



Report Number: AC22401 – 06 – R2

Road surface noise correction validation measurements

Summary report



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1.0 BACKGROUND

AES was engaged by Waka Kotahi New Zealand Transport Agency (NZTA) to undertake traffic noise monitoring at a range of sites around New Zealand over the summer of 2023. The purpose of the measurements was to provide a sample of empirical road traffic noise data in support of the ongoing Waka Kotahi NZTA research into updated road surface noise coefficients for roads in New Zealand.

This report summarises the measurement and data collection exercise. Findings and conclusions from the project will be published by Waka Kotahi NZTA in due course.

With respect to AES' scope of work, the process of selecting suitable measurement sites is explained in section 2.0 of this report below. Equipment and external data sources used, and a summary of the measurement conditions have been presented in section 3.0. Data processing and analysis have been summarised in section 4.0.

Alongside this project summary report, the full set of noise measurement data has been made available for public use. The data is contained in a total of 19 spreadsheet files (one file for each of the eighteen measurement sites, and one overall summary file). Section 5.0, below, provides an explanation of how to navigate and interpret the data spreadsheets.

Lastly, for each of the eighteen sites, a full detailed description of the measurement location, site conditions and equipment, along with photos and location maps can be found in appendix 1, at the end of this report.

2.0 SITE SELECTION

Suitable sites for noise measurements were selected based on a variety of practical and research considerations, and in close cooperation with the requirements of Waka Kotahi NZTA. The equipment available for the project consisted of six noise loggers (described in section 3.1 below), and therefore a total of eighteen sites were targeted, with six sites in each of the major centres of greater Auckland, Wellington, and Christchurch. Generally speaking, it was attempted to locate all the measurement sites such that all six sets of equipment could be deployed within a single day, for reasons of efficiency. Safe and protected access to each logger position was also a key practical consideration.

Other priorities for site selection, based on the research goals, were a simple road layout and free flowing traffic, generally flat site topography, minimal screening and reflecting objects, away from extraneous noise, among other factors. It was not always possible to select sites that fully satisfied all of these objectives, however we attempted to satisfy as many as possible.

As the goal of the research was to assess noise from different road surface finishes used across the NZ State Highway system, an additional consideration for site selection was to locate measurements such that noise from a representative sample of road top surface finishes was captured. Of the selected sites, the distribution of road surface finishes consisted of the following:

- Porous asphalt (OGPA / EPA), varying grades and ages: 7 sites
- Stone mastic asphalt, varying grades and ages: 3 sites
- Chip seals, varying chip sizes and ages: 8 sites

The locations of the selected sites for each of the regions are shown in figures 2.1 (Auckland), 2.2 (Wellington), and 2.3 (Christchurch) below.

