. The 'true' average and any trend relating to habituation may only be detectable over several years. This is true for both habituation and for more positive appearing trends.

It is worth noting that pre-treatment measurement periods for the earliest signs (which includes the signs at Sturgeon Street) were quite brief (~2 weeks), and therefore may not have adequately captured as comprehensive a sample of speeds as more recent signs. Thus, comparing years of treatment data to data garnered from such a short pre-treatment might not be as robust as more recent deployments, where pre-treatment measurement periods have been extended to months to alleviate this potential issue. Caution is therefore required in interpretations, both positive and negative.

If the modest increases in average speed observed for some signs do represent emerging driver habituation, it is important to attempt to combat it. In this circumstance, driver

habituation can be viewed as drivers coming to ignore signs, or the importance of warnings. The reasons for this might be complicated, but one major possibility is that drivers simply do not believe koalas are present near these roads. Occasional conversations with residents that have occurred during sign installations each year would suggest this, as it is not uncommon for residents to say that they haven't seen a koala in the area in years (Seydel and Rundle-Thiele, 2023).

One strategy to aid in combating driver habituation could be to bolster public awareness about koalas that are living in these areas. This might involve deploying static signs that list the names and even images of resident koalas, in an effort to reinforce awareness. Given that Sturgeon Street had a fatal koala strike this year, as did OCRE (see section 4.4), signs that indicate to passing drivers that koalas have recently been struck in the area, perhaps including a photo of the koala (alive) and even a date of the strike, might reinforce awareness. Static panels with such information are possibly best placed on or before existing VAS, so that drivers are given a chance to respond by lowering speeds accordingly.

Sturgeon Street had, at one point in the last decade, one of the highest rates of koala strikes in south-east Queensland (C. Dexter, unpublished data). The recent strike event highlights that even with the potentially beneficial presence of signs, fatal strike events can still occur. Given that potential habituation was observed for one if not both signs on Sturgeon Street, additional steps may need to be taken to ensure average speeds remain relatively low, and strike events are mitigated to the greatest extent possible.

With this in mind, there are potential options that can be considered to future-proof driver habituation to dynamic signage and address community perception. For example, in the past two years, a Griffith University team led by Professor Jun Zhou has been developing an artificial intelligence (AI)-enabled camera system capable of detecting and classifying a number of wildlife species, including koalas. The system has been successfully tested on sites throughout Queensland including in the Redlands. The system has developed to the point that it is now possible to deploy camera systems that can, in real time, correctly detect koalas and then, in principle, perform additional tasks, such as activating a warning notification to drivers. A proof-of-concept of this very system has recently been successfully tested (Prof. Jun Zhou, personal communication). This enhanced AI-camera and sign system could therefore be beneficial on problematic roads such as Sturgeon Street. The system would potentially have three important functions: (1) It would serve to immediately warn drivers of an immediate threat of striking a koala on the road; (2) It would potentially serve to reinforce to drivers that there are indeed koalas in the area (especially in

conjunction with the other anti-habituation measures mentioned above); and (3) It would provide additional data regarding koala activity near roads and the subsequent risk of strike events. Sturgeon Street is an excellent candidate road for an initial pilot-trial of this enhanced detection and warning system.

The detection of potential habituation five years into the study highlights just how important longer term monitoring can be in evaluating the efficacy of any mitigation measures. This is true even for those measures that appear to have beneficial impacts from the start. A short term study would have missed the emergence of this phenomenon and missed an opportunity for early intervention. Thankfully, because monitoring has been ongoing and comprehensive, new initiatives can be quickly instituted that will potentially combat habituation at its outset and offer scope for combatting it, which itself would be, to the best of our knowledge, a world-first. It is important to note that the vast majority of signs, including most of those operating for as long as the one sign on Sturgeon Street that showed the modest increase in average speed, continue to report potentially beneficial reductions in driver speeds. Thus, even after years of exposure and operation, driver responses to most signs appear to be resilient against habituation, which is a promising outcome in terms of the long-term viability of signs.

