# Redland Smart Signs and Smart Messages:

# A Driver Behaviour Change Project – Year 3

# Final Report (2020-2021)


Report prepared for Redland City Council

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# Executive summary

As koala populations throughout South East Queensland continue to decline, radical measures are required to reduce artificial sources of mortality and ensure long-term preservation of the species. In 2018, the Redland City Council initiated a series of innovative programs designed to provide a clearer and more accurate understanding of koala decline and associated population metrics. These programs include community education and information initiatives, and the installation of wildlife warning signage designed to encourage safer driving and reduce the prevalence of koala-vehicle collisions (or 'strikes'). Results from the initial set of sign trials were encouraging, and the study was extended over two additional years. In the current year, two additional roads were outfitted with signage, bringing the total number of roads for the study to five (and the number of signs to ten: one in each direction of vehicle travel). As with previous years, results were again encouraging. During the treatment period, nine out of ten signs recorded V2 speeds (the speed recorded as drivers drive past a sign) that were lower than V2 speeds recorded during the pre-treatment period, when signs were covered. In addition, all treatment period V2 speeds were below posted speed limits. Importantly, we found no evidence for driver habituation to signage during the treatment period, or when comparing results with a previous year. Together, these results suggest that most drivers are responding positively to dynamic wildlife signage by reducing speed. Given that koala movement and population survey data from a separate research project identified the presence of koalas near study roads (and, in one case, apparent regular crossing of a study road by a tagged koala), these reductions in average speed may be critical to ensuring koala collisions are minimised. Future research should continue to investigate driver habituation; increase replication; consolidate beneficial sign features; amalgamate independent data sources (e.g. koala ecology and population data); survey treatment roads for koala presence; and explore additional technology such as mobile phone applications, in order to enhance driver awareness and safety throughout the koala safe neighborhoods.

# Acknowledgements

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# 1. Introduction

With koala populations in South East Queensland having experienced steep decline in the last two decades (Rhodes et al. 2015), there is an urgent need for interventions to ensure the short- and long-term conservation of koalas in the region. A major, recognised source of artificial mortality for koalas is vehicle strike (Gonzalez-Astudillo et al. 2017; McAlpine et al. 2015; Niehaus and Wilson, 2018; Tisdell et al. 2017), although not in all urban locations in Australia, even when koalas regularly crossroads (Whisson et al. 2020). Methods to mitigate strikes such as infrastructure allowing koalas to bypass roads (e.g. fauna passages) or that blocks access to roads (e.g. fencing), whilst largely successful (Dexter et al. 2016; McGregor et al. 2015, 2017), are also cost-prohibitive and are often constrained by geographic and jurisdictional factors that limit their wider applicability.

An additional (or, more often, alternative) approach is the use of wildlife signage. Despite their apparent ubiquity on roads, the merits of wildlife signage in reducing collisions have been little explored. What explorations have been made suggest either poor or mixed results in this respect (Glista et al. 2009; Huijser et al. 2015) and, for koalas in particular, previous research has suggested signs are of little value (Dique et al. 2003).

However, new technology may offer opportunities to improve the effectiveness of signage, by providing a more dynamic and interactive approach in communicating with drivers. For example, enhanced features such as digital displays mean messaging can be tailored to specific local conditions, or cycle/flash messaging to improve situational awareness. Radar-equipped signage provides real-time feedback to drivers about their speed, and dynamic messaging can serve to deter drivers from excessive speeds or reinforce those driving at appropriate speeds. In broad, driver-safety terms, such technology has proven to be cost-effective in reducing traffic collisions (Wu et al. 2020), so applying it to wildlife conservation applications has promise (Bond and Jones 2013).

Speed reduction is one obvious potential benefit of effective signage, but signs may serve as a reminder of local wildlife presence and therefore result in increased driver vigilance. A compelling recent study found that even basic warning signs reduced collisions involving dummy snakes that were placed on a section of road beyond a sign, especially when the dummy snake was placed 100m beyond a sign compared to 1km beyond (Collinson et al.

2019). In this application, signs appeared to dramatically increase collision avoidance behaviours in drivers (such as slowing down, stopping or swerving) from 37% in the absence of signs to 61% with signs present. Importantly, for those whose behaviour changed, this resulted in 98% collision avoidance. Another interesting result related to driver 'occupation' (either a staff member of a nearby national park or a visitor to the park), such that visitors had a higher probability of a collision compared to staff even when both occupation classes were speeding, suggesting that speed alone is not the only important factor in reducing strike events. Here, the authors suggested that staff familiarity with the area and greater concentration on the road may have played a role. Importantly though, speeding also increased staff chances of a collision and inappropriate speeds are acknowledged as a major factor in wildlife strikes (e.g. Shima et al. 2018). Overall, the implications of such a study are that higher levels of driver vigilance/alertness coupled with a reduction in speed can work hand-in-hand to reduce the prospect of collisions.

A major concern regarding any potential benefits of signage is that over time, drivers may come to largely ignore signs (Huijser et al. 2015), a psychological process known as habituation. A key element of habituation is that signs could be ignored if drivers do not believe they are relevant and informative (Huijser et al. 2015), suggesting a need for approaches that bolster continuing relevance. One example is public education programs that inform drivers about the purpose of the signs (in this case, to remind drivers to slow down and be on the lookout for koalas that may be attempting to crossroads), and about the plight of local koalas more generally. Additional approaches include school awareness programs, advertising, and community engagement. Such approaches consistently inform and remind the public about local koalas, which, amongst other potential benefits, should help to maintain the relevance of any warning signs encountered by drivers.

In this spirit of such complementary approaches, the Redland City Council (RCC) has been investigating a raft of methods to better understand, and potentially mitigate, threats to koalas. These approaches include generating baseline population and genetic information; tracking koala movements; community engagement and education programs; and experimental investigations of wildlife warning road signage. In contrast to the more typical approach of individual research/conservation programs with a narrower or more singular focus, the hope is that operating and coordinating all these programs in unison will enhance the overall success of koala conservation in the Redlands.

Blacker et al. (2019) and Appleby et al. (2020) reported on the largely positive outcomes of experimental trials of dynamic signage in the Redlands in previous years, and here we provide an update for the latest round of experimental trials. Along with presenting general results from these particular trials, we examine habituation more closely, as well as incorporating some site-specific koala movement data, in order to provide a comprehensive overview of the successes and limitations of the current signage program.

# 2. Methodology

## 2.1 Study sites

This year five streets were selected for sign placement in Redland City. On each street, two locations (each corresponding to one travel direction) were chosen and signs were installed.

Three streets within Redland's Ormiston koala conservation safe neighbourhood were again chosen and have now been studied for three consecutive years. Starkey Street and Wellington Street would be classed as largely residential, while Sturgeon Street is a local link road in the area.

Two additional streets were selected for inclusion in the study this year. These were Old Cleveland Road East, Birkdale/Wellington Point and Fitzroy Street, Cleveland. Old Cleveland Road East is a minor arterial road, linking Birkdale to Wellington Point and Ormiston, while Fitzroy Street is predominantly residential with recreational hockey fields located between the signs. These additions were associated with the establishment of two new 'Koala Safe Neighbourhoods' (KSN) in the areas: Old Cleveland Road East - Birkdale KSN and Fitzroy Street - Thornlands KSN.

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 |

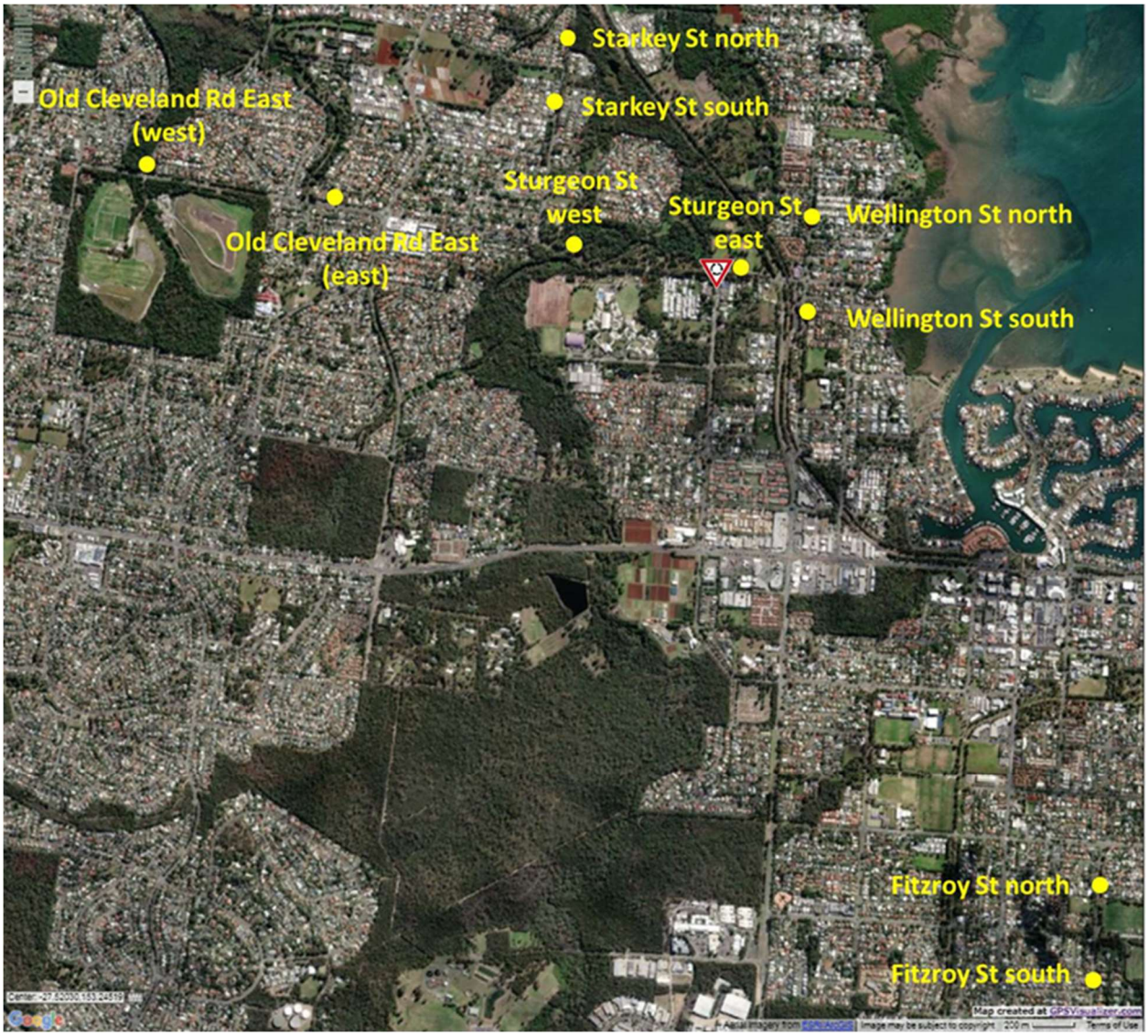


**Figure 1.** A map showing the locations of signs on three streets in Ormiston (Starkey Street, Sturgeon Street and Wellington Street), Old Cleveland Road East in Wellington Point/Birkdale and Fitzroy Street in Cleveland. symbols indicate the positions of roundabouts, although a roundabout just south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

Signs were installed on the left-side verge at all sites. Selection of locations was dependent upon several factors, including signs required to be:

- clear of obstructions, so as to present drivers with a clear view of the signs and the radar with a clear view of the oncoming traffic;
- clear of interference from power lines and other utility services in the verge;

- an appropriate distance from traffic lights, roundabouts, school zones, bus stops, and other traffic signage, where possible; and
- in sufficient sunlight throughout the day to charge the batteries enough for the sign to operate uninterrupted 24 hours a day.