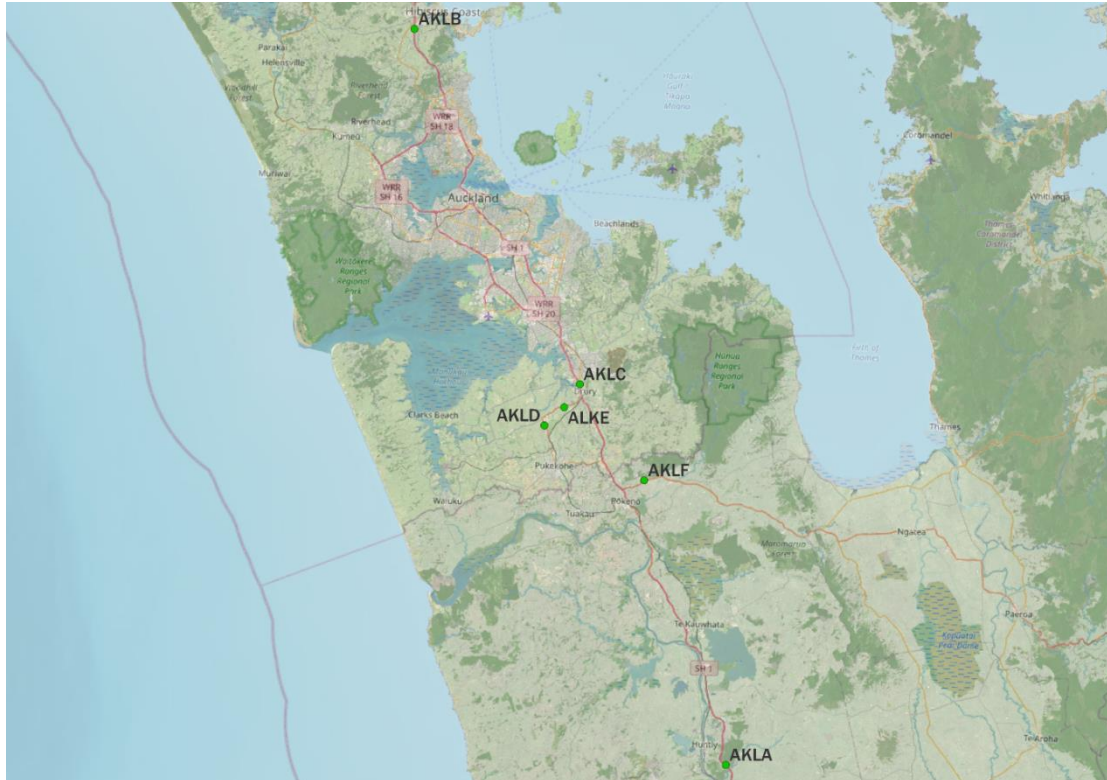


Figure 2.1 – Auckland measurement sites

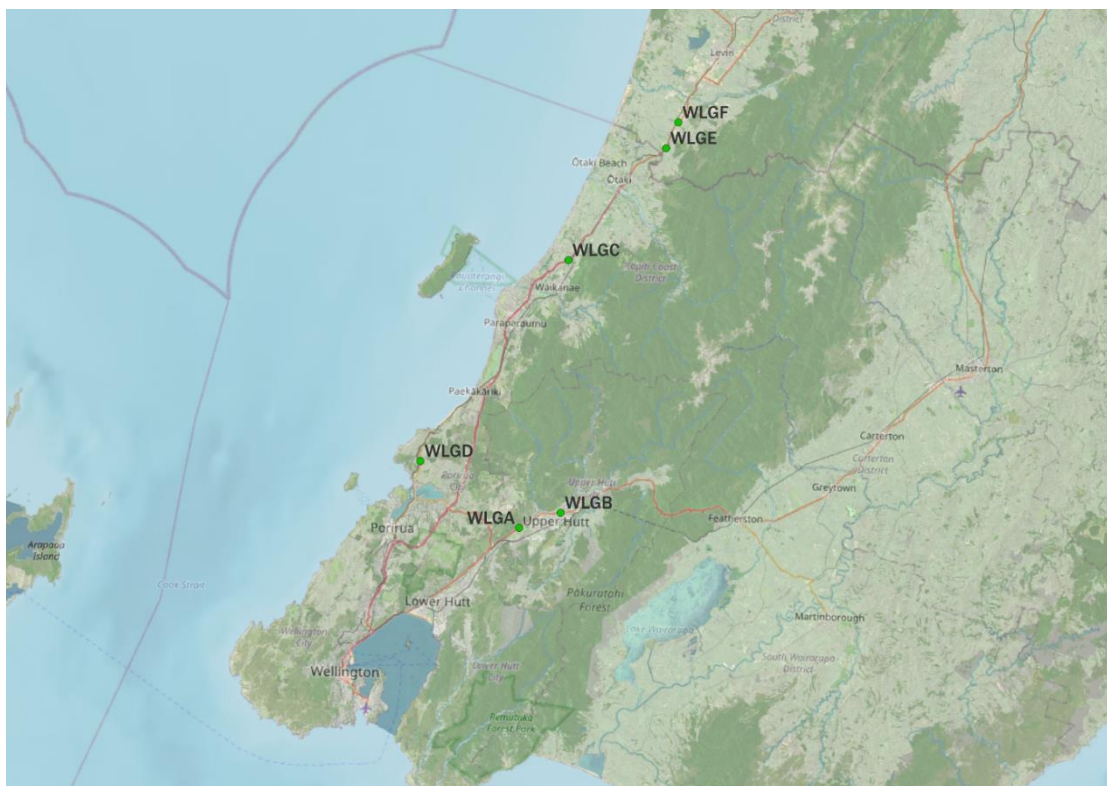


Figure 2.2 – Wellington measurement sites

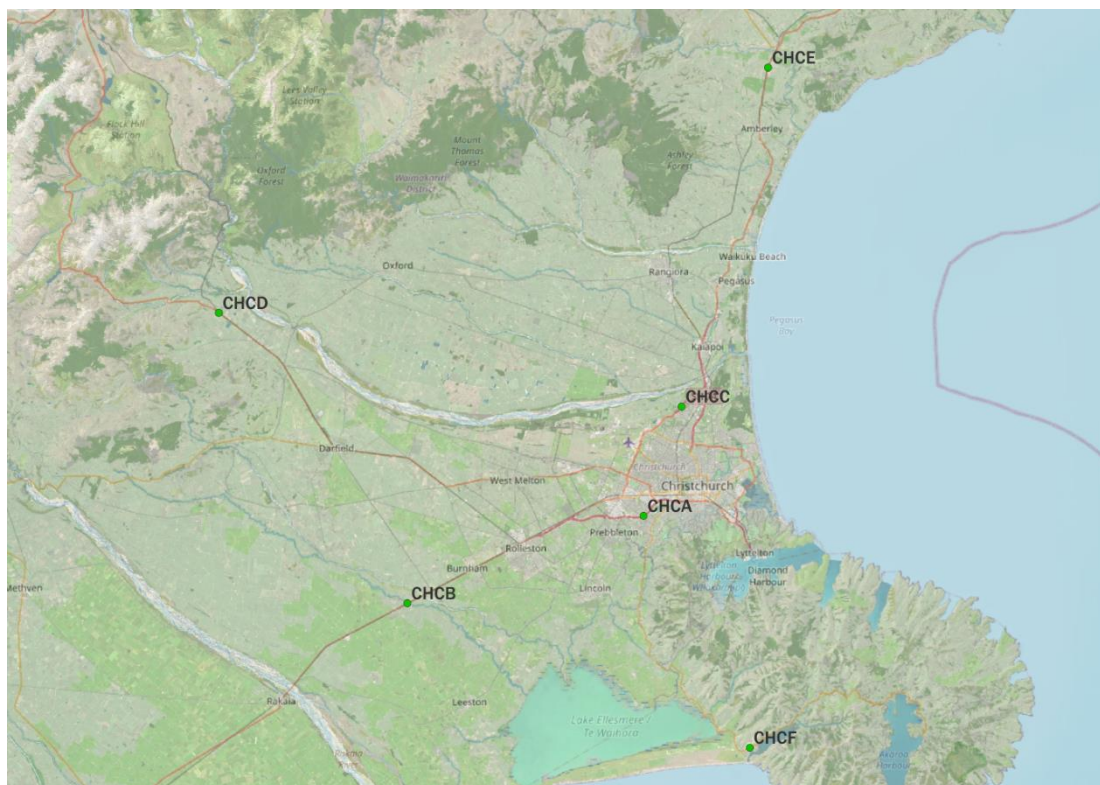


Figure 2.3 – Christchurch measurement sites

Additional location information for the selected sites is presented in table 2.1 below.

Table 2.1 – Noise logging site summary

Region	Site ID	State Highway	Location	NZTM coordinates
Auckland	A	01N	Huntly Bypass Expressway	1793908, 5837728
	B	01N	Silverdale	1748671, 5944578
	C	01N	Rosehill	1772693, 5892996
	D	22	Paerata	1767544, 5887019
	E	22	Karaka	1770420, 5889662
	F	2	Pokeno	1782049, 5879051
Wellington	A	2	Trentham	1769407, 5444526
	B	2	Upper Hutt	1774313, 5446312
	C	01N	Peka Peka	1775248, 5476190
	D	59	Plimmerton	1757730, 5452431
	E	01N	Manakau	1786812, 5489420
	F	01N	Kuku	1788248, 5492483

Table 2.1 (continued) – Noise logging site summary

Region	Site ID	State Highway	Location	NZTM coordinates
Christchurch	A	76	Wigram	1564284, 5176575
	B	01S	Dunsandel	1536308, 5166240
	C	01S	Northwood	1568775, 5189476
	D	73	Springfield	1514022, 5200577
	E	01S	Waipara	1579008, 5229563
	F	75	Little River	1576858, 5149142

3.0 MEASUREMENT AND COLLECTION OF DATA

3.1 Equipment

Noise logging equipment used for the study were Convergence Instruments NSRT ‘mini loggers’, with one logger deployed at each site. The NSRT are a battery powered, low cost, weatherproof noise data logger with a factory calibrated class 1 digital MEMS microphone. All loggers were configured to capture broadband A-weighted noise levels (L_{\max} , L_{\min} , and L_{eq}) in one-minute intervals for the duration of the measurement periods at each site. An example photo showing a mini logger is given in figure 3.1 below, along with a photo of a logger deployed in the field.



Figure 3.1 – Example photos of noise logging equipment

The loggers were field calibrated before measurements using a Brüel & Kjær Type 4231 acoustic calibrator, and the calibration was checked after measurements. No significant change (± 0.1 dB) was noted in any case. Further details of the equipment, including serial numbers and laboratory calibration dates can be found in appendix 1.

The battery life of the mini loggers is approximately 7 days, however at some sites a small USB solar panel was used to ensure that a full week of data could be collected. A wind sock was used on each logger to minimise induced wind noise in the measurements (as pictured in figure 3.1 above). The loggers were attached to fence lines, street light poles, or other solid structures. Generally speaking, it was attempted to locate the loggers at a distance of approximately 10 metres from the road edge, and at a height of 1.5 metres above the road level, and at least 1.5 metres above the local ground level.

During our time on site at each measurement position, we took a short sample of speed measurements using a handheld speed gun. The speed measurements were undertaken using a Stalker XLR Long Range Police LiDAR detector, over a period of 10 minutes at each site. The speeds of all the measured vehicles within the sample period were averaged, and the determined average speed has been provided in appendix 1, and in the data spreadsheets for each site. Additional information about the speed measurements undertaken, including the time of day that measurements at each site occurred, have been provided in appendix 1.

