Redland Smart Signs and Smart Messages:

A Driver Behaviour Change Project – Year 4

Final Report (2021-2022)

Report prepared for Redland City Council

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Executive summary

With koalas now officially recognised as endangered, more effort than ever is required to ensure their long-term survival. Vehicle strikes are one of the key causes of decline, yet the scale and ubiquitous nature of the problem requires investment in improving measures that are easily scalable. As part of a suite of continuing strategies to reverse the decline of koalas in Redland City, dynamic wildlife warning signs are being trialled in Redlands Koala Safe Neighbourhoods . As with previous years of investigation, dynamic signage again appears to be encouraging most drivers in the Redlands to slow down when passing signs. In all but one case, speed reductions recorded during the current year are either less than those in the previous year or remain unchanged. This suggests that speed reductions have probably been maximised in relation to current signage strategies. There appears to be little indication of driver habituation to signage, even after exposure of more than a year. This is a particularly positive result given that habituation has generally been a concern in relation to any benefits of wildlife signage. Additional replication and representativeness are required to confirm this trend, but current indications are certainly encouraging. Less encouraging are the results pertaining to excessive speeders: vehicles travelling at or above 100km/hr on roads with posted speed limits of 50 or 60km/hr. Whilst such events are relatively rare on some roads, it is concerningly more common on certain roads (e.g. Old Cleveland Road East and Sturgeon Street). Excessive speeding appears to be more common in one direction of travel on a given road, perhaps reflecting the placement of nearby roundabouts or traffic lights, which may also represent an opportunity for targeted police enforcement. The same is true, to a degree, in relation to temporal clustering of excessive speeding events. For example, on Old Cleveland Road East (Western sign), excessive speed records peaked from about 8PM-11PM, and again at 3AM and 5AM daily, and a slightly higher rate of events occurred on Fridays (although a reasonably high number of events occurred across all days of the week). Koalas were again active in areas close to, and sometimes directly on, roads outfitted with signs. As was the case last year, the koala nicknamed ‘Blake’ was observed to have potentially crossed Fitzroy Street. Another koala, nicknamed Benson, who had been struck by a vehicle on a nearby road and released in the area following intensive rehabilitation, also had GPS records indicating that he was potentially crossing roads. Benson’s movement patterns suggest a fairly wide area of travel since his release, which raises interesting questions about the movements of rehabilitated koalas. Intensively-recorded, fine-scale GPS data may provide greater insight into these patterns and help to better understand risks to koalas during forays.

Acknowledgements

The Redland Smart Signs project was commissioned by Redland City Council as part of their koala conservation safe neighbourhoods initiative. Dr Cathryn Dexter, Project Officer – Koala Conservation Program 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 Caio Santos Neto from the Global Change Ecology Research Group at the University of the Sunshine Coast supplied data on koala movements and road crossings in the study areas. Sharyn Rundle-Theile and collaborators from Social Marketing @ Griffith University conducted community feedback surveys during the public awareness campaigns and when the VMS were displayed.

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1. Introduction

In February 2022, koala populations in Queensland, New South Wales and the Australian Capital Territory were listed as endangered (Cox, 2022). This was in recognition that populations had continued to decline since being listed as vulnerable in 2012, and that halting this decline should be considered an urgent priority (Cox, 2022). There are several, recognised major threats to koala populations including climate change, habitat loss, disease, and vehicle strike (McAlpine et al. 2015). Vehicle strike is so pervasive that wherever roads intersect koala populations, strikes are likely to occur (Lunney et al. 2022).

Despite the acknowledgement of vehicle strike as a ubiquitous threat, the application of mitigation strategies remains somewhat haphazard and limited. Whilst fauna crossing structures are recognised as often abating the threat of strikes within an immediate area, their construction and maintenance is expensive and logistically challenging (Dexter et al. 2018). Another often applied method, wildlife barrier fencing, can be costly and problematic to implement, especially where numerous gaps (e.g. for side roads, driveways etc.) are required (Lunney et al. 2022).

Perhaps the most widely applied attempt at mitigation involves the use of warning signage. To-date, investigations of wildlife signage suggest it is of limited benefit (Huijser et al. 2015) including for koalas (Dique et al. 2003). Yet, given the inexorable challenge of applying mitigation approaches such as fauna passages and fencing at anything close to the geographic scale of vehicle strike, there seem few other options available. The question then becomes, how can signage be more effective?

An obvious opportunity to improve the benefits of signage is to apply relevant technological advances. Certain models of signage now incorporate LED display panels that can dynamically convey variable messaging to drivers in relation to their speed, which is accurately measured and recorded by on board speed radar systems. Such signage allows for messaging to be tailored to a highly specific degree. For example, if an approaching vehicle is recorded as being above a targeted speed threshold (e.g. the posted speed limit), a warning message is displayed. Importantly though, favourable driver behaviour in the form of appropriate speed can also be ‘rewarded’ or positively reinforced, using messaging designed to be encouraging.

Lunney et al. (2022) argue that education should be a major focus of future mitigation, and we agree. Here too, signage can potentially play a role, by helping to reinforce driver awareness of koalas in the landscape and the possibility that they may encounter a koala on the road. This is arguably the principle behind the rollout of warning signage on roads near schools (i.e. 'school zones') in Queensland, which has resulted in some encouraging outcomes (DTMR, 2014).

Redland City Council has a strong focus on public engagement and education in relation to koala conservation programs (Pang et al. 2022). A pertinent example is the 'Leave it' program, which, amongst other initiatives, involved a four-week dog training program co-designed by participants to help train dogs to avoid koalas (Harris et al. 2022). The same is true for koala signage, with local resident surveys being conducted in order to establish public awareness of signs, again with encouraging results (Pang et al. 2019; Seydel et al. 2021). Other information dissemination programs have also been instituted, including school presentations and public forums where researchers provide key findings to members of the public and answer questions. Together, these initiatives aim to maximise public understanding and involvement in a suite of koala conservation measures being explored in the region, each targeting aspects of key threats (e.g. vehicle strike; dog attacks) and knowledge gaps (e.g. population dynamics; disease; nutrition).

The following report is a part of an ongoing, experimental investigation of dynamic signage in Redlands Coast (see Blacker et al. 2019, Appleby et al. 2020 and Appleby et al. 2021 for previous reports). This report provides a general overview of the most recent results, again focusing on an examination of the phenomenon of driver habituation, an update on any koala movement patterns around roads outfitted with signage, and a new section investigating excessive speeding, which may represent a disproportionate risk to koalas being struck on roads.

2. Methodology

2.1 Study sites

This year the ten signs installed in 2021 were left in place to examine potential habituation over a longer period. Five streets were selected for sign placement in Redland City.

Two signs were displayed along each of the following roads, with each sign corresponding to one traffic direction: Sturgeon Street, Starkey Street, and Wellington Road in the Ormiston Koala Safe Neighbourhood (KSN); Old Cleveland Road East in the Birkdale KSN; and Fitzroy Street in the Thornlands KSN.

An additional five signs were due to be installed this year, however, significant delays in the delivery of the signs meant that this was not possible. These signs will be included in next year's report.

Table 1 provides a brief summary of each sign location, and Figure 1 shows maps of the approximate sign locations.

Table 1. Summary of sign locations.

Sign/Site Descriptor	Location	Traffic Direction	Speed Limit
Sturgeon Street west	West of Hilliards Creek crossing	Eastbound	60 km/h
Sturgeon Street east	Near house #60	Westbound	60 km/h
Starkey Street north	Just south of corner with Anhs Place	Southbound	60 km/h
Starkey Street south	Just north of corner with Gilchrist Street	Northbound	60 km/h
Wellington Street north	Near houses #134 and #136	Northbound	50 km/h
Wellington Street south	Just north of entrance to Ormiston Springs Estate – Ormiston Railway Station	Southbound	50 km/h
Old Cleveland Road East west (Birkdale)	Opposite the entrance to the Birkdale Recycling and Waste Centre	Eastbound	60 km/h
Old Cleveland Road East east (Wellington Point)	In alignment with house #657 (the sign was on the State Route 55 section, not the residential section of Old Cleveland Road East)	Westbound	60 km/h
Fitzroy Street north	Northern end of Henry Ziegenfusz Park (slightly south of house #141)	Southbound	50 km/h
Fitzroy Street south	Just north of the corner of Tarcutta Street	Northbound	50 km/h

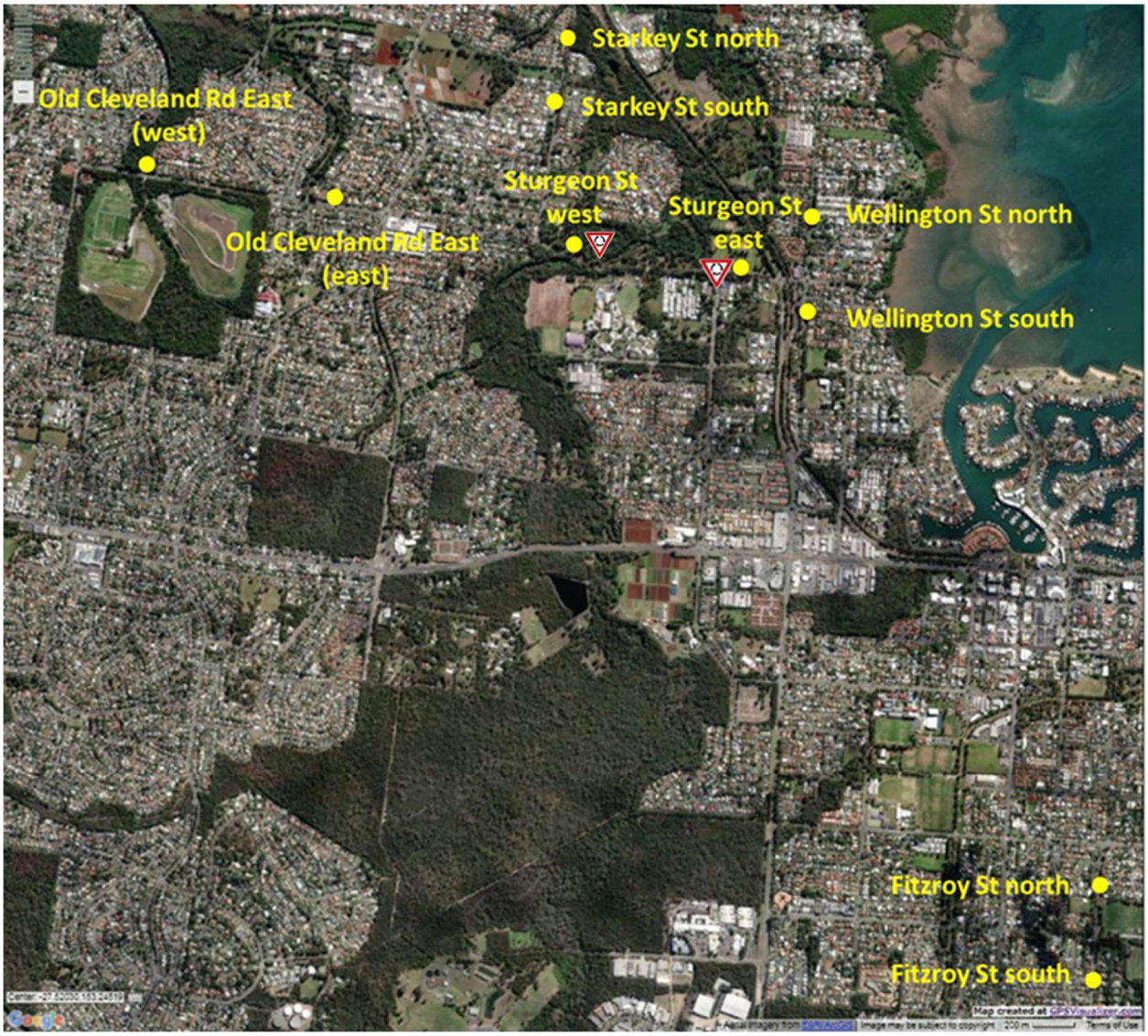

Figure 1. A map showing the locations of signs on three streets in Ormiston (Starkey , Sturgeon and Wellington Streets), Old Cleveland Road East in Wellington Point/Birkdale and Fitzroy Street in Cleveland. symbols indicate the positions of roundabouts, although a roundabout just south of the Fitzroy Street south sign is not visible on the map.