It should be noted that some signs were in close proximity to roundabouts and/or school zones that may have affected vehicle speeds approaching the signs. Sturgeon Street east was near two roundabouts, which was unavoidable, with four roundabouts within approximately 870 m. The signs at this site were positioned closer to the roundabout that vehicles were approaching than the roundabout that vehicles were exiting. Additionally there was a school zone along Sturgeon Street, in between the two signs. The school zone did not directly affect the posted speed limit at the sign locations, only for a section in between them. Wellington Road south was in close proximity to a school zone and a train station car park. Old Cleveland Road East west was opposite the Birkdale Recycling and Waste Centre, and therefore may have encountered numerous vehicles slowing to turn into the facility, particularly on weekends. Any sign that was close to a side road may have encountered numerous vehicles slowing down to turn into the adjoining street. Finally, along most road sections monitored by the signs, vehicles could pull into or out of driveways, roadside parking spaces and side streets (with the exception of Sturgeon Street west, and sites along Old Cleveland Road East).

## 2.2 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 appears to have occurred in the Ormiston neighbourhood more generally, on Hilliard Street, in between the data collection periods of years 1 and 2, on or around 23 August 2019 (RCC unpublished data). There was one other koala strike along Old Cleveland Road East on 7 March 2020, prior to the signs being installed along this road and being included in the current study.

## 2.3 Wildlife warning signs

Three types of signs were trialed, from two different manufacturers/suppliers. Two were dynamic message signs (Jenoptik) 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.** Jenoptik brand models of dynamic (variable) message signage, named for this project as ‘smiley’ (left) and ‘koala smiley’ (right).

The third sign type (ITS/Artcraft) featured two LED flasher lights that flashed on and off whenever a vehicle was detected exceeding a specifiable speed threshold. The posted speed limit was also 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 incorporated into the present study phase.

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. 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 which 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. Technical issues delayed some signs becoming operational for up to a month. Signs were covered during the pre-treatment period and then uncovered during the treatment period. Most sign covers were permanently removed on 15th December 2020, with the exception of Old Cleveland Road East east where the cover appeared to have been unintentionally removed around 5th November and was not replaced. The Sturgeon Street west cover was unintentionally removed on 31st October and replaced on 3rd November, and the Wellington Street south cover was unintentionally removed on 12th October and replaced on 14th October (these periods were removed from the datasets prior to analyses). The sign covers at Fitzroy Street were removed at the end of November, as these signs had been consistently functional for almost 2 months. 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). 'Wildlife Zone' painted thresholds and associated signs were installed along Old Cleveland Road East and Fitzroy Street in December to match the Ormiston sites where this occurred in Year 1 of the study (Table 2). It should be noted that the installation of the painted thresholds had no discernable 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 purposes and dates of 'Wildlife Zone' painted thresholds.

| Site | Sign | Date signs active and covered | Date covers permanently removed | Painted thresholds installed | Date data collection stopped |
|---|---|---|---|---|---|
| Sturgeon Street west | Koala smiley 16720 | 13/10/2020 | 15/12/2020 | Installed in year 1 | 16/04/2021 |
| Sturgeon Street east | Koala smiley 19543 | 13/10/2020 | 15/12/2020 | Installed in year 1 | 16/04/2021 |

| | | | | | |
|---|---|---|---|---|---|
| Wellington Street north | Koala smiley 19541 | 7/10/2020 | 15/12/2020 | Installed in year 1 | 16/04/2021 |
| Wellington Street south | Koala smiley 19540 | 2/10/2020 | 15/12/2020 | Installed in year 1 | 16/04/2021 |
| Starkey Street south | ITS K001-01 | 30/10/2020 | 15/12/2020 | Installed in year 1 | 21/01/2021* |
| Starkey Street north | ITS K001-02 | 30/10/2020 | 15/12/2020 | Installed in year 1 | 21/01/2021* |
| Old Cleveland Road East east | Smiley 14370 | 13/10/2020 | 5/11/2020 | 15/01/2021 | 16/04/2021 |
| Old Cleveland Road East west | Smiley 14361 | 2/10/2020 | 15/12/2020 | 15/01/2021 | 16/04/2021 |
| Fitzroy Street north | Koala smiley 16718 | 1/10/2020 | 27/11/2020 | 21/12/2020 | 16/04/2021 |
| Fitzroy Street south | Koala smiley 18935 | 1/10/2020 | 28/11/2020 | 21/12/2020 | 16/04/2021 |

*The ITS signs malfunctioned on 21/01/21 and failed to record data beyond this date. See Appendix 1 for details.

**Table 3.** The length of the pre-treatment and treatment periods for each sign and site. Note that the treatment period includes the both before and after the 'Wildlife Zone' painted thresholds were installed along Old Cleveland Road East and Fitzroy Street.

| **Site** | **Sign** | **Pre-treatment period (days)*** | **Treatment period (days)** |
|---|---|---|---|
| Sturgeon Street west | Koala smiley 16720 | 56 | 111 |
| Sturgeon Street east | Koala smiley 19543 | 56 | 122 |
| Wellington Street north | Koala smiley 19541 | 66 | 30 |

| | | | |
|---|---|---|---|
| Wellington Street south | Koala smiley 19540 | 70 | 118 |
| Starkey Street south | ITS K001-01 | 44 | 36 |
| Starkey Street north | ITS K001-02 | 44 | 36 |
| Old Cleveland Road East east | Smiley 14370 | 22 | 140 |
| Old Cleveland Road East west | Smiley 14361 | 73 | 122 |
| Fitzroy Street north | Koala smiley 16718 | 54 | 139 |
| Fitzroy Street south | Koala smiley 18935 | 57 | 126 |

*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. A possible exception was the ITS/Artcraft signs, for which just over a month of treatment data were collected, which reduces confidence in any examination of habituation. There were other 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 exported from the Sierzega GRS 5.2 software program as .txt files then compiled by sign and treatment period in Excel. For the ITS signs, raw data in the form of .dat files were 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 addition and 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 2: Technical and data issues). Dates on which signs were installed, and on which covers were taken off (and replaced after coming off unintentionally), were removed from the dataset in case of any effects of road crew presence on driver behaviour.

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.

## 2.8 Data analyses

As with the previous report (Appleby et al. 2020) 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.

Additionally, as signs utilised in this experiment were from 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. Excel was used to produce summary statistical analyses for these signs, including average vehicle speeds and 85$^{th}$ percentile vehicle speeds (the speed at or below which 85% of all cars were recorded) for both the pre-treatment and treatment periods. From these, changes in average and 85th percentile speeds between the pre-treatment and 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, 85$^{th}$ 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 Pre-treatment data

An overview of average and 85th percentile speeds for all signs during the pre-treatment period are presented in Table 4. Whilst all average V2 speeds were under posted speed limits, V1 and 85th percentile speeds were generally less encouraging (with a few exceptions). Fitzroy Street north recorded the highest V2 level above a posted speed limit.

**Table 4.** Pre-treatment overall average and 85th percentile speeds for every sign at street location, along with corresponding posted speed limits.

| Site | Posted speed limit (km/hr) | Average speed (km/hr) (average V1 speed for Jenoptiks) | Average speed (km/hr) (average V2 speed for Jenoptiks) | 85th percentile speed (km/hr) (V1 speed for Jenoptiks) | 85th percentile speed (km/hr) (V2 speed for Jenoptiks) |
|---|---|---|---|---|---|
| Fitzroy St north | 50 | 51.10 | 48.75 | 60 | 58 |
| Fitzroy St south | 50 | 44.32 | 42.88 | 53 | 52 |
| Old Cleveland Rd East east | 60 | 57.92 | 54.52 | 64 | 61 |
| Old Cleveland Rd East west | 60 | 61.83 | 59.03 | 69 | 66 |
| Sturgeon St east | 60 | 52.44 | 48.92 | 59 | 56 |
| Sturgeon St west | 60 | 57.42 | 54.97 | 64 | 61 |
| Starkey St south K001_01 | 60 | 34.40 | NA | 54.9 | NA |
| Starkey St north K001_02 | 60 | 52.80 | NA | 59.2 | NA |
| Wellington St north | 50 | 50.30 | 47.28 | 58 | 55 |
| Wellington St south | 50 | 50.13 | 47.55 | 58 | 56 |

Table 5 shows more detailed data summaries for all ten study sites during the pre-treatment period, including mean daily minimum speeds, maximum daily minimum speeds, and the number of vehicles recorded and used in the dataset. Average vehicle speeds at all sites were below the posted speed limit of the roads, as were most of the mean daily maximum speeds and three 85th percentile speeds (Sturgeon Street east and both Starkey Street sites). The two exceptions where the mean daily maximum speeds were over the speed limit, these were only slightly over the speed limit.

**Table 5.** Overall mean speeds, standard deviation, average minimum speeds, average maximum speeds, 85th percentiles speeds and vehicle count numbers for all signs in the pre-treatment period. Results in black (bold) are vehicle numbers that are unexpectedly low for a given site.

| **Site** | **Speed limit** (km/hr) | **Sign type/ID** | **Average speed (km/hr)** (average V2 speed for Jenoptiks) | **Standard deviation** | **Minimum daily average speed (km/hr)** | **Maximum daily average speed (km/hr)** | **85th percentile speed (km/hr)** (85th percentile V2 speed for Jenoptiks) | **Sample size** (number of cars) |
|---|---|---|---|---|---|---|---|---|
| Fitzroy St north | 50 | Koala smiley/ 16718 | 48.75 | 10.20 | 47.07 | 49.70 | 58 | 120,102 |
| Fitzroy St south | 50 | Koala smiley/ 18935 | 42.88 | 10.48 | 41.28 | 43.84 | 52 | 143,383 |
| Old Cleveland Rd East east | 60 | Smiley/ 14370 | 54.52 | 7.29 | 54.11 | 54.94 | 61 | 188,916 |
| Old Cleveland Rd East west | 60 | Smiley/ 14361 | 59.03 | 8.40 | 56.56 | 60.33 | 66 | 657,443 |
| Sturgeon St east | 60 | Koala smiley/ 19543 | 48.92 | 7.41 | 47.00 | 51.22 | 56 | 431,020 |
| Sturgeon St west | 60 | Koala smiley/ 16720 | 54.97 | 7.78 | 53.06 | 56.79 | 61 | 489,015 |
| Starkey St south | 60 | ITS/K001_01 | 34.40 | N/A | N/A | N/A | 54.9 | **563** |
| Starkey St north | 60 | ITS/K001_02 | 52.80 | N/A | N/A | N/A | 59.2 | **3,085** |
| Wellington St north | 50 | Koala smiley/ 19541 | 47.28 | 9.23 | 45.78 | 48.25 | 55 | 399,374 |
| Wellington St south | 50 | Koala smiley/ 19540 | 47.55 | 9.14 | 45.67 | 50.06 | 56 | 160,419 |

## 3.2 Comparison of pre-treatment and treatment data

Table 6 provides a side-by-side comparison of pre-treatment and treatment period speed data for all signs including speed changes between the two periods. In all but one case each, average and 85th percentile speeds were lower in the treatment period, albeit some differences were modest.