The true line-of sight distance from the logger position to the road surface (nearest edgeline) was also measured on site using a Bushnell Prime 1300 laser rangefinder. This value was used to calculate the baseline noise level predictions, as discussed further in section 4.1 below.

3.2 Measurement conditions

All six loggers were deployed simultaneously over the course of a week to six sites in each of the three main centres (Auckland, Wellington, and Christchurch). The logging periods in each centre took place over the summer of 2023, and suitable weeks for measurement were selected based on the weather forecast at the time. Dates of the measurement periods are given in table 3.1 below, along with general weather observations for each centre.

Table 3.1 – Measurement dates and general weather conditions

Centre	Dates	General weather observations
Christchurch	Between Thursday the 2 nd and Friday the 10 th of February 2023 **	<i>Average daily high:</i> 27 °C <i>Average daily low:</i> 16 °C <i>Average day time wind speed:</i> 4.7 m/s
Wellington	Between Wednesday the 22 nd of February and Thursday the 2 nd of March 2023	<i>Average daily high:</i> 20 °C <i>Average daily low:</i> 13 °C <i>Average day time wind speed:</i> 3.9 m/s
Auckland	Between Thursday the 9 th and Friday the 17 th of March 2023	<i>Average daily high:</i> 22 °C <i>Average daily low:</i> 14 °C <i>Average day time wind speed:</i> 4.6 m/s

** Note that a national public holiday (Waitangi Day) occurred on Monday the 6th of February during the Christchurch measurement period.

Detailed real time weather observations for each of the measurement locations are included in the data spreadsheets.

3.3 External data

Various sources of externally sourced data were used as part of the project. Full attribution of all sources can be found in the bibliography of this report. In particular, data for weather observations and traffic counts for the full measurement period were used to provide context to the measured noise logger data. Weather and traffic data sources have been explained further below.

3.3.1 Weather

Detailed weather data from weather stations nearby to each noise logging location was used to identify portions of the measurement periods where noise logging results may have been adversely affected due to weather conditions. Weather observation data was retrieved from either of two sources:

- NIWA National Climate Database (CliFlo)
 - CliFlo is a freely available (log in required) database of historic weather observations from NIWA-owned weather stations nationwide. Most stations in the network can provide 15-minute data for wind (speed and direction), rainfall, and temperature/relative humidity, among other data points.
- NZTA MetConnect
 - MetConnect is a private weather data source for internal used within NZTA. Data is sourced from NZ Met Service-owned weather stations. Hourly data for wind (speed and direction), rainfall, and temperature/humidity are available, among other data points.

For each of the selected noise logging locations, a suitable weather station was selected from either of the above sources. Time-series weather data from the chosen station for wind (speed and direction), rainfall, and temperature/ relative humidity was retrieved, and loaded alongside the logged noise data. Temperature and relative humidity were not used in the final analysis, but have been provided for context.

3.3.2 Traffic

As explained in section 2.0 above, suitable noise logging sites were selected based on their proximity to existing, permanent, Waka Kotahi NZTA-owned traffic count stations. Traffic count data for these sites is hosted on the Waka Kotahi NZTA State Highway Traffic Monitoring System (TMS) database. Key data points for the project were overall daily volumes of traffic, lane-specific volumes (for roads with more than two lanes), traffic mix (percentage of heavy vehicles), and the most recent AADT calculation for the site.

The TMS database uses a unique alphanumeric code for all traffic count sites in the network (the 'siteRef' field in the database) and a free text location description. Within this project, for the selected traffic monitoring sites we have provided the siteRef codes and location description for each counter. A publicly available GIS display of the geographic locations of traffic monitoring sites within the TMS network, including siteRef codes, location descriptions, and annual AADT values can be found in the Waka Kotahi NZTA ArcGIS web app, *State highway traffic monitoring – annual average daily traffic*.

Within the TMS system, overall AADT values are typically calculated on the 31st of December each year, based on the previous year's count data, and therefore the AADT values referenced for this project were generally the AADT calculated on the 31st of December 2022, except where this was not available as discussed further below.

During the process of retrieving the traffic volume data from the TMS database, it was found that several of the North Island traffic counters from which we had planned to source traffic data were experiencing technical problems, and count data was not available, or not complete at these sites. Traffic data corresponding to the noise measurement period was a key deliverable for the project, and therefore several work arounds were developed to interpolate and/or synthesise replacements for the missing data. A general reliability rating for each of the measurement sites was subsequently developed, with a traffic light system (green, orange, and red) indicating the extent of data synthesis used. We have explained these ratings in more detail below.

- Green – 9 sites total

Full traffic counts, lane counts, and traffic mix available for the whole measurement period. No reliability issues anticipated.

- Orange – 8 sites total

Orange rating indicates that full traffic counts, lane counts, and traffic mix (at least one of which) were not available for the site, for various reasons, and had to be synthesised based on other available data.