It should be noted that some signs were in close proximity to roundabouts, school zones, and/or other road features that may have affected vehicle speeds approaching the signs. Any sign that was close to a side road may have encountered numerous vehicles slowing down to turn into the adjoining street. Additionally, along most road sections monitored by the signs, vehicles could pull into or out of driveways, roadside parking spaces and side streets. See Appleby et al. (2021) for more details.

2.3 Wildlife warning signs

Three types of signs were trialled, from two different manufacturers/suppliers. Two were Sierzega dynamic message signs (supplied by Jenoptik Traffic Solutions) that reported tailorable messages to drivers via an LED display panel. 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 Jenoptik ‘smiley’) featured a high visibility border and the words: “DRIVE SAFELY”, whilst a koala-specific version (named Jenoptik ‘koala smiley’) featured the image of a koala with the words: “KOALA CROSSING”.

Figure 2 shows each version of the Jenoptik signs side-by-side for comparison.

Figure 2. Sierzega brand models of dynamic (variable) message signage, named for this project as Jenoptik ‘smiley’ (left) and ‘koala smiley’ (right).

The third sign type (ITS/Artcraft) featured two LED lights that flashed on and off whenever a vehicle was detected exceeding a specifiable speed threshold. The posted speed limit was displayed (and could be replaced depending on the speed of a given street) along with a smaller version of the same koala image and message featured in the Jenoptik koala smiley sign and a high visibility banner with the words: “WILDLIFE ZONE” (see Figure 3).

Figure 3. ITS/Artcraft brand koala sign.

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 also 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. The ITS/Artcraft sign only recorded the speed of vehicles as they approached signs, and data were then automatically collated by the dedicated sign software into ‘bins’ based upon a speed interval (e.g. between 50-60km/hr) and a time period (hourly).

2.4 Dynamic (variable) messaging

The two Jenoptik sign types were capable of dynamically changing (often referred to as 'variable') messaging conveyed to drivers depending on their speed. Figure 4 provides an example of the different messages drivers received at different speeds.

Figure 4. 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 that greeted drivers if they were recorded to be driving under 45 km/hr (or under 55 km/hr in a 60 km/hr zone) was unique to the Jenoptik koala smiley model (i.e. the generic Jenoptik smiley model featured a green, round 'smiley' face as pictured for the other speed thresholds).

2.5 Sign operation dates, locations and treatments

The signs were installed, covered and became operational from 1st October 2020. 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 treatment period (17/04/2021 - 24/02/2022). The location of each sign and data collection periods are detailed in Table 2.

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 3). 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.

Table 2. The sign allocation to each site, with the dates of operation for data collection during the 2020-21 and 2021-2022 treatment periods.

Site	Sign	2020-2021 Treatment start date	2020-2021 Treatment end date	2021-2022 Treatment start date	2021-2022 Treatment end date
Sturgeon Street west	Koala smiley 16720	16/12/2020	16/04/2021	17/04/2021	24/02/2022
Sturgeon Street east	Koala smiley 19543	16/12/2020	16/04/2021	17/04/2021	24/02/2022
Wellington Street north	Koala smiley 19541	16/12/2020	16/04/2021	17/04/2021	24/02/2022
Wellington Street south	Koala smiley 19540	16/12/2020	16/04/2021	17/04/2021	24/02/2022
Starkey Street south	ITS K001-01	16/12/2020	21/01/2021	17/04/2021	24/02/2022
Starkey Street north	ITS K001-02	16/12/2020	21/01/2021	17/04/2021	24/02/2022
Old Cleveland Road East east	Smiley 14370	6/11/2020	16/04/2021	17/04/2021	24/02/2022
Old Cleveland Road East west	Smiley 14361	16/12/2020	16/04/2021	17/04/2021	24/02/2022
Fitzroy Street north	Koala smiley 16718	28/11/2020	16/04/2021	17/04/2021	24/02/2022
Fitzroy Street south	Koala smiley 18935	29/11/2020	16/04/2021	17/04/2021	24/02/2022

Table 3. The length of the 2020-2021 pre-treatment, 2020-2021 treatment, and 2021-2022 treatment period datasets for each sign and site, once anomalous data were removed.

Site	Sign	2020-2021 Pre-treatment period (days)*	2020-2021 Treatment period (days)	2021-2022 Treatment period (days)
Sturgeon Street west	Koala smiley 16720	56	111	304
Sturgeon Street east	Koala smiley 19543	56	122	291
Wellington Street north	Koala smiley 19541	66	30	244
Wellington Street south	Koala smiley 19540	70	118	289
Starkey Street south	ITS K001-01	44	36	314
Starkey Street north	ITS K001-02	44	36	246
Old Cleveland Road East east	Smiley 14370	22	140	312
Old Cleveland Road East west	Smiley 14361	73	122	272
Fitzroy Street north	Koala smiley 16718	54	139	311
Fitzroy Street south	Koala smiley 18935	57	126	307

*The number of pre-treatment days were adjusted to exclude days where the covers were unintentionally removed.

2.6 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.

2.7 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 treatment period.

For the 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, 2022). Data cleaning was then conducted in both R and Excel, with graphing conducted in Excel. For the ITS signs, raw data in the form of .dat files were downloaded from the ITS Web Speedboard online web portal, imported to the software program Houston Radar Stats Analyzer then trimmed down to the relevant dates of the pre-treatment and treatment periods. The resulting summary reports were then exported to Excel.

Data processing also included the calculation of data variables that were of interest for analyses or assisted in finding data errors (for example, finding gaps in time where data were not recorded by the signs). Graphs of average daily car speeds from the Jenoptik signs were also 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 (see anomalies detailed in Appendix 1: Technical and data issues).

The raw data from the ITS signs (i.e. timestamped recordings of individual vehicle speeds) were again not available, as advised by the sign manufacturers in 2020, due to the design of the system. Therefore, for the purposes of this report, it was again not possible to check for anomalies as thoroughly as was possible for the Jenoptik sign data, given the time constraints of this project. However, periods when the signs failed to record any data were recorded and available, have been detailed in Appendix 1: Technical and data issues.

2.8 Data analyses

As with the previous two reports (Appleby et al. 2020; Appleby et al. 2021) 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 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.

Additionally, as signs utilised in this experiment were from two different manufacturers, using different radar devices and collating resultant data differently, this presented considerable challenges in directly comparing or contrasting sign performance. 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 2021-2022 treatment period. From these, changes in average and 85th percentile speeds between the 2020-2021 pre-treatment and 2021-2022 treatment periods were calculated. Again, ITS sign data summaries were produced automatically by the software prior to exporting data summaries. These included average vehicle speed, 85th percentile vehicle speed, maximum vehicle speed and number of vehicles for each treatment period, with standard deviations again unavailable. The ITS signs only record one speed per vehicle, so in tables that present data from both sign types the ‘V2’ speed data from the Jenoptik signs are presented for comparison with the single ITS speed available.

3. Results

3.1 General Summary

Across all signs (excluding Starkey Street south) in 2020-2021 the overall reduction in speed averaged to 1.667km/hr, and this essentially remained the same in 2021-2022, where the overall reduction in speed averaged to 1.668km/hr. Average reductions in 85th percentile speeds for the same periods were 1.57km/hr and 1.4km/hr respectively, with two signs performing better by an average of 1km/hr in the 2020-2021 period, and one sign performing better by an average of 0.6km/hr in the 2021-2022 period. All other signs remained unchanged.

3.2 Exploration of habituation

The focus of the project this year was to explore potential habituation of drivers to the signs. This could be shown as a gradual increase in V2 vehicle speeds and/or a reduced change in speed between the pre-treatment and treatment periods.

Table 4 shows the change in average and 85th percentile vehicle speeds between the pre-treatment and treatment periods for each year of the study. Because the 2021-2022 study period was an extension from the 2020-2021 treatment period, this year's averages were compared with the 2020-2021 pre-treatment period. The majority of signs still elicited reduced speeds compared to the pre-treatment speeds after more than a year of being displayed continuously to drivers. One exception to this is for the ITS sign at Starkey Street south, which shows substantial increases in average and 85th percentile speeds during the 2021-2022 treatment period compared to the 2020-2021 pre-treatment period. This result should be treated with some caution however, because of apparent differences in the operational characteristics of the ITS signs between the two periods suggest that sign performance was the root of the apparent difference in average and 85th percentile speeds, rather than vehicle speeds themselves.

Comparing these changes in speed between the 2020-2021 period and the 2021-2022 period (see Table 4), reductions in speed are slightly less in the current year for all signs except the Jenoptik ‘koala smiley’ sign at Sturgeon Street east and the ITS sign at Starkey Street north.

Figures 5 through to 12 present a visual representation of V1 (blue line) and V2 (orange line) speeds throughout the 2020-2022 treatment periods (signs uncovered) for all Jenoptik signs. Figure 5 shows that vehicle speeds at the Jenoptik ‘smiley’ sign at Old Cleveland Road East west suddenly increased from September 2021 and maintained this increased speed for the remainder of the data collection period. In contrast, vehicle speeds at the Jenoptik ‘smiley’ sign at Old Cleveland Road East east remained relatively stable throughout the entire 2020-2022 treatment periods (Figure 6). Fitzroy Street north vehicle speeds show a slight increase of approximately 1km/hr from August 2021 (Figure 7). An increase in vehicle speeds can be seen from December 2021 at Sturgeon Street east (Figure 10), however this coincides with the school holidays, and is possibly a result of decreased traffic congestion during this period. Nevertheless, this slight increase is not necessarily of concern, due to the average speeds still remaining well below the speed limit. As with previous years, there remains a relatively clear reduction in average V2 speeds, compared to average V1 speeds, for each sign.

Table 4. Comparison of the change in average V2 and 85th percentile vehicle speeds for Jenoptik 'koala smiley' signs (in yellow), Jenoptik 'smiley' signs (in green), and ITS signs (in blue) between the 2019/20, 2020/21, and 2021/22 study periods. The signs located on Old Cleveland Road East and Fitzroy Street were only able to be compared between 2020/21 and 2021/22, as these signs were not installed prior to this. Numbers in red represent increases in speed, or no change in speed, between the pre-treatment and treatment periods of the relevant year.