**Table 6.** Summary of car speed data for ten signs (two Jenoptik 'smileys' in green, six Jenoptik 'koala_smileys' in yellow, and two ITS koala signs in blue) across the pre-treatment period (when signs were covered) and the treatment period (when signs had no cover). The 85th percentile speed represents the speed at or below which 85% of all cars were recorded.

| Site | Speed limit (km/hr) | Sign type/ID | Pre-treatment period (sign covered) | | | | | | Treatment period (sign uncovered) | | | | | | Speed changes from Pre-treatment to Treatment period | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Average speed (km/hr) (average V2 speed for Jenoptiks) | Standard deviation | Minimum daily average speed (km/hr) | Maximum daily average speed (km/hr) | 85th percentile speed (km/hr) (85th percentile V2 speed for Jenoptiks) | Sample size (number of cars) | Average speed (km/hr) (average V2 speed for Jenoptiks) | Standard deviation | Minimum daily average speed (km/hr) | Maximum daily average speed (km/hr) | 85th percentile speed (km/hr) (85th percentile V2 speed for Jenoptiks) | 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 (%) |
| Fitzroy St north | 50 | Koala smiley/ 16718 | 48.75 | 10.20 | 47.07 | 49.70 | 58 | 120,102 | 46.11 | 9.65 | 42.37 | 48.27 | 55 | 302199 | -2.64 | -5.42 | -3 | -5.17 |
| Fitzroy St south | 50 | Koala smiley/ 18935 | 42.88 | 10.48 | 41.28 | 43.84 | 52 | 143,383 | 40.78 | 10.11 | 37.55 | 42.55 | 49 | 291570 | -2.10 | -4.90 | -3 | -5.77 |
| Old Cleveland Rd East east | 60 | Smiley/ 14370 | 54.52 | 7.29 | 54.11 | 54.94 | 61 | 188,916 | 52.81 | 7.16 | 51.86 | 53.48 | 59 | 1244765 | -1.71 | -3.14 | -2 | -3.28 |
| Old Cleveland Rd East west | 60 | Smiley/ 14361 | 59.03 | 8.40 | 56.56 | 60.33 | 66 | 657,443 | 58.35 | 8.34 | 54.95 | 58.81 | 65 | 1049831 | -0.68 | -1.15 | -1 | -1.52 |
| Sturgeon St east | 60 | Koala smiley/ 19543 | 48.92 | 7.41 | 47.00 | 51.22 | 56 | 431,020 | 48.89 | 7.61 | 44.73 | 51.16 | 56 | 940360 | -0.03 | -0.05 | 0 | 0.00 |
| Sturgeon St west | 60 | Koala smiley/ 16720 | 54.97 | 7.78 | 53.06 | 56.79 | 61 | 489,015 | 53.51 | 7.38 | 50.43 | 55.51 | 60 | 917146 | -1.46 | -2.65 | -1 | -1.64 |
| Starkey St south | 60 | ITS/K001_01 | 34.40 | N/A | N/A | N/A | 54.9 | 563 | 36.70 | N/A | N/A | N/A | 54.70 | 292 | 2.30 | 6.69 | -0.20 | -0.36 |
| Starkey St north | 60 | ITS/K001_02 | 52.80 | N/A | N/A | N/A | 59.2 | 3,085 | 51.70 | N/A | N/A | N/A | 59.10 | 1569 | -1.10 | -2.08 | -0.10 | -0.17 |
| Wellington St north | 50 | Koala smiley/ 19541 | 47.28 | 9.23 | 45.78 | 48.25 | 55 | 399,374 | 45.79 | 9.07 | 45.00 | 46.61 | 54 | 162923 | -1.49 | -3.15 | -1 | -1.82 |
| Wellington St south | 50 | Koala smiley/ 19540 | 47.55 | 9.14 | 45.67 | 50.06 | 56 | 160,419 | 45.18 | 9.29 | 42.01 | 48.42 | 54 | 245991 | -2.37 | -4.98 | -2 | -3.57 |

Table 7 provides an overview of the fastest speeds recorded by each sign. In all cases, the maximum recorded speeds are more than double, and in one case, more than triple, the posted speed limit. The proportion of excessive speeders is relatively small. Highest recorded speeds for ITS/Artcraft signs are considerably lower than for any other sign, and, as with the average speeds outputted from these signs, should be treated with caution.

| Site | Speed limit (km/hr) | Sign type/ID | Pre-treatment period | | | | | | Treatment period | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Highest speed (km/hr) (V1 speed for Jenoptiks) | No. of V1 speeds more than double the speed limit | % of V1 speeds more than double the speed limit | Highest V2 speed for Jenoptiks (km/hr) | No. of V2 speeds more than double the speed limit | % of V2 speeds more than double the speed imit | Highest speed (km/hr) (V1 speed for Jenoptiks) | No. of V1 speeds more than double the speed limit | % of V1 speeds more than double the speed imit | Highest V2 speed for Jenoptiks (km/hr) | No. of V2 speeds more than double the speed limit | % of V2 speeds more than double the speed imit |
| Fitzroy St north | 50 | Koala smiley/ 16718 | 127 | 50 | 0.0400 | 125 | 31 | 0.0257 | 153 | 91 | 0.0298 | 151 | 67 | 0.0220 |
| Fitzroy St south | 50 | Koala smiley/ 18935 | 110 | 1 | 0.0007 | 102 | 1 | 0.0007 | 113 | 5 | 0.0015 | 106 | 2 | 0.0006 |
| Old Cleveland Rd East east | 60 | Smiley/ 14370 | 169 | 23 | 0.0060 | 127 | 3 | 0.0008 | 169 | 69 | 0.0053 | 160 | 14 | 0.0011 |
| Old Cleveland Rd East west | 60 | Smiley/ 14361 | 163 | 62 | 0.0094 | 151 | 29 | 0.0044 | 157 | 41 | 0.0041 | 160 | 20 | 0.0020 |
| Sturgeon St east | 60 | Koala smiley/ 19543 | 133 | 1 | 0.0002 | 109 | 0 | 0.0000 | 114 | 0 | 0.0000 | 130 | 1 | 0.0001 |
| Sturgeon St west | 60 | Koala smiley/ 16720 | 127 | 2 | 0.0004 | 154 | 3 | 0.0006 | 133 | 3 | 0.0003 | 122 | 1 | 0.0001 |
| Starkey St south | 60 | ITS/K001_01 | 80 | NA | NA | NA | NA | NA | 70 | NA | NA | NA | NA | NA |
| Starkey St north | 60 | ITS/K001_02 | 90 | NA | NA | NA | NA | NA | 80 | NA | NA | NA | NA | NA |
| Wellington St north | 50 | Koala smiley/ 19541 | 156 | 30 | 0.0074 | 136 | 17 | 0.0042 | 132 | 21 | 0.0043 | 120 | 5 | 0.0010 |
| Wellington St south | 50 | Koala smiley/ 19540 | 144 | 17 | 0.0106 | 143 | 17 | 0.0106 | 140 | 14 | 0.0055 | 140 | 15 | 0.0059 |

**Table 7.** Summary of the highest speeds (both V1 and V2 speeds for the Jenoptik signs) recorded by each sign at each site, and the number and proportion of speeds recorded that were more than double the posted speed limit, during both the pre-treatment and treatment periods. For the Jenoptik signs these data are taken from the raw datasets from each sign after any lines containing blank V2 speeds were removed, and prior to the removal of any dates due to anomalous average speeds. For the ITS signs these data are taken from the summary data calculated and provided by the ITS software. Jenoptik koala smiley signs are in yellow, Jenoptik smiley signs are in green, and ITS signs are in blue.

Figures 5 through to 12 present a visual representation of V1 (blue line) and V2 (orange line) speeds throughout the pre-treatment (sign covered) and treatment periods for all signs. Whilst all V2 averages were lower in treatment periods compared to pre-treatment periods, it is worth noting that this was also the case with V1 speeds (with the possible exception of the beginning of the treatment periods for Sturgeon Street signs, Figures 9 and 10) , which was more unexpected. Certain 'ripples' in data are likely to represent possible anomalies, such as accidents or traffic jams. In one case (Figure 11a Wellington Street north) an extended anomalous period was recorded for V2 speeds in the treatment period, possibly due to road works. As this may not represent a source of confounding, Figure 11b presents results for Wellington Street north with this period removed. During the pre-treatment period for the sign at Old Cleveland Road East west (Figure 8), there is a clear trend of increasing speeds for both V1 and V2 recordings, which disappears in the treatment period.

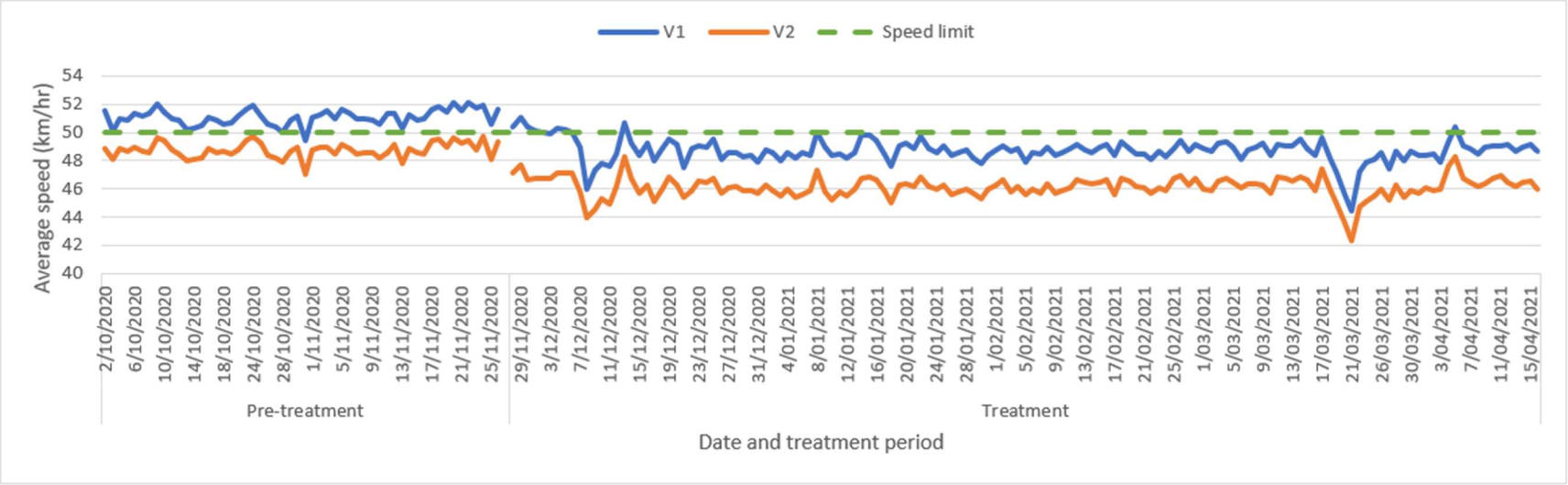


**Figure 5.** Fitzroy Street north average daily vehicle speeds during the pre-treatment period when Jenoptik 'koala smiley' sign 16718 was present but covered, and during the treatment period when the sign was uncovered. Note the pre-treatment plot shows two separate lines for V1 and V2 speeds, likely due to vehicles slowing in response to pre-existing road infrastructure or conditions. The

treatment plot shows a drop in both V1 and V2 speeds after the sign was uncovered, indicating that drivers had already seen the sign by the time they reached the V1 radar recording point and so had already begun to slow down in response. Changes in vehicle speeds between the pre-treatment and treatment periods were therefore calculated using the V2 speeds from each period.

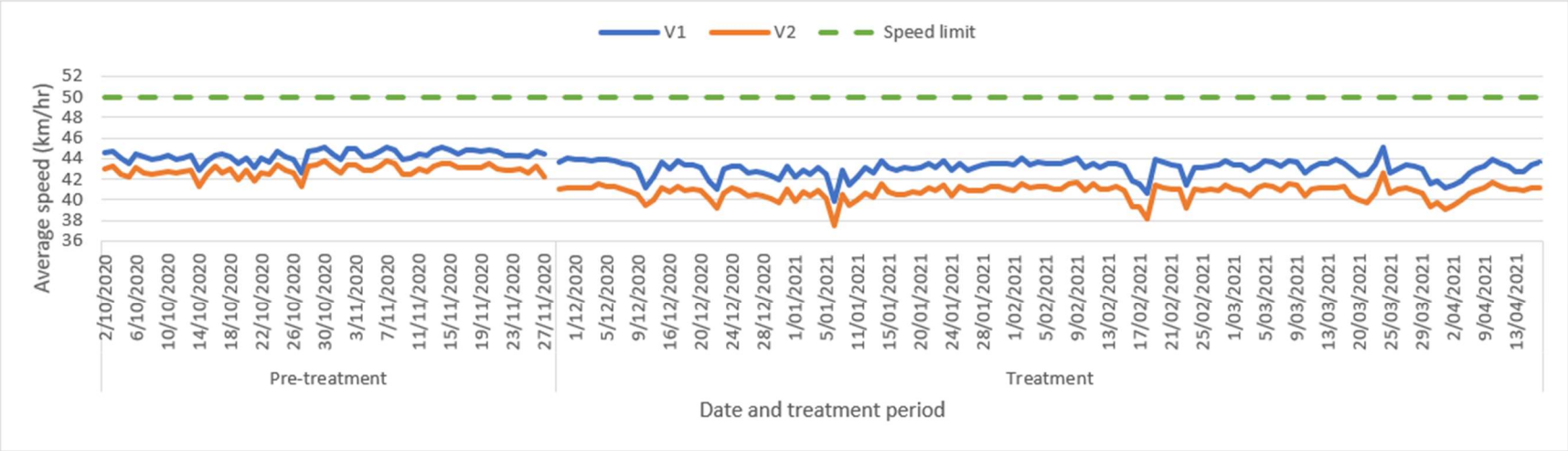


**Figure 6.** Fitzroy Street south average daily vehicle speeds during the pre-treatment period when Jenoptik 'koala smiley' sign 18935 was present but covered, and during the treatment period when the sign was uncovered. Note the pre-treatment plot shows two separate lines for V1 and V2 speeds, likely due to vehicles slowing in response to pre-existing road infrastructure or conditions. The treatment plot shows a drop in both V1 and V2 speeds after the sign was uncovered, indicating that drivers had already seen the sign by the time they reached the V1 radar recording point and so had already begun to slow down in response.