Example 1:

For several sites, traffic counters had recently stopped working due to a software update, and no counts were available from these sites for the measurement period. Where possible, we used data from a working count site that was judged to have a similar volume and flow to that of the road past the measurement site (e.g. the next counter site along the same stretch of State Highway).

Where no similar sites were available or working, we opted to use historic count data from a similar time period in a previous year. We opted to use traffic counts from the February-March period of the 2019 year, in order to avoid effects on traffic flows related to the COVID pandemic.

For historic traffic counts, we retrieved data for a minimum four week long period in 2019, and then averaged the traffic flow for week days and weekend days (or public holidays) separately, in order to reduce the likelihood of a single day or event causing abnormal traffic flow within the sample count period. For the overall AADT, the calculated AADT based on 2019 traffic counts was used.

Example 2:

In some cases, overall traffic counts were available from the nearest traffic counter (A), but we were unable to retrieve traffic mix data (separate heavy vehicle counts) due to unforeseen limitations with the count equipment. For these sites, we identified a traffic counter nearby which had traffic mix count capabilities, and which was expected to have a similar traffic mix to that of the traffic passing the noise logger location (counter B) (e.g. the next counter site along the same stretch of State Highway). Traffic mix percentages were derived from counter B, and these were applied to the overall traffic counts from counter A for the same time period. For the overall AADT, the 2022 calculated AADT from counter A was used.

For other similar cases, real time traffic mix data from counter B was unavailable for the measurement period due to the aforementioned software issues with count equipment. In these cases, we sourced historic traffic mix data from a similar period in 2019. The average week day and weekend day traffic mix was calculated from the historic data, similarly to the process explained in example 1 above, and this historic traffic mix was then applied to the overall traffic counts from counter A. Again, for the overall AADT, the 2022 calculated AADT from counter A was used.

▪ Red – 1 site only

For the Auckland A site (Huntly Bypass Expressway), we discovered that the telemetry site at the north end of the expressway was non-functional due to road layout changes since the opening of the expressway. There are no nearby permanent traffic count sites in the region from which traffic data could be sourced. Furthermore, given that the Huntly Bypass Expressway is a new stretch of highway completed in 2020, historic data from the counter was not considered a suitable alternative. A counter in Pokeno, 55 km north, was the nearest site from which we could extract real time traffic data, so this was used to estimate traffic passing the noise measurement site. Similar issues with the traffic mix data from Pokeno site were experienced (as explained in Orange Example 2 above) and so traffic mix data also had to be estimated based on data from a counter further north again (Rosehill). Therefore, for obvious reasons, findings from the Auckland A site should be treated with caution. For the overall AADT, the 2022 calculated AADT from the Pokeno counter was used.

4.0 DATA PROCESSING AND ANALYSIS

Following the completion of noise measurement at all sites, noise logging data from each mini logger was retrieved in CSV format, and then loaded into a separate spreadsheet for each site. These files were developed into the site specific data spreadsheets which have been published alongside this report, and a more detailed explanation of the structure of the available has been provided in section 5.0 below.

As requested by the Client, the main noise measurement output for the project was the daily average measured noise levels from each site in decibels (dB L_{Aeq} (24 hour)). The 24-hour averaged noise levels (in decibels L_{Aeq} (24 hour)) were calculated as the logarithmic average of the 1-minute average noise levels (L_{Aeq} (1 min)) from the measured data.

Weather and traffic data for each time period was mapped to the logged noise data. Weather condition thresholds were defined, such that where observed weather conditions exceeded the thresholds, the affected noise logger data entries were excluded from the overall calculation of L_{Aeq} (24 hour). For wind speed, separate thresholds for general wind speed exclusion and downwind speed exclusion were provided for. This enabled a lower wind speed exclusion threshold to be set where the noise logger was in a general downwind direction from the road, in accordance with the requirements in NZS 6801:2008 *Acoustics – Measurement of environmental sound*. However, separate downwind exclusion capability was not used in the final analysis, and the thresholds for general wind exclusion and downwind exclusion are the same.

A parameter for 'rain exclusion persistence' was also defined, such that where rainfall was noted in the weather station data, noise measurement results would continue to be excluded for a given period of time (in hours) to allow for road surface drying after a rain event.

Manual exclusion of logger values was also provided for, such that obvious outlier values within the measured data could be excluded. Outliers were identified by a simple visual inspection of the plotted data.

Once the weather data for each of the various sites had been sourced from the various weather stations in either the CliFlo (NIWA) and MetConnect (Met Service) networks, it was found that the weather observations generally did not correlate very well to observable weather effects in the measured noise data. It was theorised that this likely occurred due to localised weather patterns, and the geographical distance between weather stations and noise measurement positions.