		2019/20					2020/21					2021/22				
Site	Speed limit (km/hr)	Sign type/ID	Speed changes from Pre-treatment to Treatment period				Sign type/ID	Speed changes from Pre-treatment to Treatment period				Sign type/ID	Speed changes from 2020/21 Pre-treatment period to 2021/22 Treatment period			
			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	Jenoptik koala smiley/ 16720	2.12	4.30	1.00	1.79	Jenoptik koala smiley/ 19543	-0.03	-0.05	0.00	0.00	Jenoptik koala smiley/ 19543	-0.10	-0.20	0.00	0.00
Sturgeon St west	60	Jenoptik koala smiley/ 16718	-1.10	-2.05	-2.00	-3.33	Jenoptik koala smiley/ 16720	-1.46	-2.65	-1.00	-1.64	Jenoptik koala smiley/ 16720	-1.68	-3.06	-1.00	-1.64
Starkey St south	60	ITS/ K001_02	-4.79	-8.61	-1.70	-2.83	ITS/K001_01	2.30	6.69	-0.20	-0.36	ITS/K001_01	15.00	43.60	3.30	6.01
Starkey St north	60	ITS/ K001_01	-4.57	-8.20	-2.60	-4.26	ITS/K001_02	-1.10	-2.08	-0.10	-0.17	ITS/K001_02	-2.40	-4.55	-0.70	-1.18
Wellington St north	50	Jenoptik koala smiley/ 16718	-1.12	-2.34	-3.20	-5.69	Jenoptik koala smiley/ 19541	-1.49	-3.15	-1.00	-1.82	Jenoptik koala smiley/ 19541	-0.98	-2.07	-1.00	-1.82
Wellington St south	50	Jenoptik koala smiley/ 16720	-2.11	-4.66	-2.80	-5.11	Jenoptik koala smiley/ 19540	-2.37	-4.98	-2.00	-3.57	Jenoptik koala smiley/ 19540	-2.25	-4.73	-2.00	-3.57
Fitzroy St north	50						Jenoptik koala smiley/ 16718	-2.64	-5.42	-3.00	-5.17	Jenoptik koala smiley/ 16718	-2.24	-4.59	-3.00	-5.17
Fitzroy St south	50						Jenoptic koala smiley/ 18935	-2.10	-4.90	-3.00	-5.77	Jenoptic koala smiley/ 18935	-1.70	-3.96	-2.00	-3.85
Old Cleveland Rd East east	60						Jenoptik smiley/ 14370	-1.71	-3.14	-2.00	-3.28	Jenoptik smiley/ 14370	-1.66	-3.05	-1.00	-1.64
Old Cleveland Rd East west	60						Jenoptik smiley/ 14361	-2.11	-3.57	-2.00	-3.03	Jenoptik smiley/ 14361	-2.01	-3.40	-2.00	-3.03

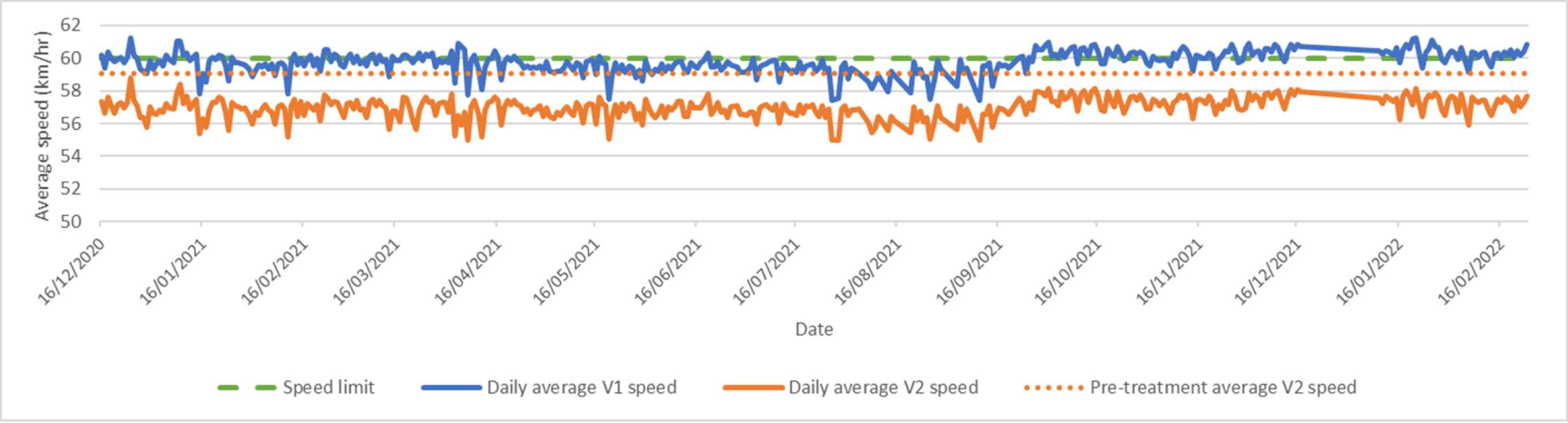

Figure 5. Old Cleveland Road East west average daily vehicle speeds during the 2020-2021 and 2021-2022 treatment periods when Jenoptik 'smiley' sign 14361 was displayed to drivers. The speed limit and average pre-treatment speed are also shown. Note: the pre-treatment line represents the overall average from the data collected in 2020-2021. 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.

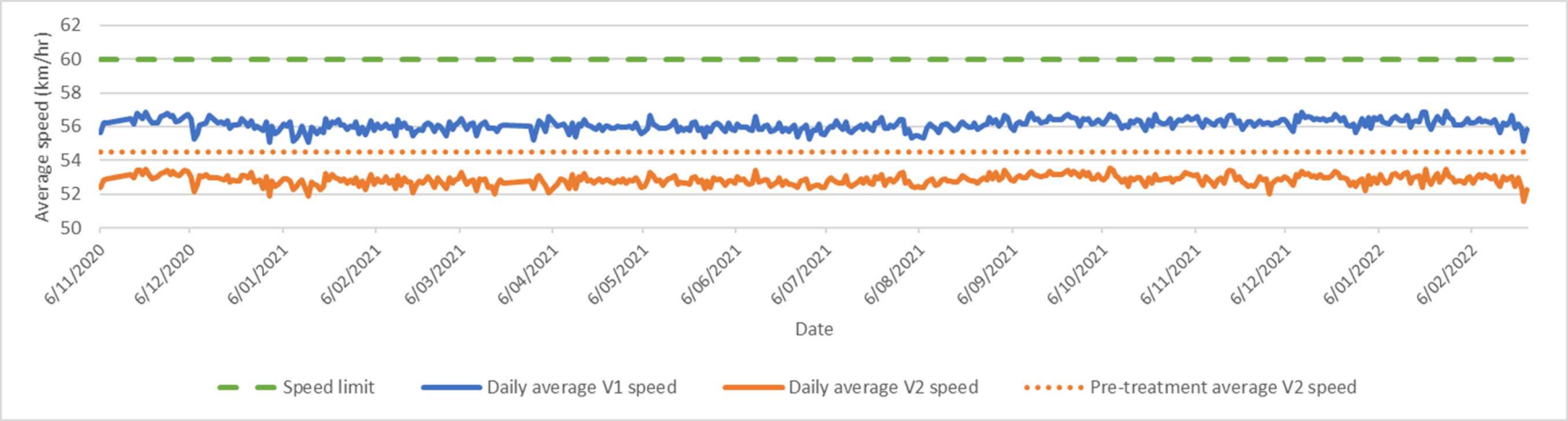

Figure 6. Old Cleveland Road East east average daily vehicle speeds during the 2020-2021 and 2021-2022 treatment periods when Jenoptik 'smiley' sign 14370 was displayed to drivers. The speed limit and average pre-treatment speed are also shown. Note: the pre-treatment line represents the overall average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

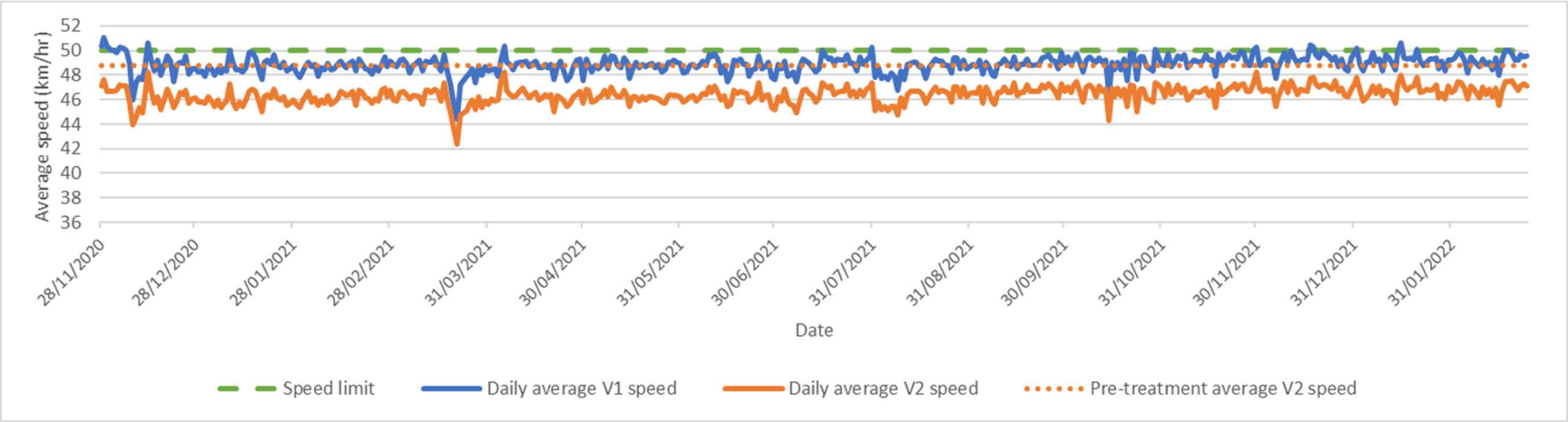

Figure 7. Fitzroy Street north average daily vehicle speeds during the 2020-2021 and 2021-2022 treatment periods when Jenoptik 'koala smiley' sign 19718 was displayed to drivers. The speed limit and average pre-treatment speed are also shown. Note: the pre-treatment line represents the overall average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

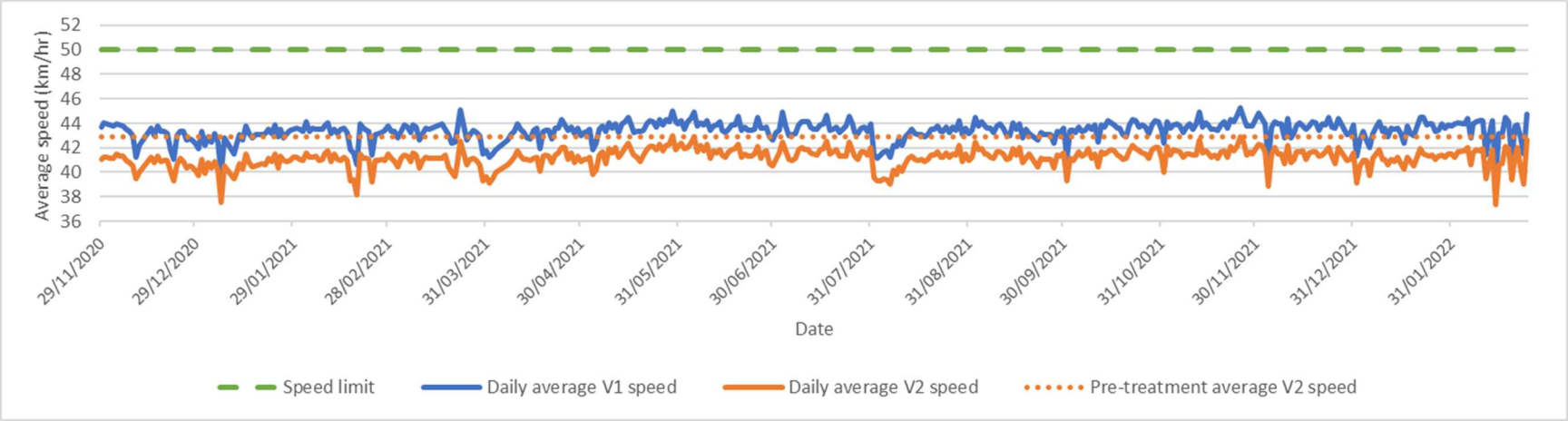

Figure 8. Fitzroy Street south average daily vehicle speeds during the 2020-2021 and 2021-2022 treatment periods when Jenoptik 'koala smiley' sign 18935 was displaying to drivers. The speed limit and average pre-treatment speed are also shown. Note: the pre-treatment line represents the overall average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