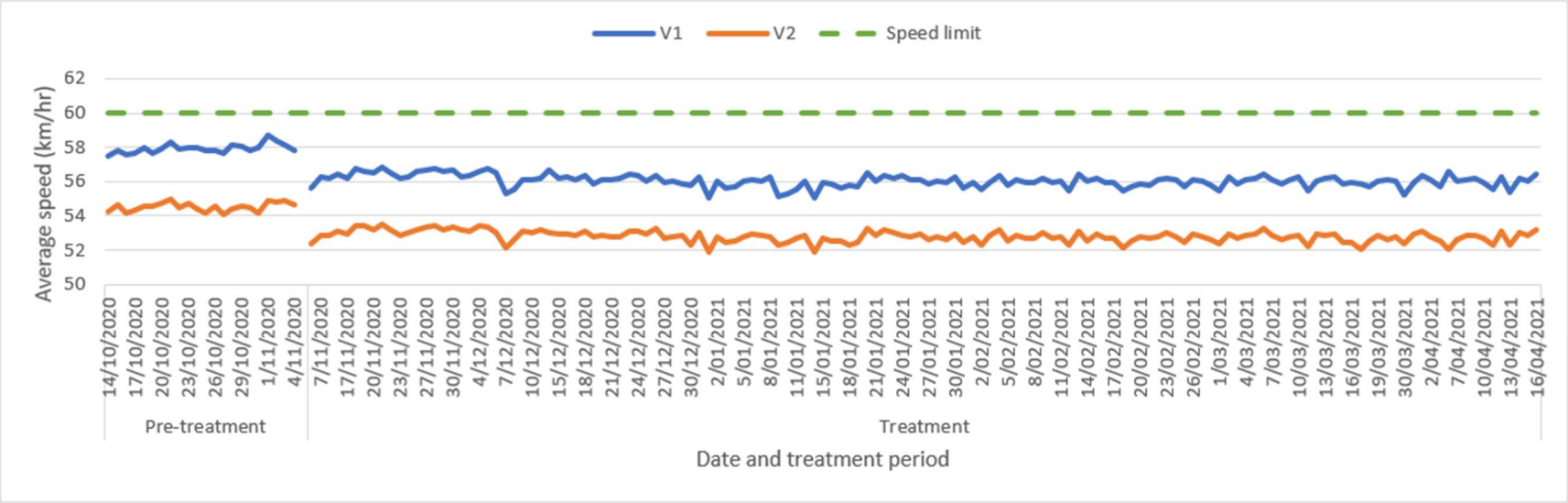


**Figure 7.** Old Cleveland Road East east average daily vehicle speeds during the pre-treatment period when Jenoptik 'smiley' sign 14370 was present but covered, and during the treatment period when the sign was uncovered. Note the pre-treatment plot shows two separate lines for V1 and V2 speeds, likely due to vehicles slowing in response to pre-existing road infrastructure or conditions. The treatment plot shows a drop in both V1 and V2 speeds after the sign was uncovered, indicating that drivers had already seen the sign by the time they reached the V1 radar recording point and so had already begun to slow down in response.

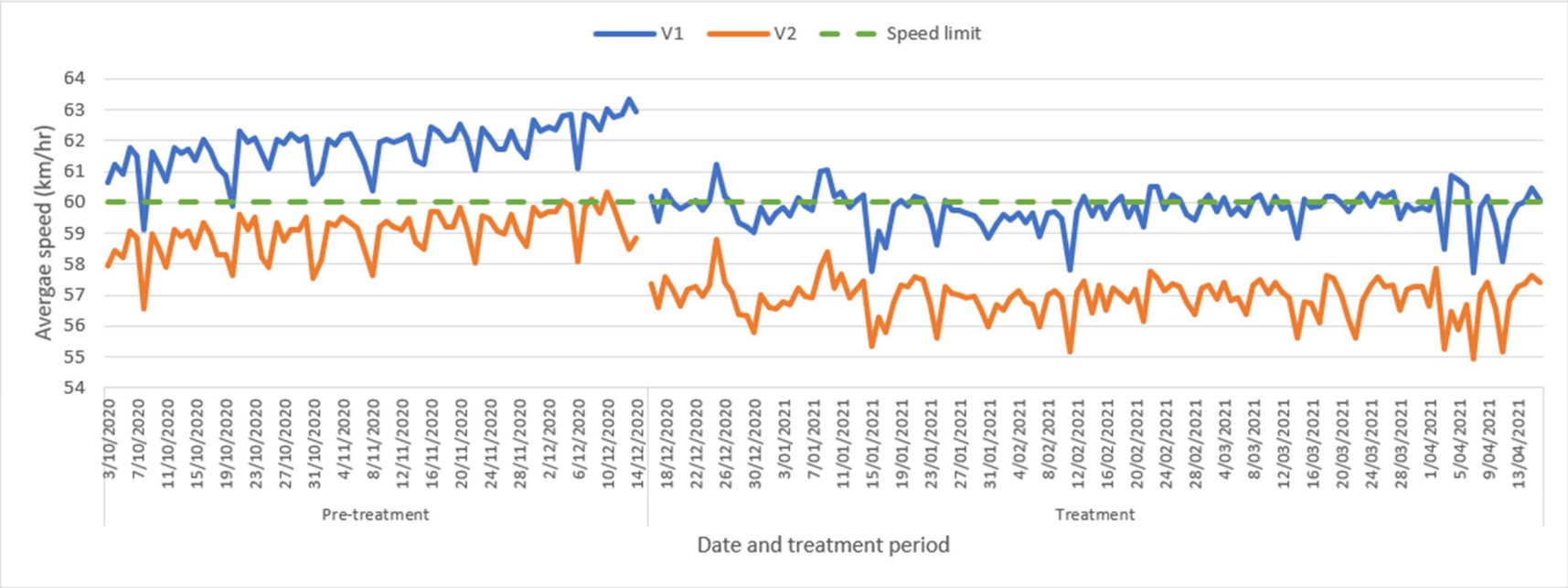


**Figure 8.** Old Cleveland Road East west average daily vehicle speeds during the pre-treatment period when Jenoptik 'smiley' sign 14361 was present but covered, and during the treatment period when the sign was uncovered. Note the pre-treatment plot shows two separate lines for V1 and V2 speeds, likely due to vehicles slowing in response to pre-existing road infrastructure or conditions. The treatment plot shows a drop in both V1 and V2 speeds after the sign was uncovered, indicating that drivers had already seen the sign by the time they reached the V1 radar recording point and so had already begun to slow down in response.

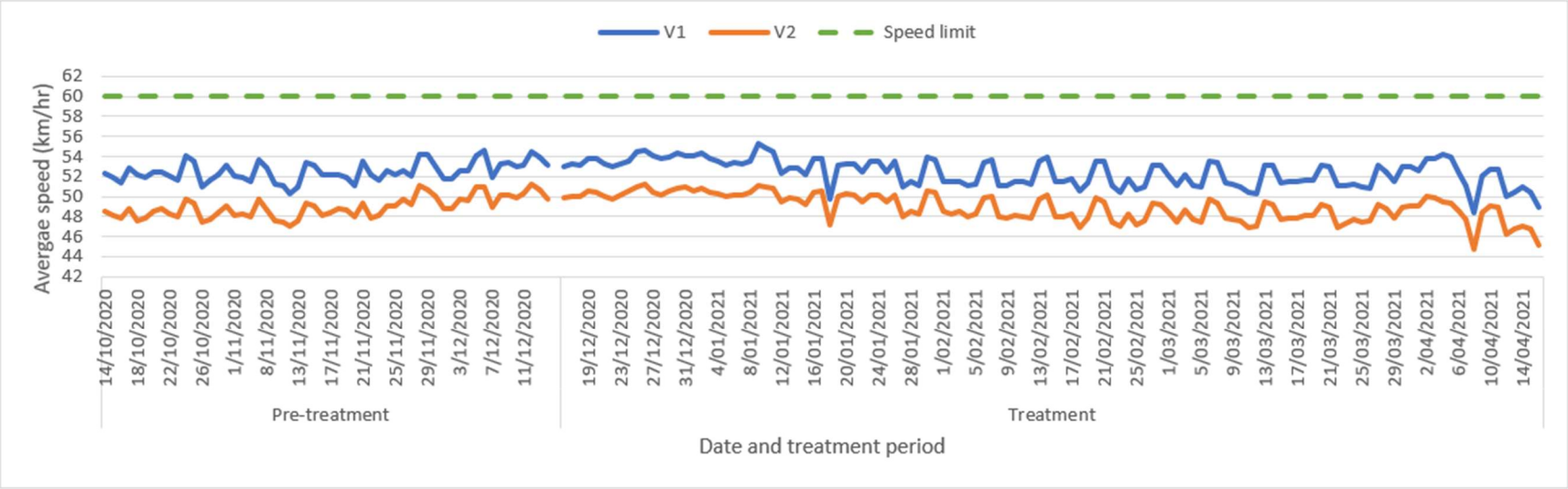


**Figure 9.** Sturgeon Street east average daily vehicle speeds during the pre-treatment period when Jenoptik 'smiley' sign 19543 was present but covered, and during the treatment period when the sign was uncovered. Note the pre-treatment plot shows two separate lines for V1 and V2 speeds, likely due to vehicles slowing in response to pre-existing road infrastructure or conditions.

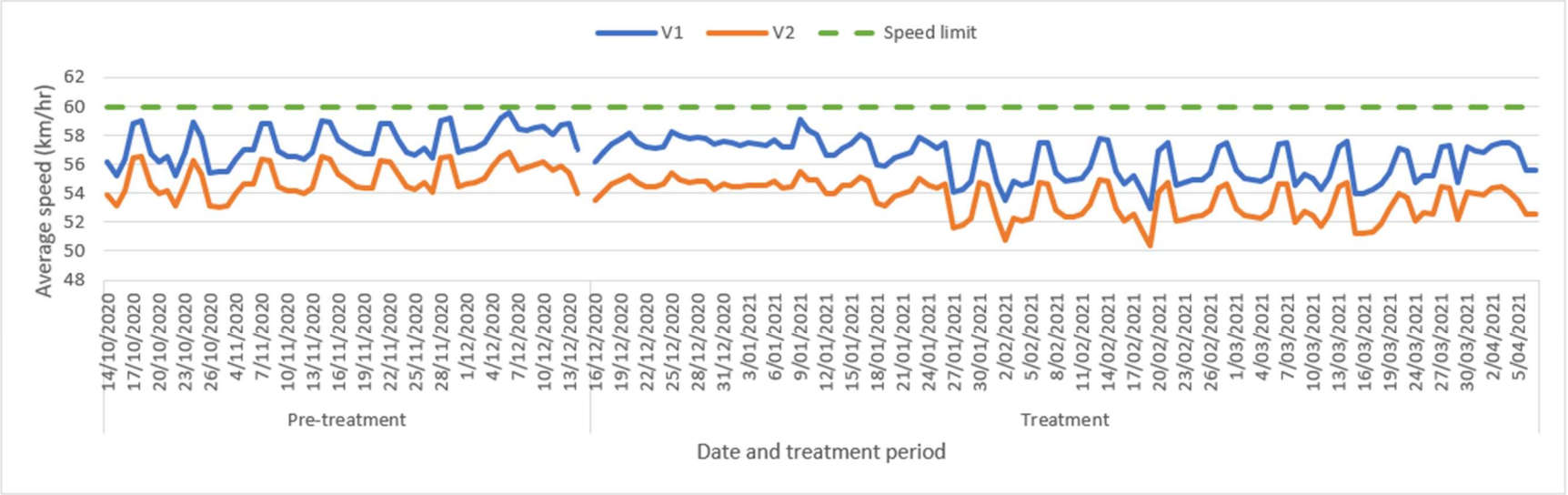


**Figure 10.** Sturgeon Street west average daily vehicle speeds during the pre-treatment period when Jenoptik 'smiley' sign 16720 was present but covered, and during the treatment period when the sign was uncovered. Note the pre-treatment plot shows two separate lines for V1 and V2 speeds, likely due to vehicles slowing in response to pre-existing road infrastructure or conditions. The treatment plot shows a drop in both V1 and V2 speeds after the sign was uncovered, indicating that drivers had already seen the sign by the time they reached the V1 radar recording point and so had already begun to slow down in response.