In particular, data for wind speeds captured at the weather station sites were generally very high, presumably due to the fact that anemometer sensors at weather stations are typically located well above ground level (in the order of 10 metres above ground) within exposed open areas, such as at airports. In contrast most noise logging sites were located in areas where some degree of localised wind shielding would be expected (from terrain, foliage, built environment etc.), and generally lower wind speeds than would be the case in fully exposed areas. We found that, if the weather exclusion thresholds were set to correspond to the meteorological window limits defined in NZS 6801 (meteorological category 5), significant portions of the noise measurement period were excluded from the overall calculation of L_{Aeq} (24 hour) – even though there was limited evidence in the noise measurement data that high wind speeds were actually having a meaningful effect on the measured data.

Therefore, an iterative process of setting the weather exclusion thresholds for each site was used, with the goal of excluding samples where clearly observable weather effects could be seen in the measured results. Manual exclusion was also used to remove isolated weather effects (such as where localised rainfall at the noise logger position had not been captured by the weather station). In consultation with the client, the following thresholds were found to be appropriate:

- Wind speed: > 10 m/s
- Downwind speed: > 10 m/s (i.e. no specific downwind exclusion)
- Rain: > 0.2 mm

- Rain exclusion persistence: 2 hours

4.1 Baseline prediction of road noise

In addition to the measured noise data, a baseline traffic noise prediction was completed for each site. The purpose of the baseline predictions was to approximate the noise level that would be predicted through a standard road noise prediction exercise as typically completed by acoustic consultants in NZ. These predicted noise levels would be used for comparison against the measured noise levels, to determine any issues with the measured data, and also to assist with the calibration of new road surface correction coefficients.

Two methods of road traffic noise prediction were used across the various measurement sites in the project. For most sites, predictions were calculated with a manual hand calculation in line with the method described in the *Calculation of Road Traffic Noise* (CoRTN) standard (Department of Transport, 1988). In other cases (two sites only), baseline predictions used the CoRTN algorithm as applied within SoundPLAN computational noise modelling software.

All noise level predictions in the study are the given as the basic noise level with no surface correction coefficients applied. This was done to facilitate the application of the new surface coefficients which are being currently validated by Waka Kotahi NZTA. However, for ease of comparison to the existing surface correction regime, the respective existing surface correction coefficients (R_c and R_t) have been provided for each site, as defined in table 2.1 of (NZ Transport Agency, 2014).

4.1.1 CoRTN hand calculation

The calculation of the baseline predicted traffic noise level using a CoRTN hand calculation was implemented directly within the logged data spreadsheets. Predictions were calculated for every day where noise logging had occurred at each site, and an overall prediction using the calculated AADT. Inputs to the calculation included daily traffic count data (as described in section 3.3.2) and/or AADT, measured distances from the road edge line to the logger position as measured on site, posted speed limit, and estimated ground absorbency. In accordance with the standard, where the road had multiple lanes in each direction the CoRTN separated method was used.

As described in section 2.0 above, emphasis was placed on selecting sites for our noise measurements where road noise propagation conditions were relatively simple, for example, sites with generally flat topography, straight road layout, minimal reflections, no screening, etc. Therefore, the prediction of noise levels at these same sites was also considered to be relatively straightforward, and procedures in the standard CoRTN algorithm to account for less simple propagation conditions were not used. Provision to use these correction procedures were included in the CoRTN calculation spreadsheet for each site, and can be activated if necessary, but are not used by default. For the same reasons, the procedure within the CoRTN algorithm for dividing the road into calculation segments was not used.

The output of the CoRTN algorithm is expressed in dB L_{A10} (18 hour). We note that while CoRTN is fundamentally a day time (18-hour) noise prediction, with night time traffic excluded. However, in common practice it is assumed to be generally equivalent to a 24-hour average noise level, once a standard conversion factor is applied. For this project, the predicted noise levels in L_{Aeq} (24 hour) were calculated as the L_{A10} minus 3 dB, as is standard for road traffic noise prediction in NZ.

4.1.2 CoRTN applied with SoundPLAN software

For sites where the road noise propagation conditions were deemed to be slightly more complex, baseline predictions were undertaken using the CoRTN algorithm applied with SoundPLAN (version 8.2) 3D noise modelling software. The sites where this was used were the CHCA (Wigram) site, due to potential reflecting objects opposite the measurement site, and WLGA (Trentham), due to the hilly terrain around the measurement site.

Predictions were calculated for every day where noise logging had occurred at each site, and an overall prediction using the calculated AADT. Inputs to the calculation included daily traffic count data (as described in section 3.3.2) and/or AADT, posted speed limit, and estimated ground absorptency, among other factors. Externally sourced GIS data was used in the model, including terrain contours at 1 metre vertical resolution (derived from LiDAR survey data), and built environment.

As with the CoRTN hand calculations above, for the noise levels derived from SoundPLAN, a -3 dB conversion from L_{A10} to L_{Aeq} (24 hour) was used.