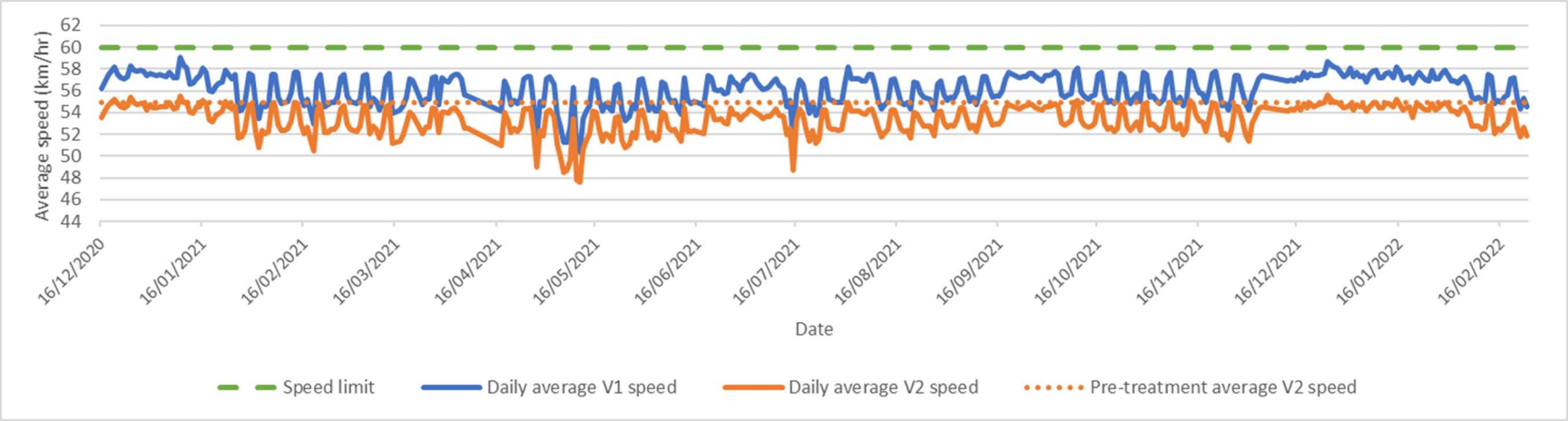

Figure 9. Sturgeon Street west average daily vehicle speeds during the 2020-2021 and 2021-2022 treatment periods when Jenoptik 'koala smiley' sign 16720 was displayed to drivers. The speed limit and average pre-treatment speed are also shown. Note: the pre-treatment line represents the overall average from the data collected in 2020-2021. The linear section at around 07/04/2021 to 17/04/2021 represents a period of anomalous data that was removed.

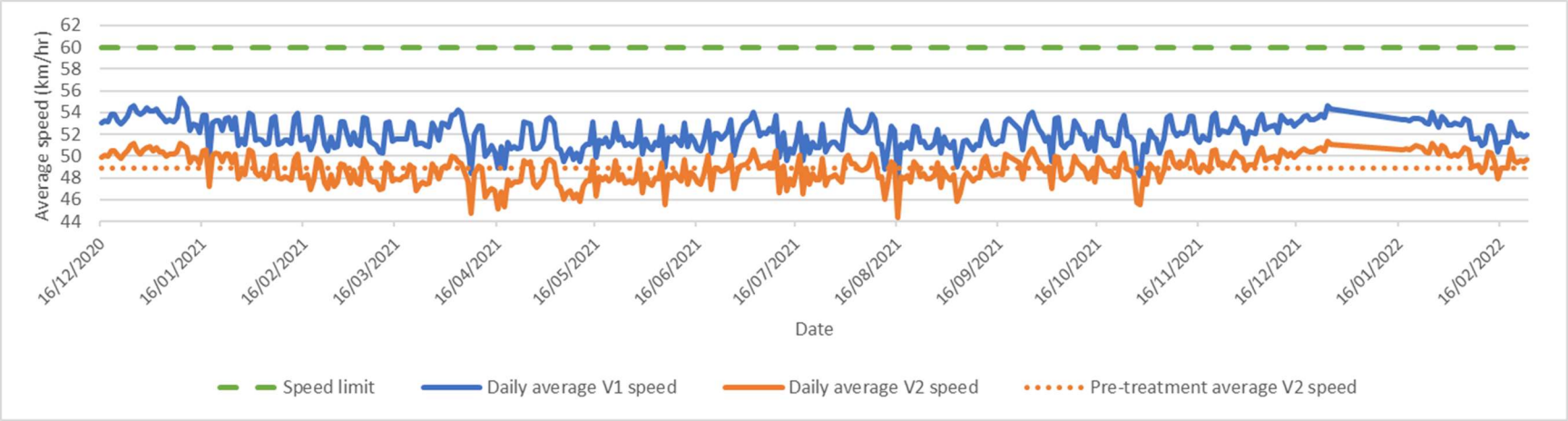

Figure 10. Sturgeon Street east average daily vehicle speeds during the 2020-2021 and 2021-2022 treatment periods when Jenoptik 'koala smiley' sign 19543 was displayed to drivers. The speed limit and average pre-treatment speed are also shown. Note: the pre-treatment line represents the overall average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

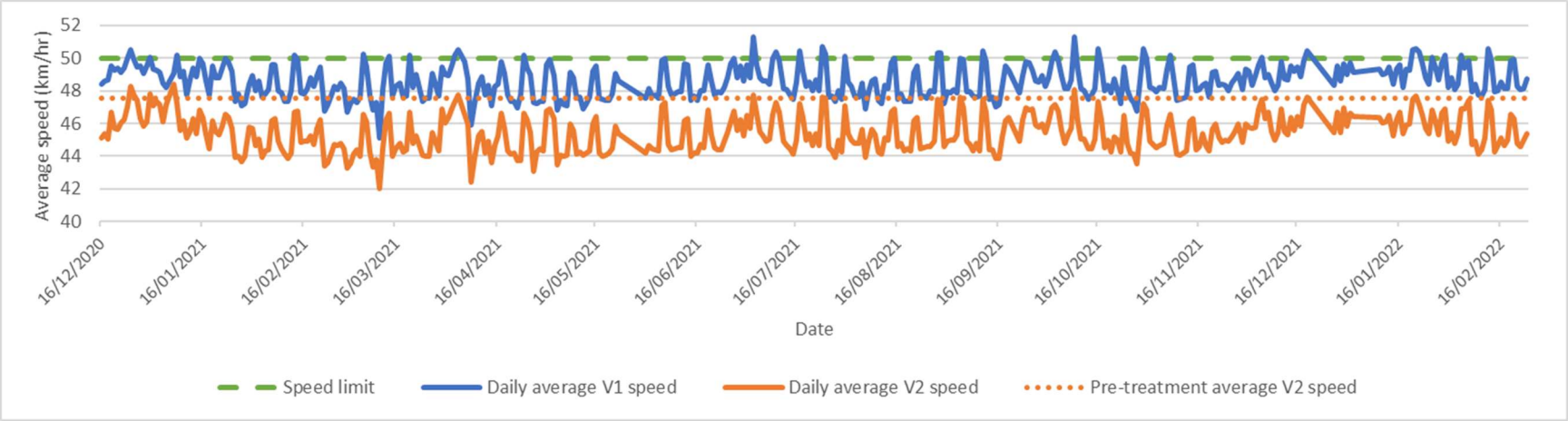

Figure 11. Wellington Street south average daily vehicle speeds during the 2020-2021 and 2021-2022 treatment periods when Jenoptik 'koala smiley' sign 19540 was displayed to drivers. The speed limit and average pre-treatment speed are also shown. Note: the pre-treatment line represents the overall average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

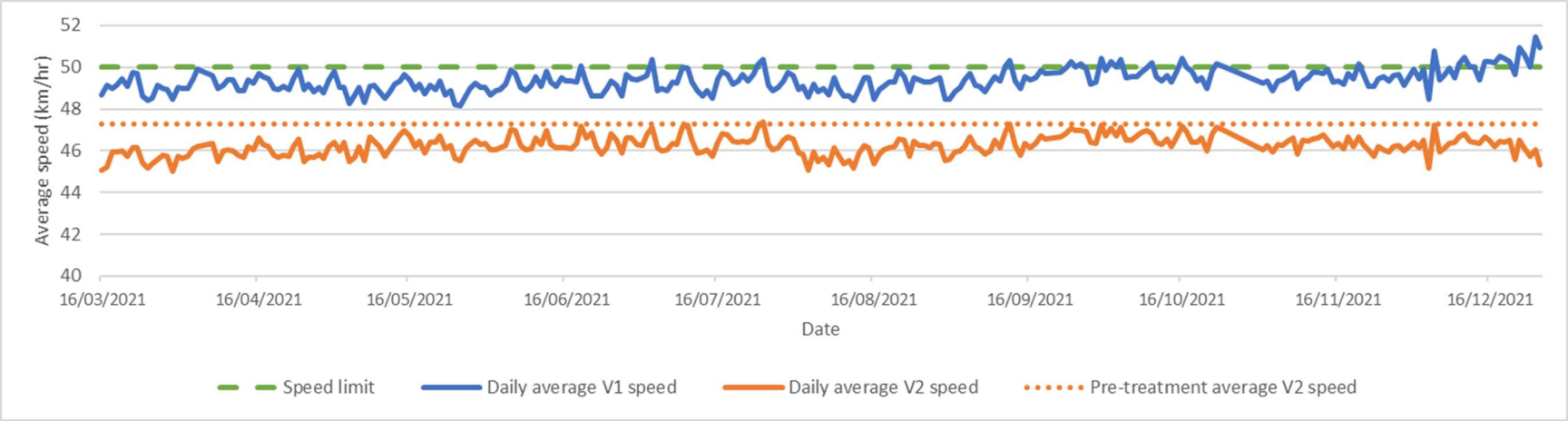

Figure 12. Wellington Street north average daily vehicle speeds during the 2020-2021 and 2021-2022 treatment periods when Jenoptik 'koala smiley' sign 19541 was displayed to drivers. The speed limit and average pre-treatment speed are also shown. Note: the pre-treatment line represents the overall average from the data collected in 2020-2021. The linear section at around 24/10/2021 to 01/11/2021 represents a period of anomalous data that was removed.

3.3 Excessive speeding

As Figures 13-20 demonstrate, there is a consistently higher proportion of excessive speed records (vehicles travelling at or above 100km/hr) in one direction of travel (e.g. see Figure 15 for a stark difference), as well as a reasonable degree of temporal clustering for each study road. On certain roads (and directions of travel) such as Old Cleveland Road East and to a lesser degree, Sturgeon Street, pooled observations of excessive speeders grouped into days of the week are often above 100, and can go above 350, suggesting that such events are not rare on these particular roads (see Figures 14 and 18). The particularly high numbers of excessive speeders along Old Cleveland Road East suggest that this could be an almost daily occurrence.