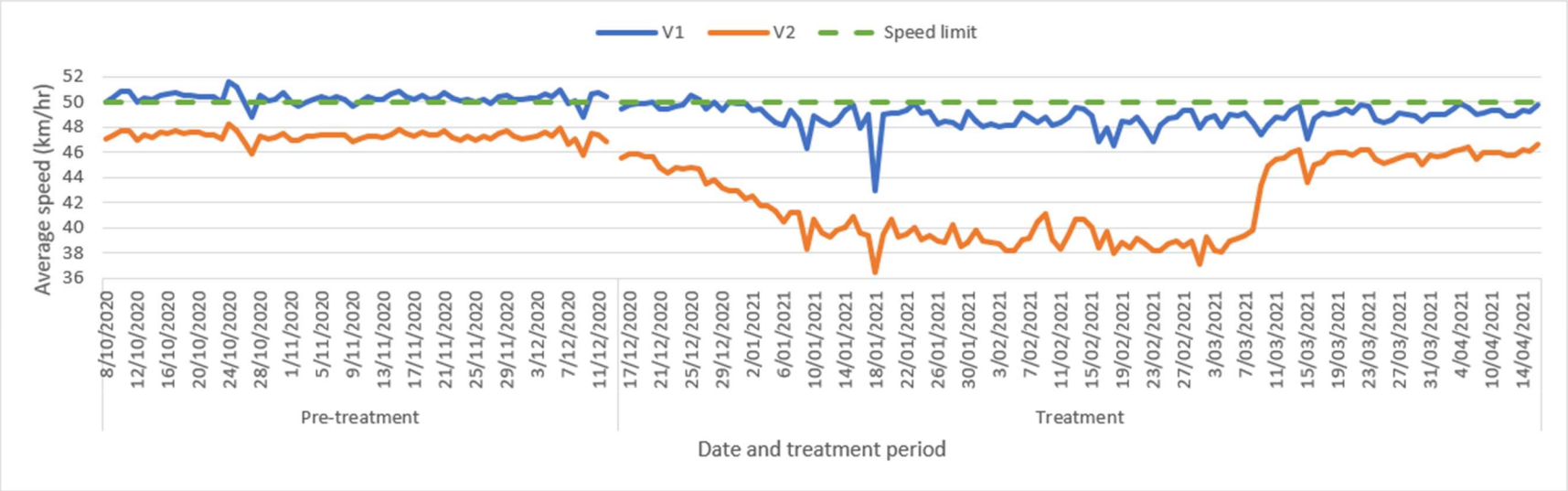


**Figure 11a.** Wellington Street north average daily vehicle speeds during the pre-treatment period when Jenoptik 'smiley' sign 19541 was present but covered, and during the treatment period when the sign was uncovered. Note the pre-treatment plot shows two separate lines for V1 and V2 speeds, likely due to vehicles slowing in response to pre-existing road infrastructure or conditions. The treatment plot shows a drop in both V1 and V2 speeds after the sign was uncovered, indicating that drivers had already seen the sign by the time they reached the V1 radar recording point and so had already begun to slow down in response.

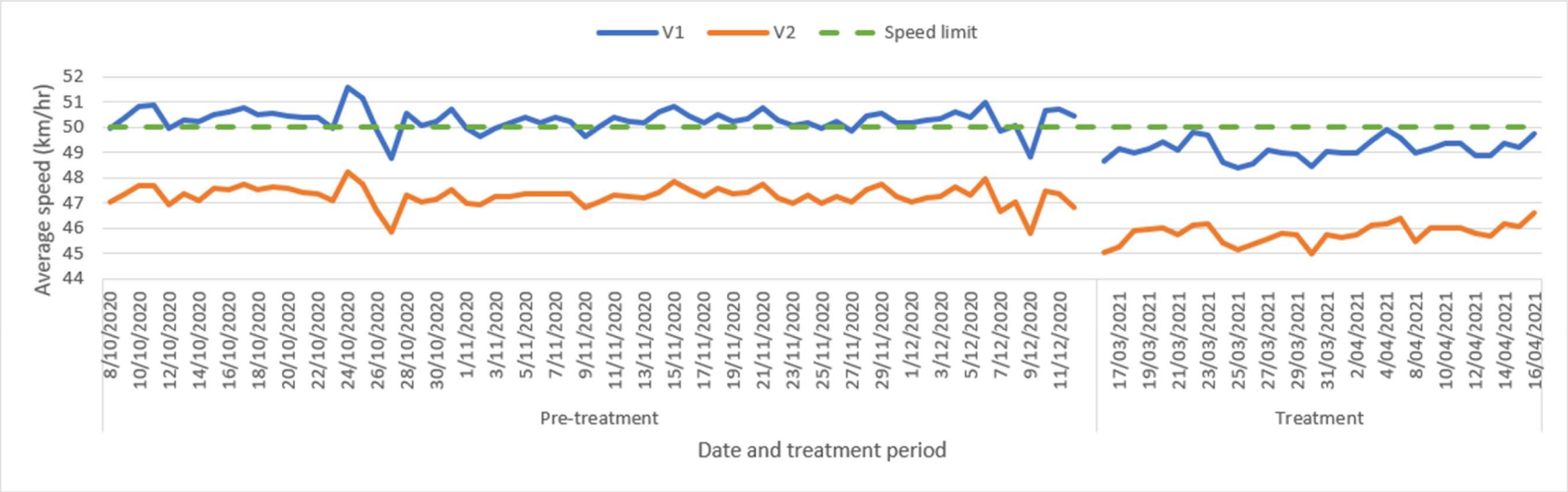


**Figure 11b.** Wellington Street north average daily vehicle speeds during the pre-treatment period when Jenoptik 'smiley' sign 19541 was present but covered, and during the treatment period when the sign was uncovered, with anomalous dates appearing in Figure 11a removed. Note the pre-treatment plot shows two separate lines for V1 and V2 speeds, likely due to vehicles slowing in response to pre-existing road infrastructure or conditions. The treatment plot shows a drop in both V1 and V2 speeds after the sign was uncovered, indicating that drivers had already seen the sign by the time they reached the V1 radar recording point and so had already begun to slow down in response.

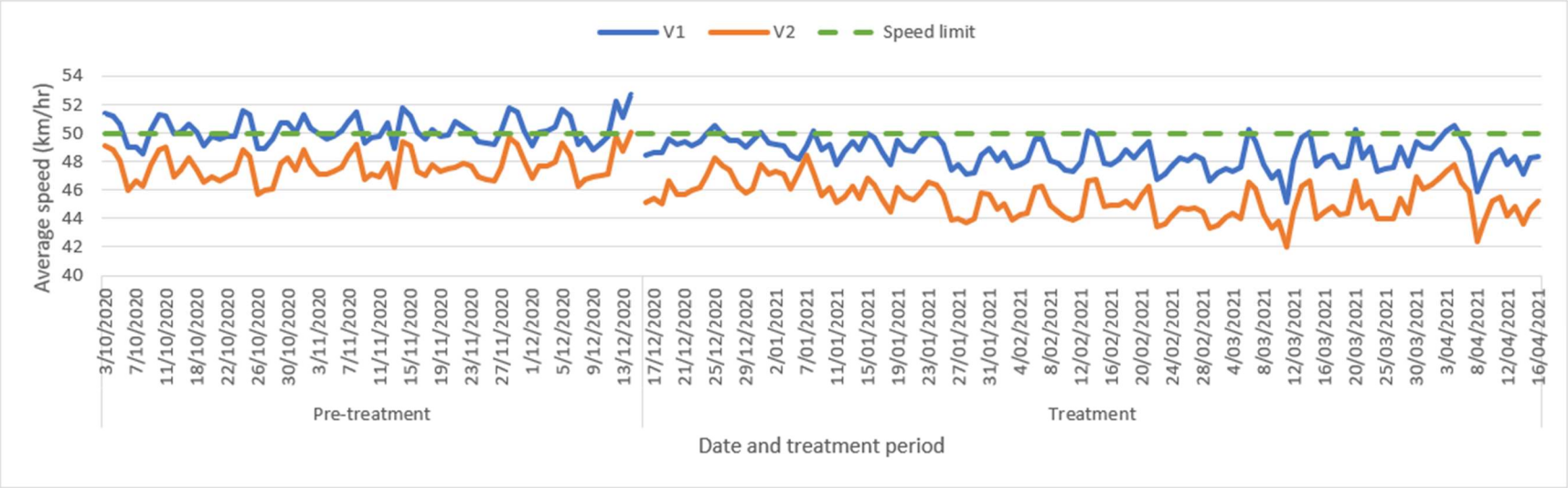


**Figure 12.** Wellington Street south average daily vehicle speeds during the pre-treatment period when Jenoptik 'smiley' sign 19540 was present but covered, and during the treatment period when the sign was uncovered. Note the pre-treatment plot shows two separate lines for V1 and V2 speeds, likely due to vehicles slowing in response to pre-existing road infrastructure or conditions. The treatment plot shows a drop in both V1 and V2 speeds after the sign was uncovered, indicating that drivers had already seen the sign by the time they reached the V1 radar recording point and so had already begun to slow down in response.

## 3.3 Exploration of Habituation

Whilst the results above for the current treatment period do not suggest any trend or indication of driver habituation during treatment periods, we were interested to know if there was any potential indication of a general change in driver behaviour towards signs between the current and previous years. Table 8 provides a comparison of data for the two years for occasions where the same sign type was installed on the same road. Most signs in the current year recorded larger drops in average speeds (between pre-treatment and treatment periods) than the previous year (though this was not the case for 85th percentile speeds). Whilst the signs on Starkey Street suggest drivers did not reduce speeds this year as much as they did in the previous year (in one case speeds actually increased) the average speeds (see Table 6) were already well below posted speed limits and low vehicle numbers recorded for these signs suggest some caution is required in interpreting any results. Overall, there appeared to be no clear evidence of behaviour suggestive of habituation.

**Table 8.** Comparison of car speed change data for Jenoptik 'koala smiley' signs (in yellow) and ITS signs (in blue) between the 2019/20 study period and the 2020/21 study period. Jenoptik 'smiley' signs cannot be compared across study periods because in 2020/21 they were located only on Old Cleveland Road East, which was not a site used in 2019/20. 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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | | | |
| | | | 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 | 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 | -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 |
| 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 |
| Wellington St north | 50 | Jenoptik koala smiley/ 16718 | -1.12 | -2.34 | -3.20 | -5.69 | Jenoptik koala smiley/ 19541 | -4.39 | -9.28 | -3 | -5.45 |
| 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 | -3.57 |

## 3.4 Koala sightings and movement around the study sites

As there are koalas living throughout the Redlands, we examined available koala movement data provided by a separate, but related, study being conducted by the University of the Sunshine Coast (USC) researchers. One koala in particular, named Blake, was suspected to have crossed a study road several times. Blake's GPS collar data points (see Figure 13), found on either side of Fitzroy Street (a new street added to this year's trials), strongly suggest that Blake moved across that street 11 separate times between September 2020 and May 2021 (a clear example is given in Figure 14). Other GPS-collared koalas were located in the vicinity of the study sites, but were not recorded crossing the study roads (see Appendix 3).