5.0 PUBLISHED DATA

The measurement data captured for the project have been made publicly available, to provide a source of empirical traffic noise data for use on other projects. The collection is formed of eighteen spreadsheets (.xlsx format) containing the raw data for each site, and a single summary spreadsheet collating the overall findings from each site. We have included a brief explanation of the available data in sections 5.1 and 5.2 below.

5.1 Summary spreadsheet

Key parameters in the summary spreadsheet are described below.

- Site ID and filenames – The site ID is a unique identifier for each noise measurement site, following a naming convention developed for the project (e.g. “CHCD Springfield”). The two digit site number (“19, 21, etc.”) were used internally during the project and are not of any importance in the final presentation of data. File names for the site specific data spreadsheets are also given.
- Percentage of the 24 hour period where logged values are counted (column L) – As noted in section 4.0 above, logged noise measurement values were excluded for various reasons, including weather conditions, extraneous noise, and partial days of measurement (set up and pack down days). This value refers to the percentage of the measurement day for which noise logger values are not excluded, and therefore included in the overall calculation of $L_{Aeq(24\text{ hour})}$. The percentage value gives a general guide to the reliability of the measured 24-hour average noise level in column X.
- Monitoring distance to nearest edgeline (column H) – The distance from the noise logger to the nearest edgeline of the nearest road lane, as measured on site and described further in section 3.0 above.
- Speeds (columns P – R) – The posted speed limit at the logger position is given. Also given is the ‘estimated actual speed’ being the average speed that we measured during our visits to each site as described in section 3.0 above. The speed used for the baseline prediction is also given, and as noted previously this was set to match the posted speed limit rather than the measured average speed.
- Surface type and year (columns S – T) – The top surface type and year are provided, as sourced from the Mobile Road database and verified on site with photos. During the site selection process it was attempted to place the noise loggers at positions where the road surface in all lanes was the same type and age, with minimal patching and repairs, and away from any surface type changes. Therefore, in most cases only one surface type and date is required to be listed for each site.
- Surface correction coefficients (columns U – V) – As discussed in section 4.1 above, for ease of comparison to the existing surface correction regime, the respective existing surface correction coefficients (R_c and R_t) have been provided for each site.
- Measured dB $L_{Aeq(24\text{ hour})}$ (column X) – The logarithmic average of all allowed noise measured levels for all days of the measurement period at each site. This is the main noise measurement deliverable for the project.
- Baseline prediction (columns Z - AH) – The baseline prediction method, traffic counts, and sound pressure level results, as described in section 4.1 above, are given. The daily predictions are given, based on daily traffic flow during the measurement period are provided, as well as an overall annual baseline prediction, based on the determined AADT for the site.
- General reliability rating (columns AJ – AK) – As described in section 3.3.2 above, due to the issues that we encountered with sourcing reliable traffic counts for the project, a general reliability rating was developed to indicate the extent of abstraction and interpolation involved with the traffic count data for each site (as given in columns AA – AC, and AF – AG). The reliability rating is given, with a short explanation for any low scores. It should be noted that the reliability rating is only intended to indicate

the reliability of the traffic counts associated with each site, and does not account for other potential reliability issues, such as a low percentage of the 24 hour period where logged values are counted, non-normal traffic flow, abnormal weather conditions, etc.

5.2 Site specific data spreadsheets

There are a total of eighteen site specific data spreadsheets containing all the raw data for the project. These spreadsheets were developed to have a consistent format, for ease of use. Key parameters in the spreadsheets are described below. In general, cells coloured in light green indicate manually entered values. Other cell colours are automated fields.

Summary tab

The Summary tab includes various general information about the site and measurements. All relevant fields in this tab are the same as that discussed for the overall Summary spreadsheet, described in section 5.1 above.

Figures tab

The Figures tab provides visualisation of the collected data over the full 7-day measurement period. Three plots are included, showing logged noise levels, observed weather conditions, and traffic counts. For the logged noise levels, values shown in blue are the 'allowed' values, included in the calculation of L_{Aeq} (24 hour), while values in grey are excluded, as described in section 4.0 above.

Logger data tab

The logger data tab includes the raw logged noise levels, and most of the data processing and calculation is done on this tab. The raw noise logger data is located in columns A – D, and comprises the total output from the logger device, including values for L_{Amax} , L_{Aeq} , and L_{Amin} in 1-minute increments for the duration of the measurement period. As discussed previously, only the L_{Aeq} field was used for this project. L_{Amax} and L_{Amin} are not used, but have been provided for completeness.