Generally, drivers were more likely to drive at excessive speeds between 6pm and midnight, with these peaks extending until 6am along Old Cleveland Street East and Sturgeon Street.

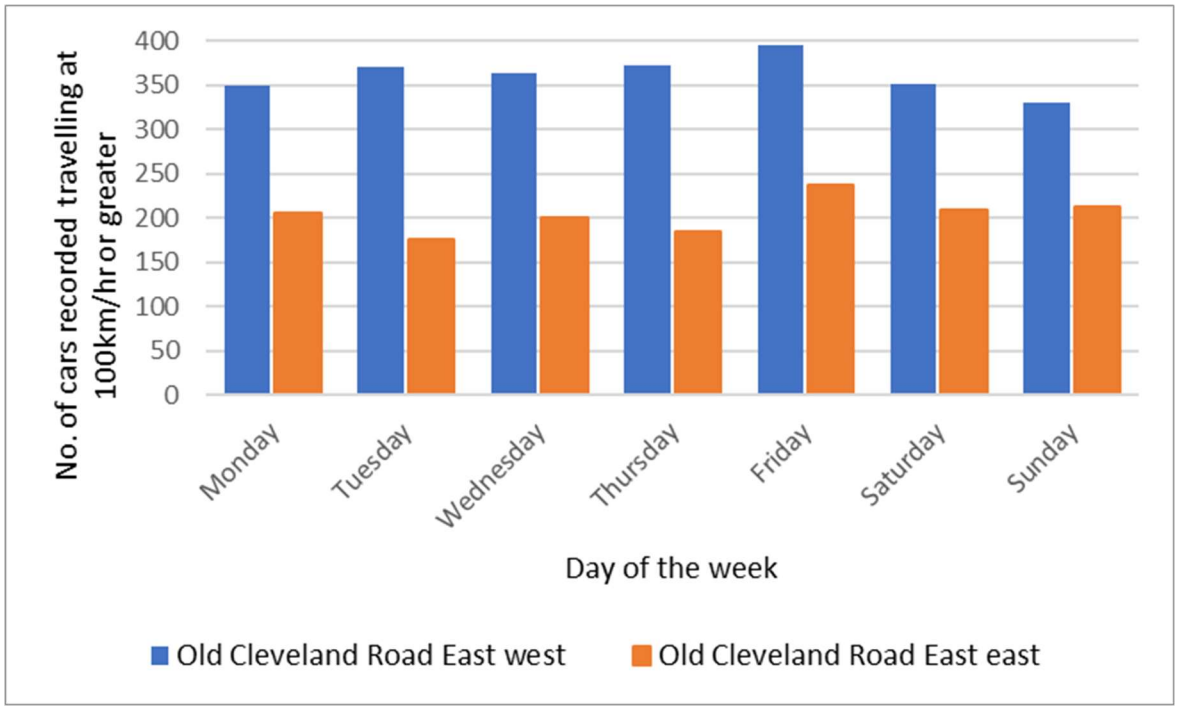

Figure 13. Counts of the number of cars travelling at 100km/hr or greater on Old Cleveland Road East (speed limit 60km/hr) during each day of the week for the period 17/04/2021 - 24/02/2022. Speeds were recorded at two sites by Jenoptik signs 14361 (Old Cleveland Road East west) and 14370 (Old Cleveland Road East east).

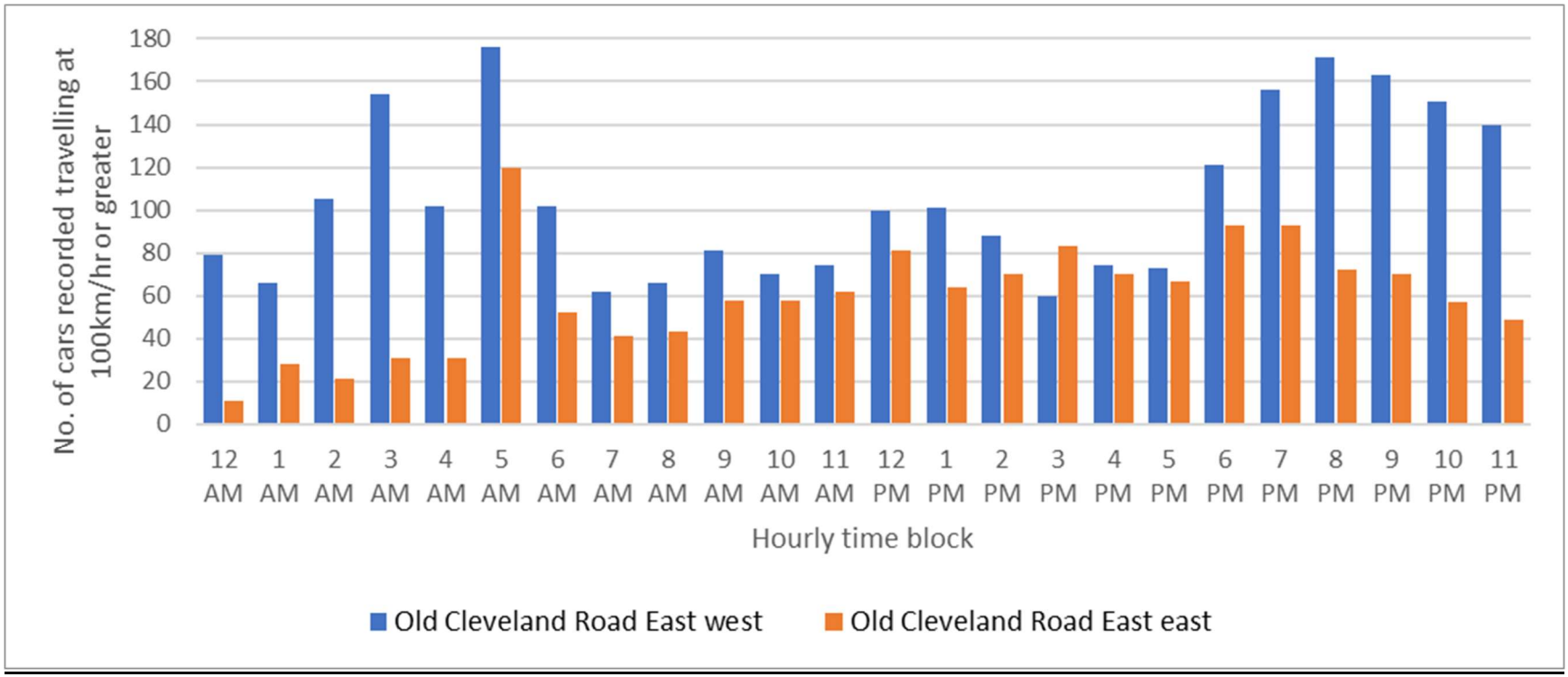

Figure 14. Counts of the number of cars travelling at 100km/hr or greater on Old Cleveland Road East (speed limit 60km/hr) during each hourly time block for the period 17/04/2021 - 24/02/2022. Speeds were recorded at two sites by Jenoptik signs 14361 (Old Cleveland Road East west) and 14370 (Old Cleveland Road East east).

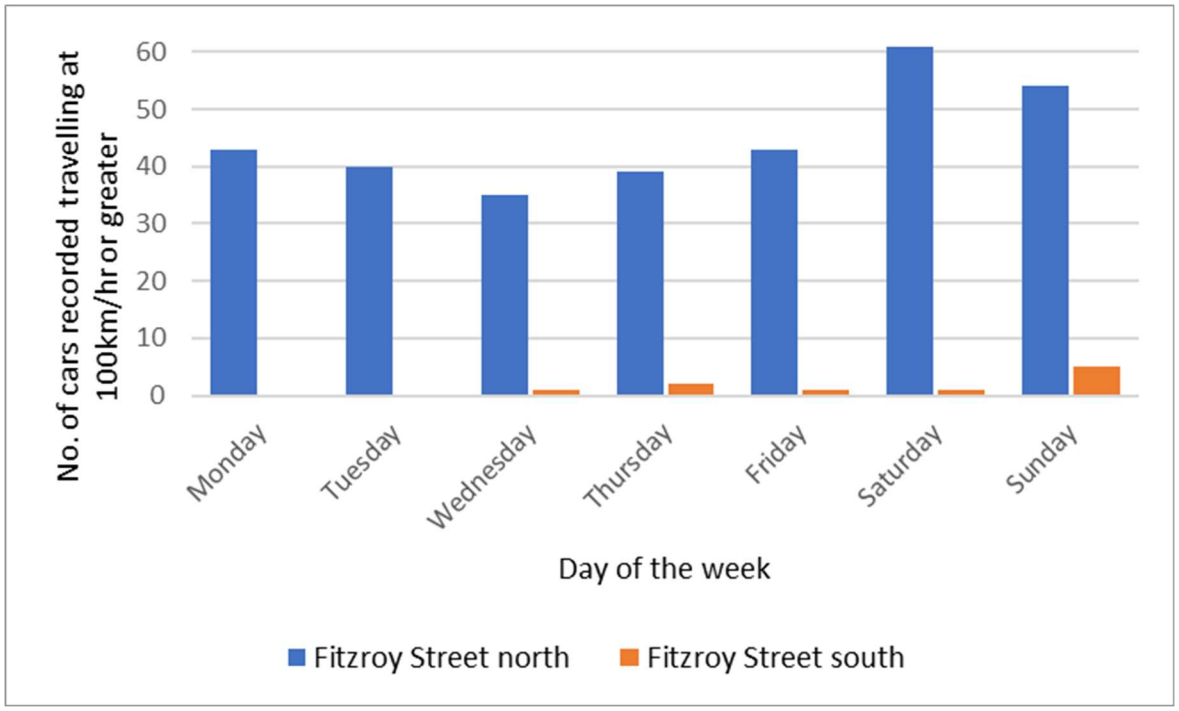

Figure 15. Counts of the number of cars travelling at 100km/hr or greater on Fitzroy Street (speed limit 50km/hr) during each day of the week for the period 17/04/2021 - 24/02/2022. Speeds were recorded at two sites by Jenoptik signs 16718 (Fitzroy Street north) and 18935 (Fitzroy Street south).