4.2 Newly-installed signs

There were five new signs installed in the current year of the experiment: one at Collingwood Road, one at Nelson Road, two at South Street and an additional one at Wellington Street (to the north of the previous northern sign). All but the sign at Collingwood Road observed a drop in average and 85th percentile speeds between pre-treatment (signs covered) and treatment (signs uncovered) periods. However, there was an anomalous situation at South Street east sign, where the V2 average speeds (measured at/after the sign) were actually higher than V1 speeds (measured well before the sign). It isn't entirely clear why this occurred. The sign is situated in between two roundabouts however, so the most likely reason is that V1 speeds were being measured as people emerged from a roundabout, and by the time they had reached the sign, where V2 speeds were measured, they were simply travelling closer to a 'normal' speed. The consistently lower, and declining trend in average speeds during the treatment period provides confidence that the sign still operated in a beneficial manner. There is a roundabout close to the South Street west sign that likely confounded results to a degree, although even here, there was a noticeable drop in average daily speeds during the treatment period.

Very encouragingly, the sign at Wellington Street (which recorded a pre-treatment average speed above the speed limit) was observed to see a drop in average speed during the treatment period to below the posted speed limit (50km/hr). Given that there is a school and aged care residences in the near vicinity of this sign, this is a positive result. As has been the case with most other signs, observed reductions have been modest, but the result at Wellington Street demonstrates that even relatively small reductions in speed can be the difference between vehicles travelling above or below posted speed limits. The same occurred in relation to 85th percentile speeds in relation to the South Street west sign, where these speeds dropped to the posted speed limit for the road. Again, an encouraging result.

The sign at Collingwood Road saw a very slight increase in average speed, representing 0.02km/hr (0.05%). This is small enough to potentially be of little overall consequence, but it raises an interesting question about this sign, given how low (relative to the posted speed limit of 60km/hr) vehicles were already travelling during the pre-treatment period. Average speeds around 13km/hr below the posted speed limit (~22%) during the pre-treatment period suggest that drivers are already travelling at a much-reduced speed, and a look at the road characteristics may provide some indication as to why. The sign is located right before what is essentially a road junction with Spoonbill Street, which curves around, ending up perpendicular to Collingwood Road. There are moderate speed reduction measures in place at this junction where Collingwood Road continues. As is the case with certain signs placed near, for example, roundabouts, traffic lights or high volume turns onto other roads, drivers are already likely to be slowing down, making it very difficult to capture any changes that a sign might introduce. Importantly though, signs in such locations may still be reminding drivers to be vigilant for koalas and other wildlife.

For those signs in less ambiguous locations however, there was a very clear drop in average daily speed corresponding with the exact point in time that signs were uncovered (visible in Figures 14-17). As with previous years, this is a good indication of the positive impact signs have on reducing vehicle speeds. Importantly, these drops in speed also appeared to remain consistent throughout the treatment period, suggesting no indication of habituation.

4.3. OCRE bicycle messaging experiment

This year saw the first trial of displaying different messages to drivers at different times. This pilot-level experiment was limited to a single road (OCRE) and involved new bicycle-specific messaging being displayed during essentially day time hours and previously used koala/smiley messaging at night. To account for any pre-existing effect of time period (day

vs night) on average vehicle speeds, the average day and night speeds during the bicycle experiment treatment period (‘Bicycle’) were also compared with the average day and night speeds during the preceding 'koala/smiley' treatment period (‘Koala’). Results for the sign at OCRE west were complicated by what appeared to be relatively high levels of daily average speed variation throughout the ‘Koala’ treatment period. Night time records, when drivers were never exposed to bicycle messaging, still appeared to show a difference in average speeds when comparing the bicycle and standard koala messaging periods, clearest for OCRE east. This is not immediately explainable, but suggests some caution might be needed against drawing any strong conclusions regarding differences in driver responses to messaging, as other confounding variables may have played a role.