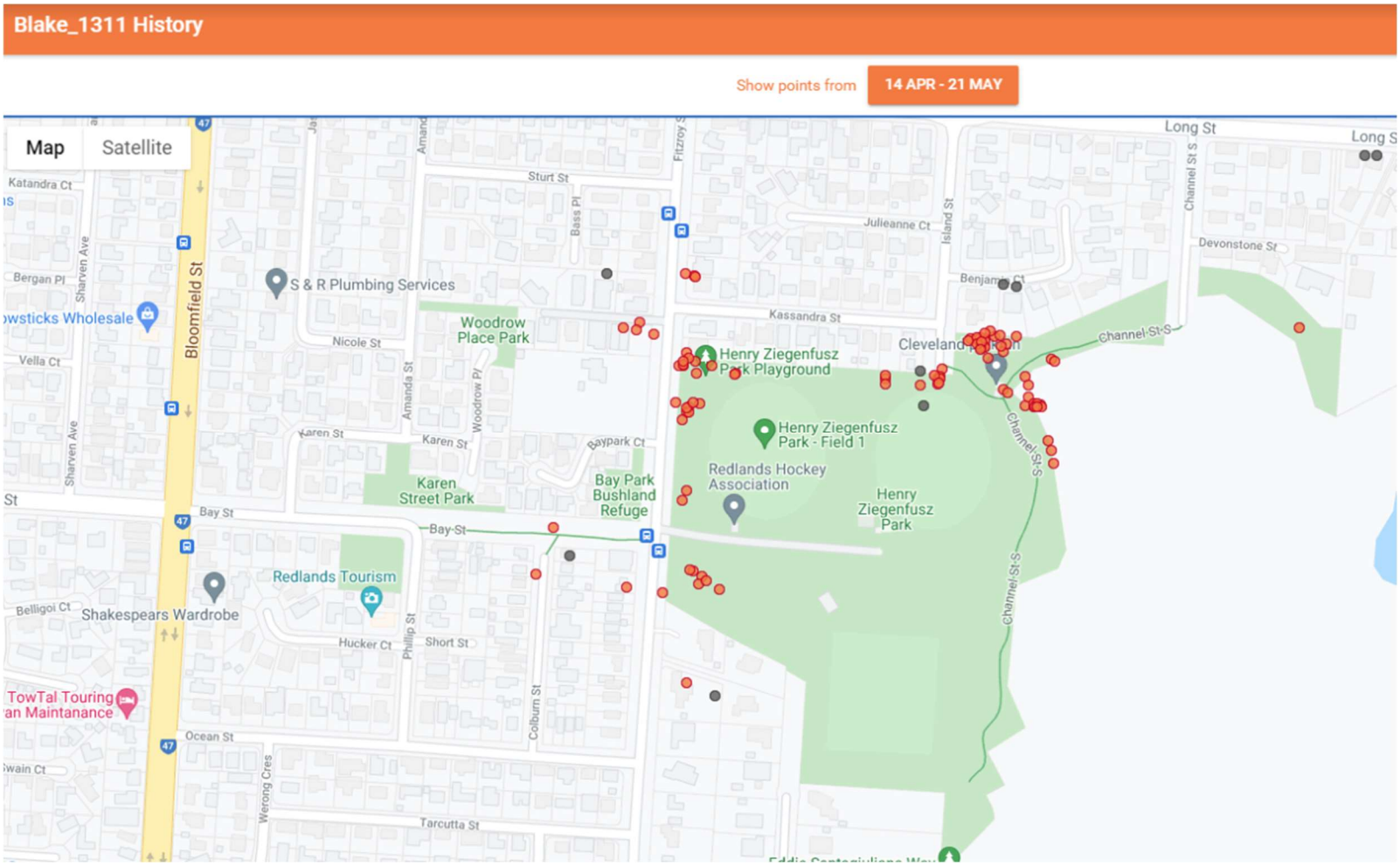

**Figure 13.** GPS locations for Blake (male koala) with several sets of points on either side of Fitzroy Street, suggesting that he crossed multiple times. Source: Caio Santos Neto and Dr Romane Cristescu, University of the Sunshine Coast.

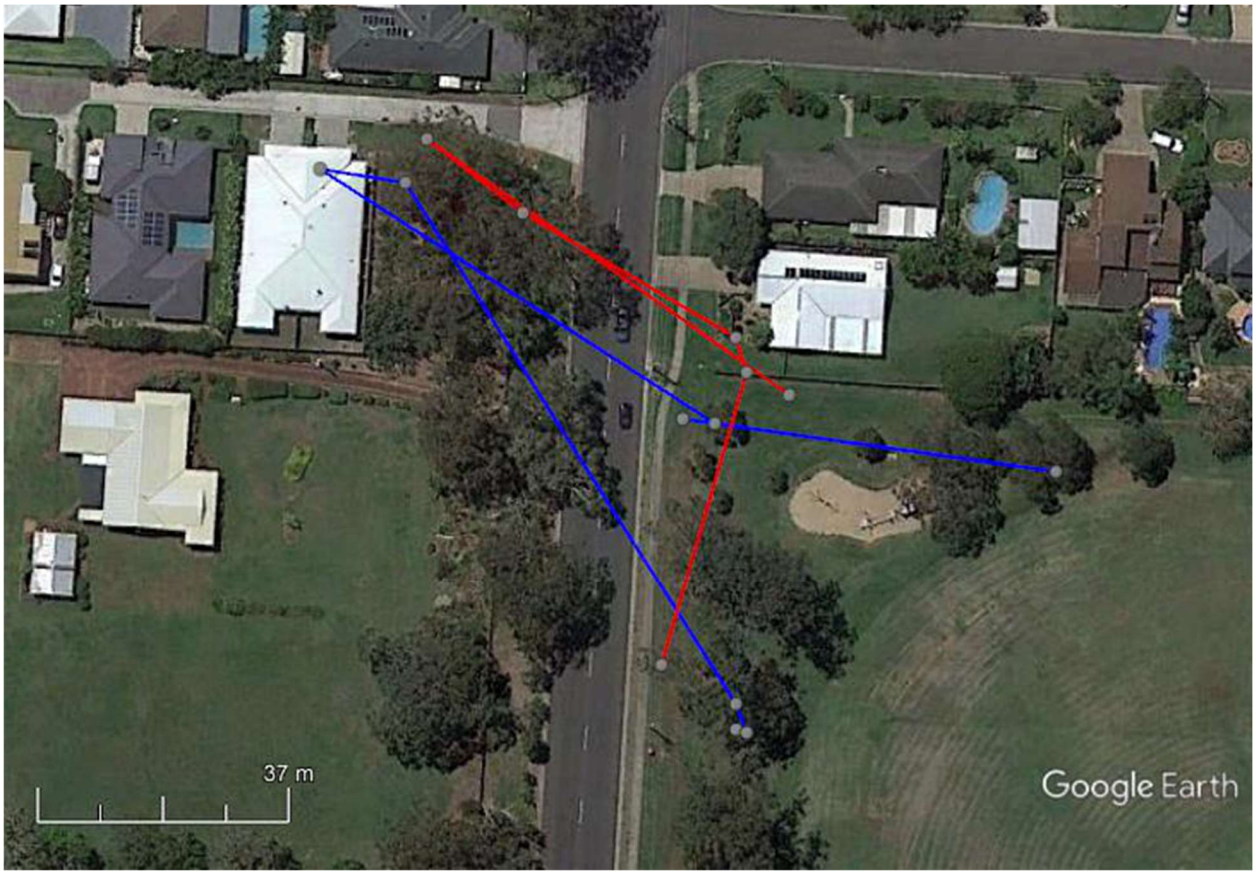


**Figure 14.** Two examples of possible crossings of Fitzroy Street by Blake the koala. The blue lines connect locations from 30 April to 3 May 2021 and the red lines connect locations from 7 to 10 May 2021, as indicated by GPS collar data. [Map created in Google Earth, using GPS Visualizer]

USC researchers also recorded koala sightings and scat locations during 2019 and 2020 (when possible given COVID restrictions), with a number of relevant recordings made close to Sturgeon Street and Old Cleveland Road East (Figure 15).


**Figure 15.** Koala sighting and scat data collected by USC researchers in 2019 and 2020 indicating koalas were relatively close to Sturgeon Street and Old Cleveland Road East. [Map created in GPS Visualizer (Koala icon image from: https://www.iconfinder.com/)]

# 4. Discussion

As in previous years, results for the current trials were encouraging, with the vast majority of V2 treatment period speeds being lower than V2 speeds in the pre-treatment period. In the case of the signs on Starkey Street, unexpectedly low vehicle counts led to a suspicion that results may not be representative. Therefore, whilst one of the signs on this street suggested a higher treatment period average speed compared to the pre-treatment period, we suggest caution in interpreting the given results this way. Average speeds recorded for both these signs were well below posted speeds limits, in one case by almost 16 km/hr, but sign malfunction and 'grouped' data (rather than individual vehicle speed recordings) prohibit any strong conclusions.

With regard to 85th percentile speeds, one sign recorded no change between periods, while the remaining signs all reported reductions. Taken together, these results support the contention that drivers are responding to signs by slowing down. A more unexpected result was that this also appeared to be the case when comparing V1 speeds between pre-treatment and treatment periods, with a drop in average V1 speeds coinciding with the dates that covers were removed, suggesting that the presence of uncovered signs alone may have influenced driver response, with drivers slowing before the sign had displayed a message in response to their individual vehicle speed. There were unfortunately some examples of dangerously excessive speeds on certain roads.

It is possible that certain geographic (e.g. road dips) or road features (e.g. roundabouts) influenced vehicle speeds, for example this may explain the drop between V1 and V2 speeds during the pre-treatment period when the signs were still covered, when we would otherwise expect to see no difference between the V1 and V2 speeds. Such environmental variables may have confounded results to some degree (as also noted in previous reports), although treatment period V1 and V2 speeds were almost always lower than their respective pre-treatment counterparts. It is possible that sign presence alone, even when signs were covered, encouraged slowing down in drivers, as evidenced by V2 speeds being lower than V1 speeds in the pre-treatment period, a difference also witnessed in previous years. Critically however, V2 speeds during treatment periods, when signs were uncovered, most often dropped to even lower levels, highlighting the potential importance of dynamic messaging.

As is visible in Figures 5-12, a very encouraging result was that all V2 average speeds were notably below posted speed limits, and in most cases so were V1 speeds. 85th percentile speeds, whilst not as encouraging, still showed reductions, suggesting that signs were at least having some positive impact on most drivers. Any consistent reduction in vehicle speeds has the potential to be of benefit in reducing collisions/accidents, both generally, and with regard to koalas and other wildlife.

With the exception of the sign at Old Cleveland Road East west (see Figure 8, where there appears to be a rising trend in speed) during the pre-treatment (covered) period only, we found no clear signs of habituation to operational signage, either within this year's results, or in comparison with the previous year. We note that habituation might be a relatively slow process, and any future years of data should be re-examined for this phenomenon. There are a number

of potential reasons for there being no signs of habituation to-date. The first is that signs are not constantly on display throughout a given year, but have been strategically deployed during periods where koala activity might lead to higher rates of road crossing. The second is that dynamic messaging/alerting relating to speed adjustment (or a lack thereof) is likely serving as a form of reinforcement to passing drivers, and helps to keep sign information relevant. The third is the broader community engagement program being employed throughout Redland City. Just as dynamic signs may help to keep signs relevant in-situ, the importance of signs and their potential role in helping to protect koalas is a message being reinforced in the community. This is conjectural at present, but could be experimentally examined through residential surveys.

Aligned with this exploration of habituation is the notion of driver vigilance, which currently remains a significant knowledge gap. Unlike speed, which is relatively straightforward to measure, driver vigilance is challenging to evaluate. Possible avenues for exploring it further include residential surveys and in-vehicle head-eye tracking. The latter is the most sophisticated approach and possibly the most objective, but is the most complicated to employ. It may be possible to develop a mobile phone application (app) that volunteers could utilise during driving to help assess head and eye movements, which could reduce overall cost and difficulty. There are existing phone apps that provide real-time speed advice to drivers, which showed beneficial results in simulations (Starkey et al. 2020). In the coming years, in-car phone apps could provide a myriad of uses in koala and wildlife conservation (and safety more generally), including those stated above, along with alerting drivers when koalas are on or near roads. Apps provide an additional avenue for ongoing community engagement and as new technologies emerge, a medium through which to conduct research.