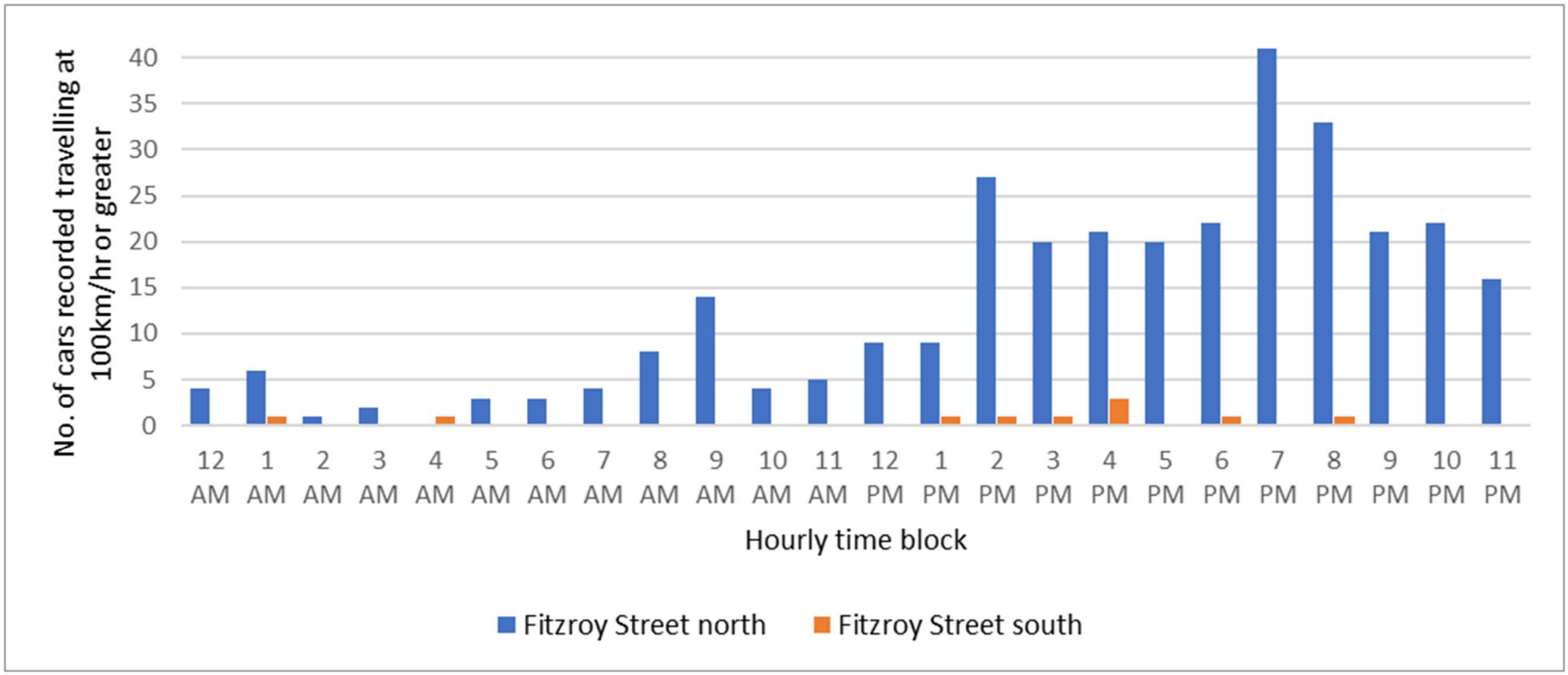

Figure 16. Counts of the number of cars travelling at 100km/hr or greater on Fitzroy Street (speed limit 50km/hr) during each hourly time block for the period 17/04/2021 - 24/02/2022. Speeds were recorded at two sites by Jenoptik signs 16718 (Fitzroy Street north) and 18935 (Fitzroy Street south).

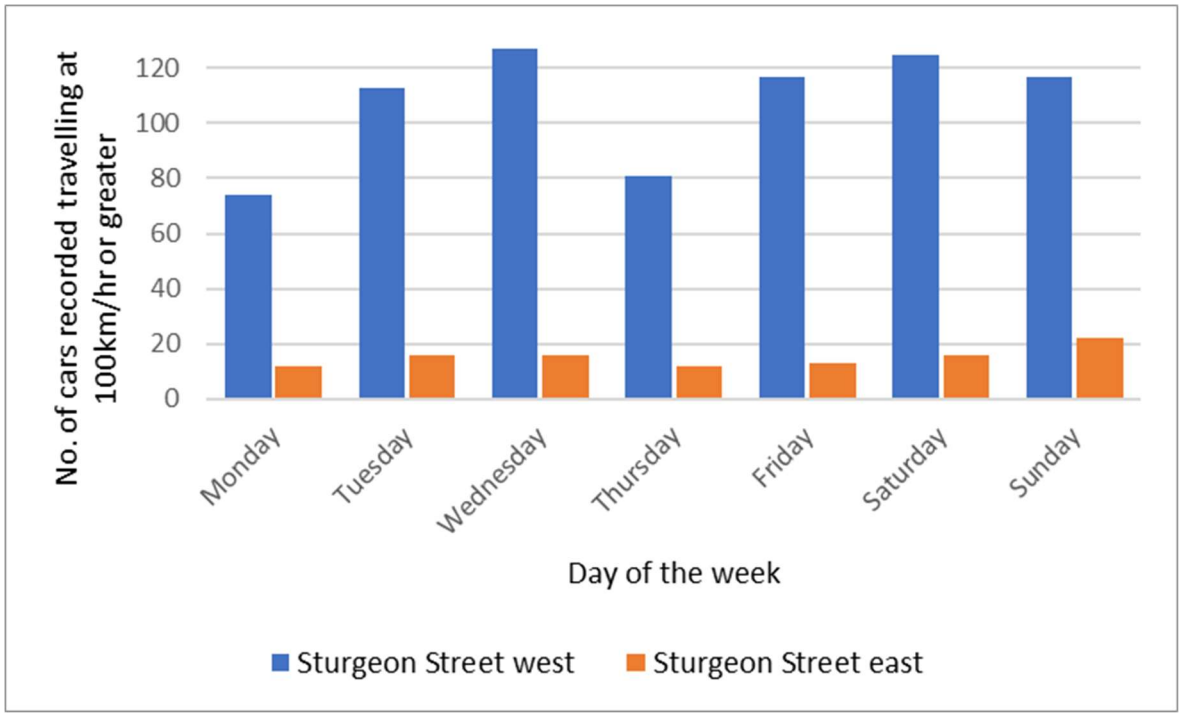

Figure 17. Counts of the number of cars travelling at 100km/hr or greater on Sturgeon Street (speed limit 60km/hr) during each day of the week for the period 17/04/2021 - 24/02/2022. Speeds were recorded at two sites by Jenoptik signs 16720 (Sturgeon Street west) and 19543 (Sturgeon Street east).

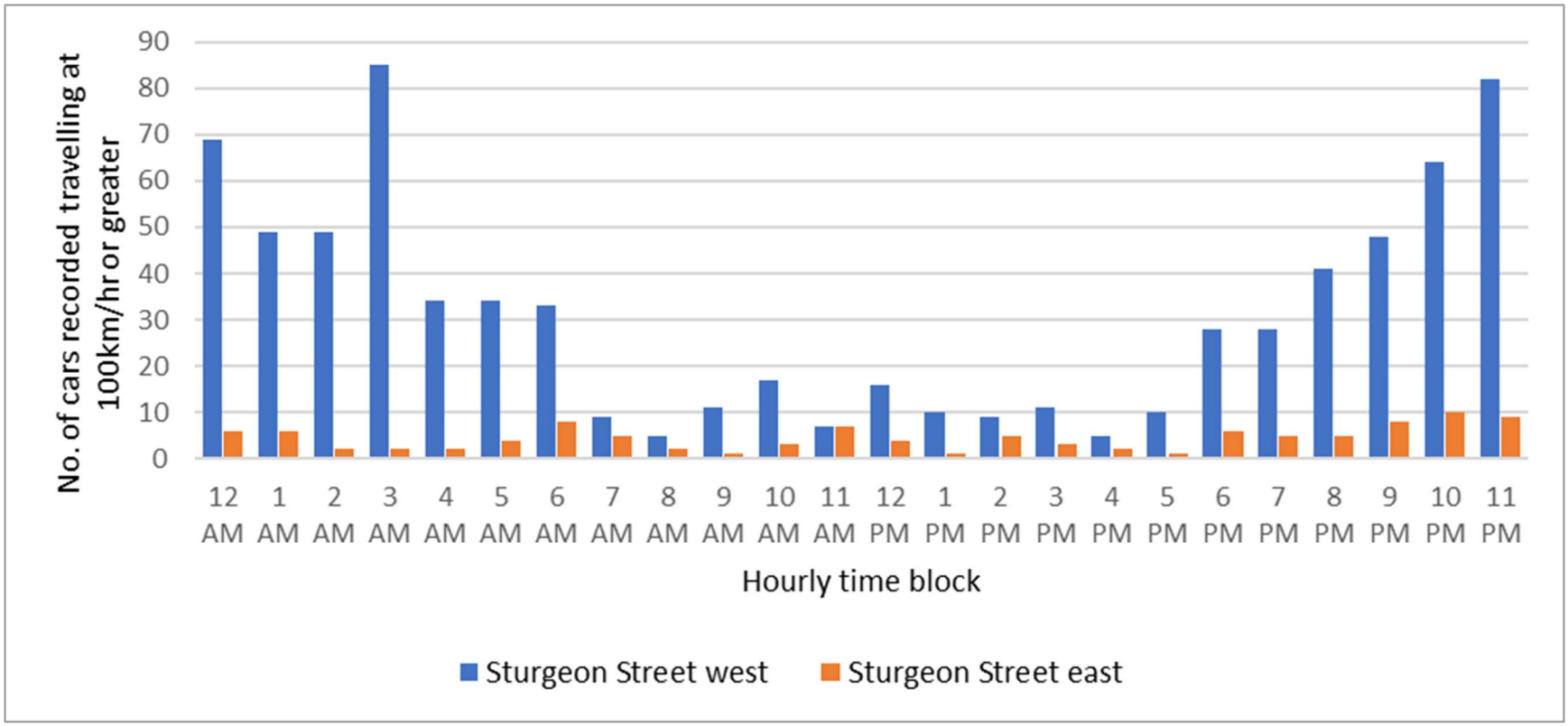

Figure 18. Counts of the number of cars travelling at 100km/hr or greater on Sturgeon Street (speed limit 60km/hr) during each hourly time block for the period 17/04/2021 - 24/02/2022. Speeds were recorded at two sites by Jenoptik signs 16720 (Sturgeon Street west) and 19543 (Sturgeon Street east).

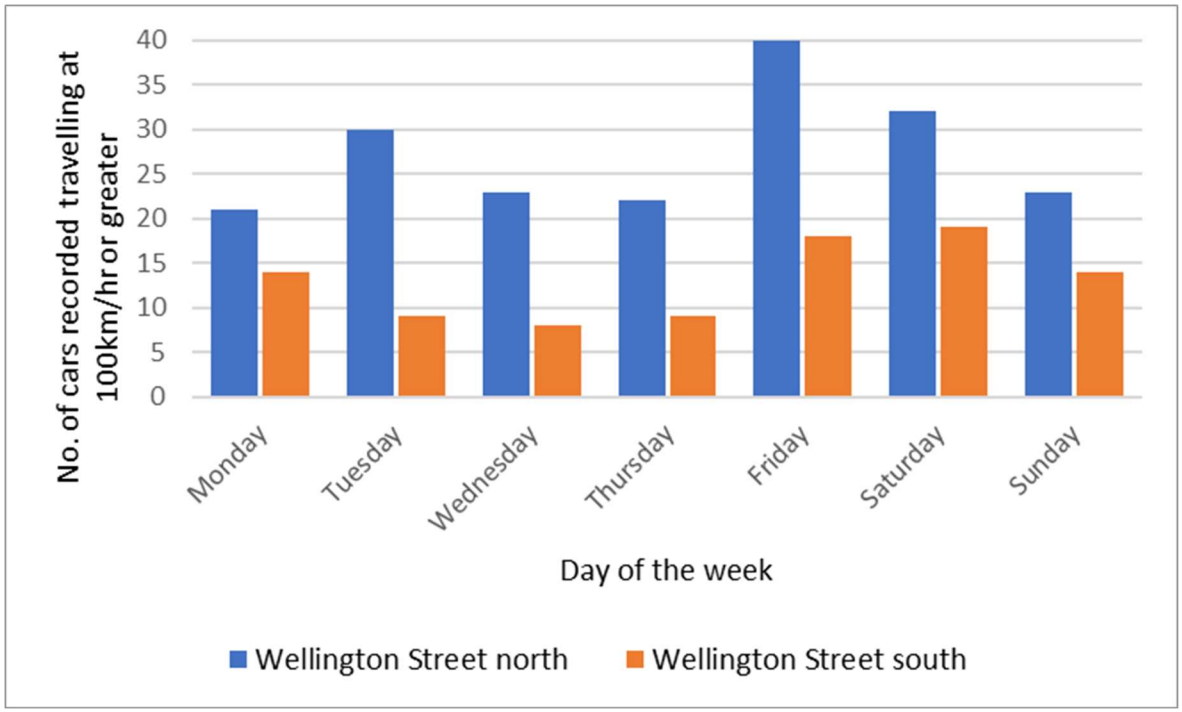

Figure 19. Counts of the number of cars travelling at 100km/hr or greater on Wellington Street (speed limit 50km/hr) during each day of the week for the period 17/04/2021 - 24/02/2022. Speeds were recorded at two sites by Jenoptik signs 19541 (Wellington Street north) and 19540 (Wellington Street south).