Noting this, there was, however, a clear difference in daytime average speeds (when, during the ‘Bicycle’ treatment period, bicycle-specific messaging was displayed to passing drivers) between the ‘Koala’ treatment period and the ‘Bicycle’ treatment period for both signs. This suggests that koala/smiley face imaging may have a greater impact in terms of reducing average speeds than bicycle-specific messaging. In turn, it is reasonable evidence that drivers are indeed paying attention to specific messaging and are, as a consequence, not showing any signs of habituation. This response is clearly indicated in, for example, Figure 19 for the OCRE east sign, where as soon as the bicycle-specific messaging period begins, there was a notable increase in V2 daily average speed.

This was a relatively short experiment with no replication, so we are cautious to dismiss the opportunity of potentially augmenting certain signs with additional safety messaging, particularly if there is good reason to consider such augmentation (e.g. cyclists have been struck on or near such signed roads). At present however, these initial data do not provide evidence that such mixed messaging, at least in its current format, is beneficial in producing or maintaining lower average speeds compared to koala/smiley messaging.

Given that a koala was struck and killed on OCRE this year, it is, along with Sturgeon Street, an important road to continue monitoring and may benefit from site-specific surveys for nearby koalas to help further elucidate risk. It may be an excellent candidate road for additional measures such as anti-habituation signage and, if efficacy is proven, additional AI-camera signage enhancements (see: Recommendations).

4.4 Excessive speeding

The occurrence of drivers travelling at excessive speeds (i.e. at or above 100 km/hr) on signed roads was again investigated and as with previous years, results were sobering. Across all signs and roads, there were many thousands of instances of vehicles travelling at excessive speeds. The worst offending location appeared to OCRE west, where approximately 2400 records of excessive speeding were recorded across the sampling period. The sign at OCRE east had approximately half as many such instances, but still equated to over 1000. In contrast, the sign at South Street west had relatively few occurrences of excessive speeding. Another location of some concern was Wellington Street North_2 (the newest sign installed on Wellington Street), where excessive speeder numbers far exceeded those for the other signs on the same road (see Figure 28). It is unclear why this might be. Given however, that speeds in excess of 80 km/hr and occasionally above 120 km/hr were recorded during afternoon hours on weekdays, with schools and residencies nearby, such driving behaviour is highly dangerous.

In relation to the koala that was struck and killed on OCRE, apparently not far from a sign (although exactly which side of the road the collision occurred is unclear), it is at least plausible that the relatively high rate of excessive speeding observed on this road might have played a role. Driving at such speeds would certainly mean that drivers would have very little chance of reacting in time to avoid striking a koala on the road, and such speeds pose a considerable risk to both humans and wildlife alike. Police radar or speed cameras may be one potential deterrent worth exploring at locations such as OCRE and Wellington Street, but such options are obviously beyond the remit of the RCC itself. Employing traffic calming measures might also be a consideration in the future.

4.5 Koala strike events

The first fatalities of koalas on signed roads during this year's experiment is a sobering reminder that although signs may help in reducing risk of koala strike, by encouraging drivers to slow down and remain vigilant, they cannot prevent it outright. It highlights that a significant knowledge gap regarding signs (and many other mitigation measures) relates to the actual risk of koalas being struck. Put another way, whilst data about koala strikes is readily available through road kill and wildlife ambulance records, there is no equivalent data available regarding strikes that were avoided because of mitigation measures.

4.6 Road crossing events

One element that highlights 'successful' (i.e. without a strike occurring) road crossing events by koalas comes from GPS collar data. During this year's study period, three koalas appear to have crossed roads outfitted with signs, based upon GPS collar data. GPS fixes were spaced too far apart to provide a clear indication of crossing times and specific crossing locations, which would be useful additional data. Two koalas, Benson and Blake regularly crossed the same road (Fitzroy Street) as well as several roads and streets in the surrounding area. Blake has also been recorded crossing Fitzroy Street in two previous years, which, given with the apparent regularity that he appears to cross roads, suggests he may either have some road sense, is extremely lucky, or some combination of both.