Redland City Council has established the foundations for such a program with many of the area's koalas having been tagged electronically, allowing them to be monitored much more effectively. While few tagged koalas appeared to regularly cross study roads, Fitzroy Street, which was added this year, was a notable exception. One koala, Blake, was observed to have (most likely) crossed Fitzroy Street on several occasions, and USC researchers collected multiple sightings/scat records of koalas close to Sturgeon Street and Old Cleveland Road East, bringing home the importance of reminding drivers in the Redlands that they may encounter koalas whilst driving. In the near future, signs, phone apps and koala tracking technologies could all work together to provide residents with real-time and highly relevant information to help them avoid collisions.

# 5. Recommendations

1. Extend the study so that habituation, a key factor in the long-term performance of signs, can be investigated over a longer time period.
2. Consider leaving one or more signs continuously operational to better explore habituation.
3. Expand the study to include more sites, which will improve replication, and may in turn help ascertain a clearer picture of which sign model and features consistently produce the most beneficial reductions in vehicle speed (and on roads with higher speed limits). 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).
4. 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.
5. Consider amalgamating features from all three sign types/models as each may appeal to different sets of drivers.
6. 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.
7. Explore opportunities for additional technological enhancement of signs and driver safety alerts (e.g. phone applications) and koala-borne tracking technologies.

# 6. Conclusion

All signs, except one, recorded reductions in average vehicle speeds between pre-treatment and treatment periods. This is encouraging given that many drivers were already driving below the posted speed limit. The only sign that recorded an increase in speeds was the ITS sign at Starkey Street south, which recorded very few vehicles, and thus is likely unrepresentative, a problem that also occurred in the previous year. Results from two additional study roads also suggest signs performed well, particularly on Fitzroy Street where the koala smiley signs were

installed. Importantly, there was no evidence of driver habituation occurring throughout the longer exposure treatment period investigated this year, nor between last year and this year using comparable periods for the Ormiston study sites. This is a very encouraging result considering drivers were exposed to the signs for around four months. Although the presence of the signs cannot be directly related to the incidence of koala-vehicle strikes, no koalas were recorded being struck on the study roads during the period that the signs were installed, despite evidence of koala presence along the roads and evidence indicating one koala crossed Fitzroy Street on multiple occasions. These dynamic signs are an important part of the Redlands' Koala Safe Neighbourhoods, prompting drivers to reduce speeds and remain vigilant for koalas in the area. These signs have the potential to become part of a larger strategy to reduce koala-vehicle collisions, reduce driver speeds and aid in increasing public awareness of local koalas.

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# Appendices

## Appendix 1 – Technical and data issues

- Data from the ITS/Artcraft signs is currently only available up until ~21/01/2021, possibly due to sign malfunctions that are being investigated by the manufacturers
- The Jenoptik signs record two speeds for each car: V1 is the initial car speed as the driver approaches the sign, and V2 is the car speed after the driver has (presumably) seen the sign. In many cases (around 44% 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 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 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 14370 pre-treatment period is missing data from 9-15/11/2020, and the 14370 treatment period is missing data from 22-29/03/2020. The longer time periods suggest a technical issue with the signs rather than an absence of cars
- The following dates were removed from the Fitzroy Street north 16718 pre-treatment dataset: 1) 19/10/2020, due to an anomalous dip in speeds (below 40km/hr) from ~11am until ~2:30pm due to unknown traffic disturbance e.g. roadworks, accident, etc; 2) 21/10/2020, due to an anomalous dip in speeds (below 40km/hr) from ~7:45am until ~12:15pm due to unknown traffic disturbance
- The following dates were removed from the Fitzroy Street north 16718 treatment dataset: 1) 23/03/2021, due to an anomalous dip in speeds (below 15km/hr) from midnight until ~1:30pm due to unknown traffic disturbance
- The following dates were removed from the Fitzroy Street south 18935 treatment dataset: 1) 12-14/12/2020 due to an anomalous dip in speeds. On 12/12 most speeds were extremely low (many ~10km/hr) between midnight and 5am. Across the rest of the time on all these dates there were many low speeds (e.g. below 30km/hr). An unusually high number of cars was recorded on all these dates (up to almost twice as many as the daily car count during the rest of the treatment period)
- The following dates were removed from the Fitzroy Street south 18935 treatment period: 1) 8-9/01/2020 due to anomalous dips in speed (e.g. ~11km/hr and below) from ~8pm on 8/1 until ~5am on 9/1. On 9/1 fewer than half the number of cars than the average were recorded; 2) 18/01/2021 due to an anomalous dip in speeds from ~7pm until midnight (less than 15km/hr); 3) 15-16/03/2021 due to anomalous dips in speed (lower than 20km/hr) from ~3pm 15/3 until ~6am 16/3. A relatively high number of cars was also recorded on 15/3; 4) 24/03/2021 due to an anomalous dip in speeds (averaging ~30km/hr) from ~7:30am until ~11:30am; 5) 5-6/04/2021 due to an anomalous dip in speeds (averaging around 15km/hr) from ~10pm 5/4 until ~4:30am 6/4, and ~8pm until ~10:30pm 6/4. A higher number of cars than average was recorded 6/4
- The following dates were adjusted in the Old Cleveland Road East east 14370 pre-treatment and treatment datasets: the cover accidentally came off earlier than planned (it looks like it came off 5/11/20), so the pre-treatment end date was brought forward to 4/11/20 (subtracting 21 days) and the treatment start date to 6/11/20 (adding 20 days)

- The following dates were removed from the Old Cleveland Road East east 14370 pre-treatment dataset: 1) 24/11/2020 due to an anomalous dip in speeds (to ~30km/hr) from ~7:30pm until ~10:30pm
- The following dates were removed from the Old Cleveland Road East east 14370 treatment dataset: 1) 13-14/12/2020 due to an anomalous dip in speeds (many very low speeds ~20km/hr and lower), recorded mostly from ~9pm 13/12 until ~4:30am 14/12. There was a comparatively low number of cars recorded on 13-14/12; 2) 13/01/2021 due to an anomalous dip in speeds (~40km/hr) from ~10am until ~3pm; 3) 21/03/2021 due to an anomalous dip in speeds (many very low speeds below 20km/hr) between ~2:30pm and ~5:30pm, and again between ~7pm and ~10pm. There was a comparatively low number of cars recorded on this date; 4) 5-6/04/2021 due to an anomalous dip in speeds (to below 20km/hr) from ~9:30pm 5/04 until ~5am 6/04. There was a comparatively low number of cars recorded on these dates, particularly 5/04
- The following dates were removed from the Sturgeon Street east 19543 pre-treatment dataset: 1) 29-30/10/2020 due to an anomalous dip in speeds (many lower than 30km/hr) from ~7am to ~6pm 29/10, then from ~8am until ~6pm 30/10. There was a comparatively low number of cars recorded on both these dates; 2) 2-4/11/2020 due to an anomalous dip in speeds, particularly from ~8am until ~4:30pm 2/11 and ~6:30am until ~6pm 3/11. There was a comparatively low number of cars recorded on 2/11 and 3/11; 3) 12/11/2020 due to an anomalous dip in speeds (many lower than 30km/hr) from ~9am until ~1:30pm
- The following dates were removed from the Sturgeon Street west 16720 pre-treatment dataset: 1) 29-30/10/2020: due to an anomalous dip in speeds (~20km/hr) from ~8am until ~9am and from ~3:15pm until ~6pm on 29/10, and from ~8-8:30am, ~3:30-4pm, and ~5-5:30pm 30/10
- The following dates were removed from the Sturgeon Street west 16720 treatment dataset: 1) 22-23/03/2021 due to anomalous dips in speeds (~20km/hr), particularly from ~7:50am until ~8:30am 22/03, and from ~7:45am until ~8:30am and ~3:20pm until ~3:45pm 23/03. There was a comparatively low number of cars recorded both dates; 2) 8-16/04/2021 due to anomalous dips in speeds (many below both 20km/hr and 10km/hr), including from ~7:30am until ~1pm 8/04, from ~4:45am until ~6:45am 9/04 and from ~11:30pm 9/04 until ~6am 10/4, from ~6am until ~9am 11/04, from ~9am until ~3pm 12/04, from ~9:30am until ~2:45pm 13/04, from ~9am until ~3:20pm 14/04, from ~9:15am until ~2:45pm 15/04, and from ~10:20am until ~4:20pm 16/04

- The following dates were removed from the Wellington Street north 19541 pre-treatment dataset: 1) 13-14/12/2020 due to an anomalous dip in speeds (averaging ~20km/hr) particularly from ~10:30pm 13/12 until ~12pm 14/12. There was a comparatively low number of cars recorded both dates
- The following dates were removed from the Wellington Street north 19541 treatment dataset: 1) 22/12/20 – 12/03/2021 due to an anomalous dip in V2 speeds (dropping below an average of 40km/hr over a very long period), corresponding closely with comparatively low car numbers recorded, possibly due to roadworks; 2) 5-6/04/2021 due to an anomalous dip in speeds (below 20km/hr) from ~8:30pm 5/04 until ~4am 6/04
- The following dates were removed from the Wellington Street south 19540 treatment dataset: 1) 6/01/2021 due to an anomalous period where the average V2 was higher than the average V1, due to multiple relatively low V1 speeds throughout the day, indicating that many cars were increasing speed as they passed the sign due to an unknown traffic disturbance; 2) 23/03/2021 due to an anomalous dip in speeds (below 15km/hr) over the course of the day; 3) 28/03/2021 due to an anomalous dip in speeds (~30km/hr) from ~1am until ~10am; 3) 5/04/2021 due to an anomalous spike in speeds, caused by a comparatively low number of cars being recorded combined with three cars recorded at speeds over 100km/hr ~7:22pm