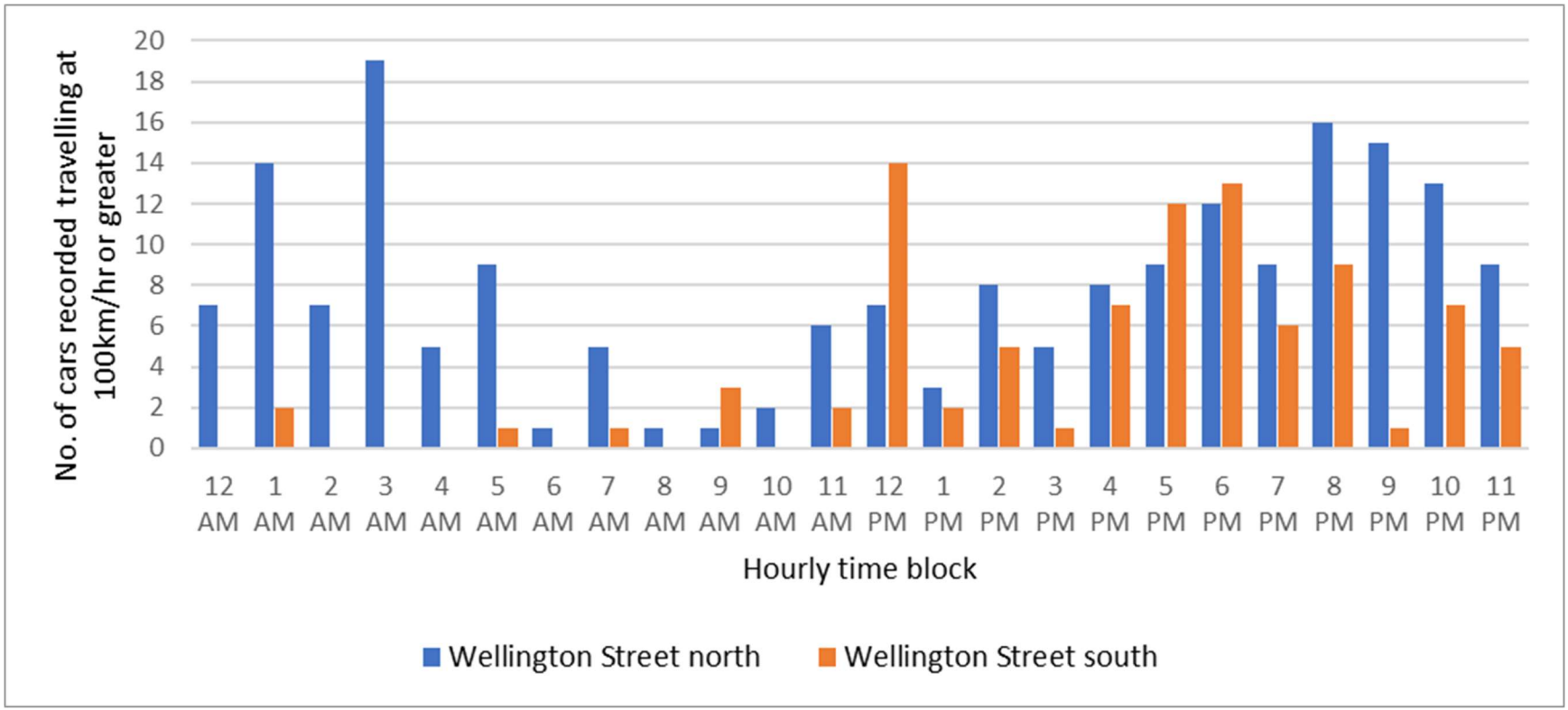

Figure 20. Counts of the number of cars travelling at 100km/hr or greater on Wellington Street (speed limit 50km/hr) during each hourly time block for the period 17/04/2021 - 24/02/2022. Speeds were recorded at two sites by Jenoptik signs 19541 (Wellington Street north) and 19540 (Wellington Street south).

3.4 Koala vehicle strike data

To the best of our knowledge, no koalas have been hit by vehicles along any street used in the study since starting the sign trial in 2018 (Blacker et al. 2019; Appleby et al. 2020). One strike occurred in the Ormiston neighbourhood, on Hilliards Street, in between the data collection periods of years 1 and 2, on or around 23 August 2019 (RCC unpublished data). There was one koala strike along Old Cleveland Road East on 7 March 2020, prior to the signs being installed along this road. A koala nicknamed Benson who is part of the USC Koala Monitoring study, was suspected of being injured by vehicle strike in December 2021. This koala was found near the corner of Coburg Street East and Passage Street in Cleveland, and treated at the Australia Zoo Wildlife hospital. Once Benson was fully recovered, he was released to the same area, being his known home range. Although this area is not part of the sign trial, it is approximately 1.5 km from the Fitzroy Street north sign in Thornlands.

3.5 Koala sightings and movement around the study sites

To determine whether koalas were actually living and moving around close to the signs, we examined available koala movement data provided by a separate, but related, study being conducted by the University of the Sunshine Coast (USC) Detection Dogs for Conservation researchers.

Similar to last year, one koala in particular, named Blake, was likely to have crossed a study road several times, as well as other roads in the area. Blake's GPS collar data points between September 2021 and March 2022 (see Figure 13) were located on either side of Fitzroy Street, Long Street and other local roads, suggesting that Blake regularly crossed the roads in this area. In the three months between January and March 2022, it is possible that Blake moved across Fitzroy Street and Long Street 12 separate times. The three likely road crossings near the Fitzroy Street north sign by Blake is given in Figure 14. Given each possible crossing involved multiple GPS locations on each side of the road, it is highly likely that all of these crossings actually occurred and are not a result of GPS error.

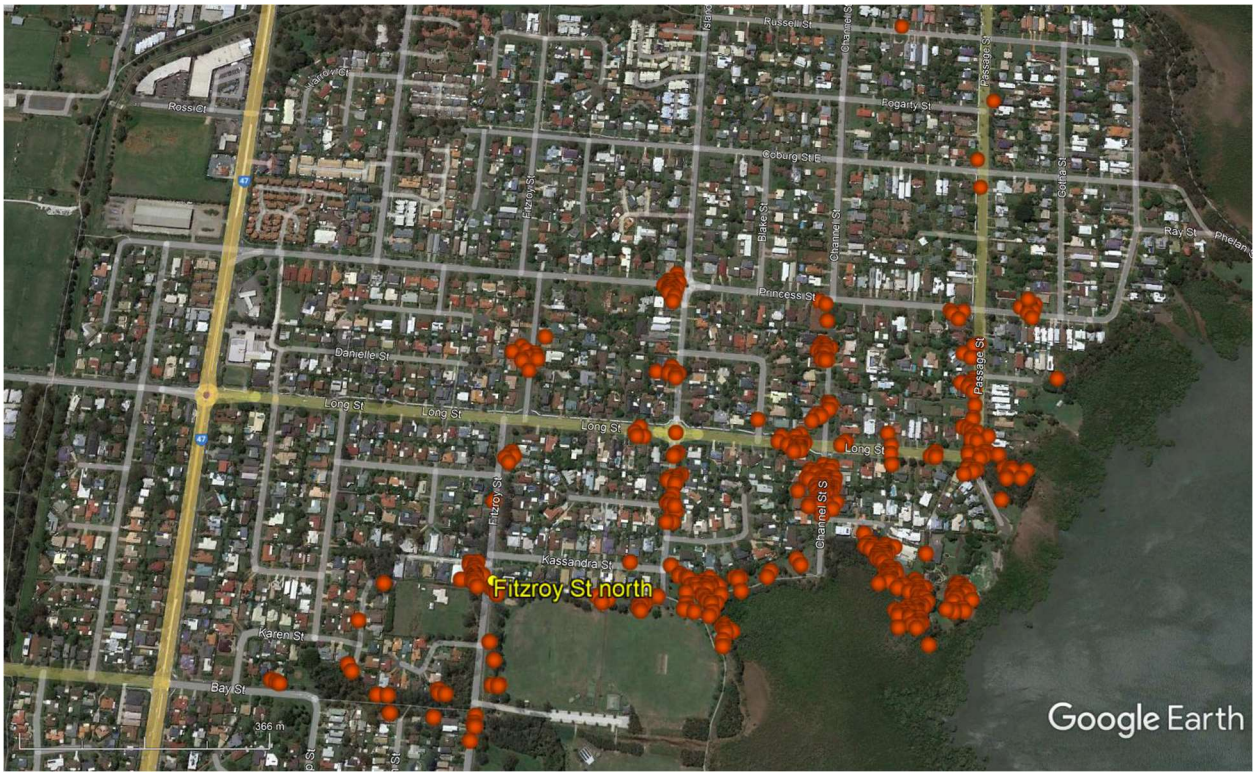

Figure 13. GPS locations for Blake (male koala) between September 2021 and March 2022. Several sets of points are on either side of Fitzroy Street, Long Street, and other roads in the area, suggesting that he crossed several roads multiple times. Data source: Caio Santos Neto and Dr Romane Cristescu, University of the Sunshine Coast. [Map created in Google Earth]

Figure 14. An example of possible crossings of Fitzroy Street by Blake the koala near the Fitzroy Street north sign. The red lines connect locations from 19 to 23 March 2022 (moving north), as indicated by GPS collar data. The GPS locations shown in the figure had errors of 30m or less. Data source: Caio Santos Neto and Dr Romane Cristescu, University of the Sunshine Coast. [Map created in Google Earth, using GPS Visualizer].

Benson was another male koala that lived near Fitzroy Street that likely crossed a nearby road multiple times. Benson's GPS collar data points from 20 April to 30 May 2022 (see Figure 15) were located on either side of Beach Street suggesting that he regularly crossed this road during this period. It should be noted that these location data were recorded following Benson's rehabilitation and release after he was thought to be struck by a vehicle in December 2021 (see section 3.4). Four possible road crossings over Beach Street by Benson is shown in Figure 16. Again, given most possible crossings involved multiple GPS locations on each side of the road and all GPS locations have an error of 30m or less, it is highly likely that these crossings actually occurred and were not a result of GPS error.

Three other GPS-collared koalas were located in the vicinity of current and future study sites (five new signs were installed on 23 March 2022), and possibly having crossed roads during 2021-2022 (see Appendix 3).