5. Recommendations and conclusions

1. Initiate a new phase of research aimed at enhancing driver awareness and improving understanding of strike risk to koalas. This will likely involve additional, static signage that provides drivers with specific messaging about resident koalas, as well as any recent strikes or sightings for target roads. Prototype AI-enabled camera systems should be deployed and tested on high-risk roads (e.g. Sturgeon Street) that are capable of immediately warning drivers that koalas have been detected near roads (via signage). Existing signage may need to be augmented with additional, cost-effective display panels that can directly communicate with cameras avoiding the need to network with existing signage. Initially, a pilot study involving one-two roads should be conducted in which camera and sign systems are evaluated with a view to a larger study once the technology has been adequately vetted.
2. In association with the AI-camera system trials outlined in (1), detailed surveys of roadside koala habitat should be undertaken to collect information about koala abundance, distribution and movements near roads. These are likely to involve drone, scat, ground-based thermal and spotlighting surveys.
3. Consider investigating potential, roadside koala deterrents for trials in high-risk situations such as roads with recently recorded strike events. These would involve deploying devices along target roads/road sections that elicit stimuli designed to repel or deter koalas from crossing roads while cars are passing by. This would also take advantage of AI-enable cameras and sensor systems that can both intelligently

activate deterrents as well as collate and relay associated, important data to researchers.

4. Continue research in relation to driver habituation to signage and explore the efficacy of measures suggested in Recommendation 1 that may slow or eliminate habituation, as well as any other emerging methods for counteracting the phenomenon. Prioritise any roads where there are signs present and koalas have been recently struck, or, there are other indications of koalas entering or attempting to cross such roads.
5. Undertake an examination of any newly-installed signage datasets to ensure that they are operating as expected and are having a desirable effect on reducing vehicle speeds.
6. Avoid mixed message programs unless there are very specific cases where such mixed messaging might be directly beneficial (e.g. signs are on a road with recent accidents or near-accidents involving cyclists). If mixed message programs are initiated, attempt to retain message/image patterns that closely resemble successful 'smiley' messaging, wherever practicable.

The previous five years of research have provided a rich array of data on the use of koala signs aimed at prompting drivers to slow down and be vigilant. Results have been generally positive and encouraging, with most signs consistently recording reductions in vehicle speeds during treatment periods. In turn, this has hopefully led to a better outcome for local koalas, by reducing the risk that they will be struck if attempting to cross such roads. There are however, notable knowledge gaps in relation to strike risk, and, together with the emergence of potential driver habituation in relation to some roads/signs, this serves as the impetus to further refine and enhance the existing koala sign program. A new phase of research will help to ensure that the Redlands Smart Signs and Smart Messaging program continues to be one of the most forward-looking and innovative of its kind anywhere in the world.

6. References

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Appendices

Appendix 1 – Technical and data issues

- All Jenoptik signs record two speeds for each car: V1 is the initial car speed recorded as the driver approaches the sign, and V2 is the car speed recorded after the driver has (presumably) seen the sign. In many cases (around 49% of the raw data collected during treatment periods) the V1 was recorded but the V2 was not recorded, so any records without V2 speeds were removed to prevent the data being skewed by the higher proportion of V1 speeds (see Appendix 2)
- All Jenoptik signs showed a drop in speed between V1 and V2 during the 2020/21 and 2022/23 (for the new signs) pre-treatment periods when the signs were still covered, where we would expect to see no change between V1 and V2. We think this is due to traffic slowing in response to existing road infrastructure, e.g. as they approached roundabouts or traffic lights. However, it could be an indication that drivers were already slowing in response to the presence of the sign, before the cover had even been removed. Multiple signs recorded a drop in V1 speeds during the 2020/21 treatment period, after the sign covers had been removed. We think this is due to the sign being visible to drivers prior to this point in the road so they were already slowing in response to the sign by the time they passed the V1 radar point. Subsequently, when comparing average and 85th percentile speeds between pre-treatment and treatment periods in all years, the comparisons were made between the V2 speeds to account for the already slowing traffic in both cases
- Periods of missing time were found in all Jenoptik sign datasets, where no cars were recorded. These missing time periods range from less than an hour to periods of multiple consecutive days e.g. the Wellington Street north_2 (sign 26981) pre-treatment period is missing data from 22-28/8/2022; the Collingwood Road (sign 26986) pre-treatment period is missing data from 4-10/07/2022 and 25-31/07/2022; the South Street east (sign 26987) pre-treatment period is missing data from 20-26/06/2022; the Sturgeon Street west (sign 16720) treatment period is missing multiple periods of data from 29/03-03/04/2022, 25/04-1/05/2022, 16/05-5/06/2022, 15/08-21/08/2022, 29/08-11/09/2022, 3/10-23/10/2022, 31/10-6/11/2022, 21/11-4/12/2022, 13/12-18/12/2022, and 16/01-5/02/2023; the Sturgeon Street east (sign 19543) treatment period is missing data from 1-6/3/2022 and 21-27/3/2022; the Wellington Street south (sign 19540) treatment period is missing data from 21-27/11/2022; and the Wellington Street north (sign 19541) treatment period is missing data from 1-6/3/2022. The longer time periods suggest a technical issue with the signs rather than an absence of cars