# Appendix 2 – Data loss summary

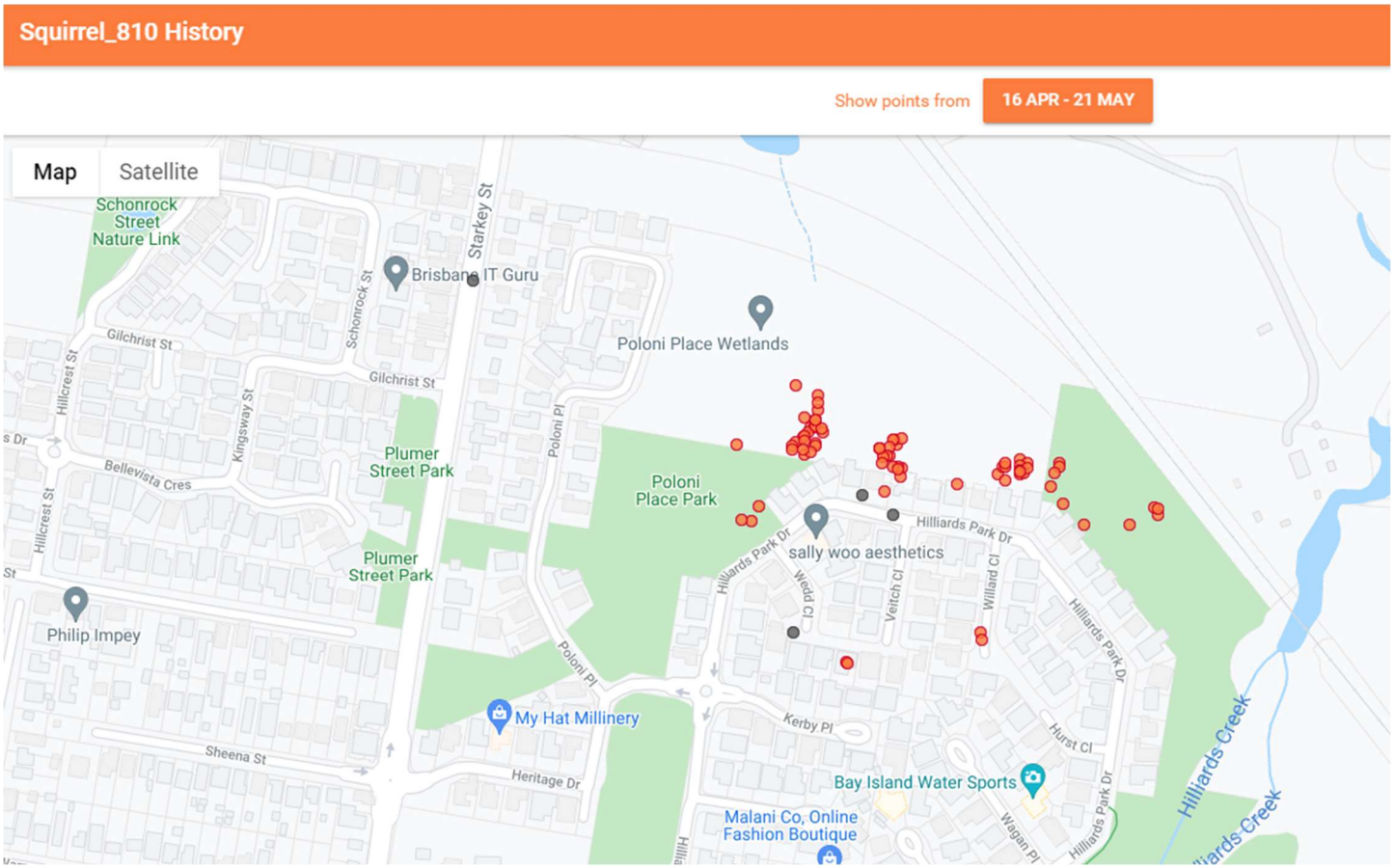
**Appendix Table 1.** The number of cars recorded by each sign in the raw datasets; the total number of recordings removed; the number of recordings removed due to Jenoptik signs failing to record a V2; the number of recordings removed due to other anomalies (detailed in Appendix 1); the number of remaining 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 |
|---|---|---|---|---|---|---|

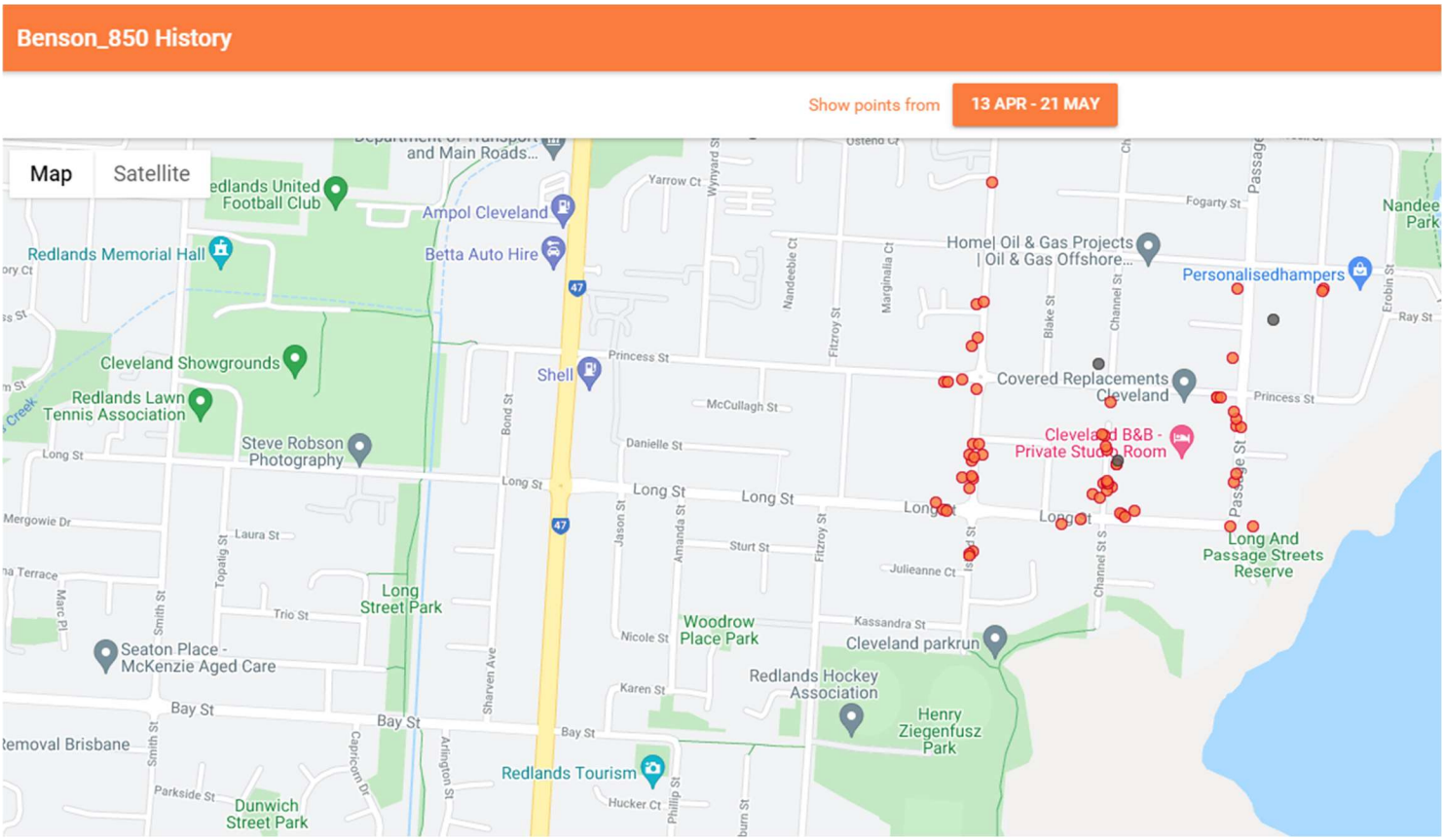
| | | | | | | |
|---|---|---|---|---|---|---|
| Jenoptik smiley 14361 | 3432046 | 1724772 | 1724772 | 0 | 1707274 | 50 |
| Jenoptik smiley 14370 | 2303283 | 869602 | 630991 | 238611 | 1433681 | 38 |
| Jenoptik koala smiley 16718 | 1130935 | 708634 | 252911 | 455723 | 422301 | 63 |
| Jenoptik koala smiley 16720 | 2935209 | 1529048 | 1427971 | 101077 | 1406161 | 52 |
| Jenoptik koala smiley 18935 | 982781 | 547828 | 513472 | 34356 | 434953 | 56 |
| Jenoptik koala smiley 19540 | 807187 | 400777 | 393659 | 7118 | 406410 | 50 |
| Jenoptik koala smiley 19541 | 1867156 | 1304859 | 969454 | 335405 | 562297 | 70 |
| Jenoptik koala smiley 19543 | 2485803 | 1114423 | 1079080 | 35343 | 1371380 | 45 |
| ITS koala K001_01 | 855 | 0 | | | 855 | 0 |
| ITS koala K001_02 | 4654 | 0 | | | 4654 | 0 |
| **Total** | 15949909 | 8199943 | 6992310 | 1207633 | 7749966 | 51 |

# Appendix 3 – Koala movement data around the study sites

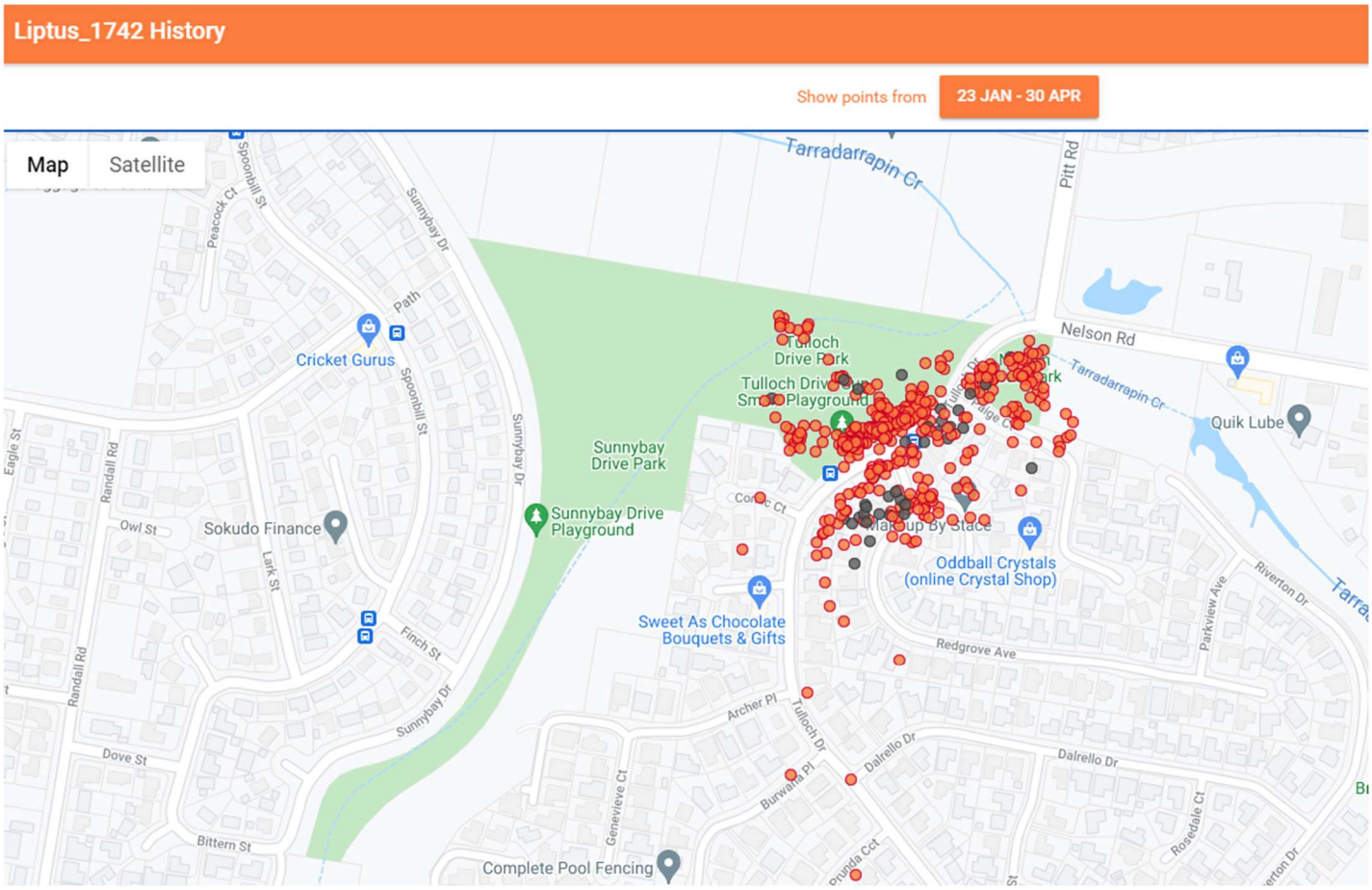
In a separate study, conducted by researchers from the University of the Sunshine Coast, some koalas were located close to our study sites. Although some of these koalas may have crossed roads in the area, there was no clear evidence of them crossing any of the study roads. The following figures show the locations of these koalas during the time that the signs were installed.




**Appendix Figure 1.** GPS locations for Squirrel in parklands to the east of Starkey Street. Source: Caio Santos Neto and Dr Romane Cristescu, University of the Sunshine Coast.




**Appendix Figure 2.** GPS locations for Benson with several sets of points on either side of local streets, suggesting multiple road crossings to the north-east of Fitzroy Street. Source: Caio Santos Neto and Dr Romane Cristescu, University of the Sunshine Coast.




**Appendix Figure 3.** GPS locations for Liptus with several sets of points on either side of local streets, suggesting multiple road crossings. The majority of Liptus' locations were approximately 500 m north of Old Cleveland Road East. Source: Caio Santos Neto and Dr Romane Cristescu, University of the Sunshine Coast.