Figure 15. GPS locations for Benson (male koala) between 20 April and 30 May 2022 following rehabilitation and release after being thought to be struck by a vehicle in December 2021 (see section 3.4). Several sets of points are on either side of Beach Street, suggesting that he crossed this road multiple times. Data source: Caio Santos Neto and Dr Romane Cristescu, University of the Sunshine Coast. [Map created in Google Earth, using GPS Visualizer]

Figure 16. An example of possible crossings of Beach Street by Benson the koala, south of the Fitzroy Street south sign. The blue lines connect locations from 11 to 18 May 2022 (moving north), as indicated by GPS collar data. The GPS locations shown in the figure had errors of 30m or less. Data source: Caio Santos Neto and Dr Romane Cristescu, University of the Sunshine Coast. [Map created in Google Earth, using GPS Visualizer]

4. Discussion

As with previous years, the latest results from our ongoing sign experiment encouragingly indicate that drivers consistently continue to respond to dynamic signage by slowing down. In this sense, our conjecture would be that signs are acting to reinforce appropriate driver behaviour.

Although there were some differences between the two primary years of comparison (2020-2021 and 2021-2022) in relation to specific signs, overall, any differences between the two periods were generally marginal. This suggests that signs are performing consistently to lower drivers' speeds, albeit by modest levels. Importantly, the advent of any obvious signs of habituation were generally not observed. There were some cases of ambiguity in this regard, such as a period from about 16/09/2021 at Old Cleveland Road East west (see Figure 5) where V1 speeds crept above and consistently remained above the posted speed limit. However, there were other, earlier periods of a similar nature on this street, making it unclear whether these increased V1 speeds were related to driver habituation or some other phenomenon. For instance, a raft of roadworks was conducted in the nearby area (Pers. comm. Peter Hudson, Redland City Council Asset Engineer, May 2022) that may have played some role. The fact that few other signs showed any consistently similar patterns, and that, overall, average differences in speed across all sites remained essentially the same in both years of study, suggests a possible anomaly limited to this one area.

However, this may also represent an opportunity for further testing. We suggest re-covering the sign at Old Cleveland Road East west for a short period so that once again messaging to passing drivers is obscured. This would allow for an examination of any changes in speed in what might be considered a 'post-treatment' period (when the sign is re-covered) and then again when the sign is uncovered for a second treatment period at a later date (e.g. 8 weeks later). The primary point of interest here would be whether this process of re-covering and re-exposure produces any noticeable changes in vehicle speeds that helps to disambiguate driver responses and subsequent interpretation of habituation.

In contrast to the generally encouraging results indicating that most drivers are responding beneficially to signs, excessive speeding was recorded at all sites. Although proportionally speaking, the numbers of vehicles driving at excessive speeds are low, it is reasonable to

assume that if they were to encounter a koala on the road, a strike would be all but unavoidable. Combating such driving in suburban areas is not just a priority for protecting wildlife, as excessive speeding also represents a clear threat to people. Speed enforcement measures may be one avenue worth considering, as might education campaigns. Although we found no clearly discernible patterns in speeding behaviour, it appeared that speeding occurred more frequently in the late afternoon and early evening, peaking at around 8pm. There was a slightly higher tendency for occurrence on Fridays and/or Saturdays.

A similar pattern was observed on Old Cleveland Road East west, where the number of excessive speeders was regularly more than five per day, and peaked at 15 in one day. Enforcement is obviously not under the purview of the council, being a matter for the police, but, if it could be arranged, occasional randomised increased police presence on roads such as Sturgeon Street, Fitzroy Street and Old Cleveland Road East may serve as an adequate deterrent.

Movement pattern data for Blake shows a relatively high degree of passage across or near to roads throughout his local home range, including on Fitzroy Street where warning signs have been outfitted. This highlights the potentially important role that signs might play in reminding residents of koala presence. This reminder may be further amplified with the addition of passive signage that informs passers-by about specific koalas (e.g. Blake) residing in nearby trees. Further, in any case where a koala is struck on nearby roads, such signs could serve to highlight this, in line with recommendations from Lunney et al. (2022). Reinforcing public awareness of the presence and activity of koalas is reasonably likely to have beneficial impacts in relation to any mitigation measures employed by the council, as well as counteracting perceptions that koalas are not in the area and mitigation measures are therefore moot.

5. Recommendations

1. Expand the study to include more sites, which will continue to improve replication and representativeness. This includes the use of true control roads if at all possible (roads where, for example, vehicle speeds in relation to passive/generic wildlife signs are consistently measured over an entire study period), as a direct point of comparison.

2. Conduct a short study with signs/sign radars side-by-side at the same location to examine any differences in individual data collection performance and potentially allow for better calibration.

3. Continue to draw data from a variety of sources in an effort to explore any relationships between community engagement programs, koala movement and ecology, sign presence/absence and strike events.

4. Explore opportunities for additional technological enhancement of signs and driver safety alerts (e.g. phone applications), machine learning-based detections and koala-borne tracking technologies.

5. Consider adding passive signage in areas where specific koalas are known to reside that show an image or images of those koalas, including a name, and indicating that they are a resident koala in the area (e.g. in residential parks). This may help to further reinforce the idea that there are koalas in these areas even though people may not see them directly. These signs could serve as additional information points if any local koalas are struck on nearby roads, and should be made ‘editable’ (e.g. velcro or magnetic metal overlays of images and text) so that new koalas can be added as they are discovered in the area.

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Appendices

Appendix 1 – Technical and data issues

- All signs: the 2021-2022 treatment period end date was brought forward from 28/02/2022 to 24/02/2022 due to significant widespread anomalous dips in recorded speeds during periods of heavy rain prior to a major flooding event.
- The ITS/Artcraft sign datasets had multiple gaps of missing data for the 2021-2022 treatment period. Sign K001_01 at Starkey St south was missing data from the following times/dates: 5pm 17/07/2021 - 11am 18/07/2021, 1am - 7pm 23/07/2021, 1pm 24/07/2021 - 7am 25/07/2021, 9pm 27/01/2022 - 3pm 28/01/2022, 5am - 11pm 2/02/2022, 7pm 3/02/2022 - 11am 4/02/2022; and sign K001_02 at Starkey St north was missing data from the following times/dates: 17/04/2021 - 23/06/2021, 4am - 9am 27/06/2021, 5pm 17/07/2021 - 11am 18/07/2021, 1am - 6pm 23/07/2021, 1pm 24/07/2021 - 7am 25/07/2021, 10am - 11am 24/01/2022, 9pm 27/01/2022 - 3pm 28/01/2022, 5am - 11pm 2/02/2022, 6pm 3/02/2022 - 11am 4/02/2022, 6pm - 7pm 19/02/2022
- The 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 48% 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 2020-2021 pre-treatment period 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 2020-2021 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, 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 Sturgeon St east (sign 19543) treatment period is missing data from 20-21/09/2021 and 27/12/2021 - 16/01/2022; and the Wellington St north (sign 19541) treatment period is missing data from 20-21/09/2021, 25-31/10/2021, and 17-30/1/2022. The longer time periods suggest a technical issue with the signs rather than an absence of cars.
- The following date was removed from the Fitzroy Street north (Jenoptik sign 16718) 2021-2022 treatment period dataset due to an anomalous dip in recorded speeds caused by an unknown traffic disturbance (e.g. roadworks, accident, etc.): 11/11/2021 (averaging ~38km/hr)
- The following dates were removed from the Fitzroy Street south (Jenoptik sign 18935) 2021-2022 treatment period dataset due to anomalous dips in recorded speeds caused by unknown traffic disturbances: 30/11/2021 (averaging ~33km/hr), 27-28/12/2021 (averaging ~35km/hr), 20/1/2022 (averaging ~34km/hr), 3/2/2022 (averaging ~33km/hr)
- The following date was removed from the Sturgeon St west (Jenoptik sign 16720) 2021-2022 treatment period dataset due to anomalous dips in recorded speeds caused by unknown traffic disturbances: 16/8/2021 (averaging ~44km/hr)
- The following dates were removed from the Old Cleveland Rd East west (Jenoptik sign 14361) 2021-2022 treatment period dataset due to anomalous dips in recorded speeds possibly caused by an ongoing issue with the culvert near the entry to Judy Holt Park (as advised by Council): 27/6/2021 (averaging ~52km/hr), 28/7/2021 (averaging ~54km/hr), 5-6/8/2021 (averaging ~54km/hr), 11-12/8/2021 (averaging ~53km/hr), 16-19/8/2021 (averaging ~54km/hr), 30/8-2/9/2021 (averaging ~51 - 54km/hr), 7-9/9/2021 (averaging ~51 - ~54km/hr), 18/12/2021 – 9/1/2022 (averaging ~51km/hr)
- The following dates were removed from the Wellington St south (Jenoptik sign 19540) 2021-2022 treatment period dataset due to anomalous dips in recorded speeds caused by unknown traffic disturbances: 8/11/2021 (averaging ~41km/hr), 11/11/2021 (averaging ~40km/hr)
- The following dates were removed from the Wellington St north (Jenoptik sign 19541) 2021-2022 treatment period dataset due to anomalous dips in recorded speeds caused by unknown traffic disturbances: 30/11/2021 (averaging ~42km/hr), 27/12/2021 – 24/2/2022 (averaging ~33km/hr)

Appendix 2 – Data loss summary

Appendix Table 1. The number of cars recorded by each sign in the raw 2021-2022 treatment period datasets; the total number of recordings removed; the number of recordings removed due to Jenoptik signs failing to record a V2; 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 ID	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
Jenoptik smiley 14361	5515276	3136573	2803373	333200	2378703	57
Jenoptik smiley 14370	4333775	1566988	1566988	0	2766787	36
Jenoptik koala smiley 16718	1725781	1064324	1061660	2664	661457	62
Jenoptik koala smiley 16720	4946675	2427413	2421399	6014	2519262	49
Jenoptik koala smiley 18935	1462209	783036	762581	20455	679173	54
Jenoptik koala smiley 19540	1201755	601585	596409	5176	600170	50
Jenoptik koala smiley 19541	3451874	1995949	1693596	302353	1455925	58
Jenoptik koala smiley 19543	4287599	1930533	1930533	0	2357066	45
ITS koala K001_01	14559	0			14449	0
ITS koala K001_02	5405	0			5405	0
Total	26944908	13506401	12836539	669862	13438507	50

Appendix 3 – Koala movement data around current and future study sites

Appendix Figures 1-3 show koala movement have been recorded in areas nearby current and future study sites, including some road crossings.

Appendix Figure 1. GPS locations for Grace in parkland and residential areas to the east of Fitzroy Street in Thornlands. Data source: Caio Santos Neto and Dr Romane Cristescu, University of the Sunshine Coast. [Map created in Google Earth]

Appendix Figure 2. GPS locations for Axle in parklands and residential areas either side of Collingwood Road and Pitt Road, and just north of Nelson Road. New Jenoptik 'koala smiley' signs were recently installed on Collingwood Road and Nelson Road on 23 May 2022 for inclusion in next year's study. Data source: Caio Santos Neto and Dr Romane Cristescu, University of the Sunshine Coast. [Map created in Google Earth]

Appendix Figure 3. GPS locations for Blinky in South Street Conservation Area just north of South Street in Cleveland. New Jenoptik 'koala smiley' signs were recently installed along a section of South Street to the east of this area on 23 May 2022 for inclusion in next year's study. Data source: Caio Santos Neto and Dr Romane Cristescu, University of the Sunshine Coast. [Map created in Google Earth]