- The following dates were removed from the Wellington Street north (sign 19541) treatment dataset due to an extended period of both missing data and anomalous dips in speed: 26/12/2021 - 13/06/2022
- The following dates were removed from the South Street west (sign 27633) pre-treatment dataset due to an anomalous dip in speeds (greater than 1 standard deviation below the average speed of the dataset): 23-24/5/22
- The following dates were removed from the Fitzroy Street south (sign 18935) treatment dataset due to anomalous dips in speed (greater than 1 standard deviation below the average speed of the dataset): 28/03/2022, 23/10/2022, and 1/12/2022

Appendix 2 – Data loss summary

Appendix Table 1. The number of cars recorded by each Jenoptik sign during the 2022/23 pre-treatment (for the new signs) and treatment periods; the total number of recordings removed; the number of recordings removed due to Jenoptik signs failing to record a V2 speed; the number of recordings removed due to other anomalies (detailed in Appendix 1); the number of remaining recordings used for analyses; and the percentage of raw data lost due to removals.

Sign location	Sign	No. of cars recorded in raw data		No. of recordings removed		Removals due to blank V2s		Removals due to other anomalies		No. of recordings used		% of raw data lost
		Pre-treatment	Treatment	Pre-treatment	Treatment	Pre-treatment	Treatment	Pre-treatment	Treatment	Pre-treatment	Treatment	
Old Cleveland Rd East west	Generic smiley 14361		5021194		2633659		2633659		0		2387535	52
Old Cleveland Rd East east	Generic smiley 14370		4547018		1590023		1590023		0		2956995	35
Fitzroy St north	Koala smiley 16718		1885239		1237919		1237919		0		647320	66
Sturgeon St west	Koala smiley 16720		3864699		1911772		1911772		0		1952927	49
Fitzroy St south	Koala smiley 18935		1728986		898330		888840		9490		830656	52
Wellington St south	Koala smiley 19540		1410708		711838		711838		0		698870	50
Wellington St north	Koala smiley 19541		3053311		1711558		1654154		57404		1341753	56
Sturgeon St east	Koala smiley 19543		5620193		2618352		2618352		0		3001841	47

Nelson Rd	Koala smiley 26978	317527	547558	165250	284639	165250	284639	0	0	152277	262919	52
Wellington St north2	Koala smiley 26981	456790	848073	225041	419998	225041	419998	0	0	231749	428075	49
Collingwood Rd	Koala smiley 26986	642802	1335615	347730	730659	347730	730659	0	0	295072	604956	55
South St east	Koala smiley 26987	306403	565992	154431	284657	154431	284657	0	0	151972	281335	50
South St west	Koala smiley 27633	462912	788476	237705	399205	234789	399205	2916	0	225207	389271	51
Total		2186434	31217062	1130157	15432609	1127241	15365715	2916	66894	1056277	15784453	**50**