Other information included within the Logger data tab are as follows:

- Weather (columns I – N) – Observed weather conditions for each time slice of the measurement period are given. The source weather station provider (NIWA, etc.) and location are shown in cells J1 – J2. Cells K5 – K10 contain the weather exclusion threshold parameters. These can be set dynamically to exclude more or less logged data from the overall calculation of L_{Aeq} (24 hour). Where weather-related exclusions occur, column N displays a text string giving the reason.
- Traffic (columns P – S) – Traffic counts for each time slice of the measurement period are given. The source traffic counter is given in cells Q1 – S5.
- Manual exclusion (column U) – Provision to manually exclude values from the daily average measured noise level is given. Reasons for the manual exclusion are listed in these cells. There were various reasons for manually excluding logged noise levels, as described in section 4.0 above.

The layout of the logger data tab is shown in figure 5.1 below.

Figure 5.1 – ‘Logger data’ tab layout

Site details

Logger sheet

OH AC22401_6_2023_02_02_14h11m34s

Site ID

10

CHCA

Wigram

Weather station

17244

Rangitoto

< NWA agent name

< Location

Weather exclusion thresholds

General wind speed

Downloaded speed threshold

Downloaded bearing

Downloaded arc distance

Rule

Rule exclusion persistence

Traffic count station(s)

07610013

07620013

Dunbars overbridge inc

E of Dunbars overbridge Dec

Traffic

Manual exclusion

Reason

Allowed

Excluded

analog

L_{eq}

Time

Day (for 24 hour analysis)

Time

Day (for 24 hour analysis)

Time

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Time

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6.0 CONCLUSION

This report has provided a summary of the work undertaken by AES to support the Waka Kotahi NZTA-led road surface noise correction validation project. The project involved the deployment of noise logging equipment at eighteen different sites around the NZ State Highway network, across a six week period during the summer of 2023. A variety of road surface types were included in the spread of selected sites.

Real time weather observation and traffic count data has been sourced from various locations, and is presented alongside the measured noise levels. Various limitations of this externally sourced data have been discussed, with descriptions of the methods used to develop work arounds and alternative data sets.

Baseline traffic noise predictions were also undertaken for each measurement site. The purpose of the baseline predictions was to approximate the noise level that would be predicted through a standard road noise prediction exercise as typically completed by acoustic consultants in NZ. The new surface correction coefficients under validation by the Waka Kotahi NZTA team can be tested against these baseline predictions. The methods used for baseline prediction have been discussed, and the results are presented for comparison to the measured noise levels.

The full set of noise measurement data from this project has been made available for public use. Section 5.0 of this report has explained the available data, and how to navigate the respective spreadsheets. Key parameters within the supplied data set have been discussed. Lastly, for each of the eighteen measurement sites, a full detailed description of the measurement location, site conditions and equipment, along with photos and location maps can be found in appendix 1 below.

7.0 BIBLIOGRAPHY

7.1 Literature and standards

New Zealand Transport Agency (2014). *Guide to state highway road surface noise*. Retrieved on the 10th of May 2023 from: <https://www.nzta.govt.nz/>

Department of Transport Welsh Office (1988). *Calculation of Road Traffic Noise*. London: Her Majesty's Stationery Office. ISBN 0-11-550847-3. Retrieved on the 15th of March 2023, from: <https://www.bradford.gov.uk/>

Standards New Zealand. (2008) *Acoustics – Measurement of environmental sound* (AS/NZS Standard Number 6801). ISBN 1-96975-088-8.

7.2 Database sources

Author / publisher	Name		Open access	Date accessed	URL
Waka Kotahi New Zealand Transport Agency (NZTA)	National Speed Limit Register (NSLR)	Speed limits	Yes	January-February 2023	https://opendata-nzta.opendata.arcgis.com/datasets/NZTA::national-speed-limit-register-nslr/about
	NZ State Highway Centrelines	Road geometry	Yes	January-February 2023	https://catalogue.data.govt.nz/dataset/nz-state-highway-centrelines
	MetConnect	Weather	No	February-March 2023	https://nzta.metconnect.co.nz/
	State Highway Traffic Monitoring System (TMS)	Traffic counts	No	March-June 2023	https://tms.nzta.govt.nz/
	State highway traffic monitoring – annual average daily traffic	Annual traffic counts	Yes	March-June 2023	https://maphub.nzta.govt.nz/public/?appid=31305d4c1c794c1188a87da0d3e85d04
	RAMM database “top_surface” table	Road surface types	No	December 2022	-
	RAMM “carr_way” table	Road geometry	No	December 2022	-
	CAPTIF database	CPX data	No	December 2022	-

Author / publisher	Name		Open access	Date accessed	URL
Fujitsu	MobileRoad database	Road surface types	Yes – with restrictions	January-June 2023	https://mobileroad.org/
National Institute of Water and Atmospheric Research (NIWA) Taihoro Nukurangi	CliFlo National Climate Database	Weather	Yes – with restrictions	February-March 2023	https://cliflo.niwa.co.nz/
Argonaut	Road Runner	On road imagery	No	January-February 2023	https://roadrunner.argonautltd.co.nz/
Google	Google Maps	On road imagery	Yes	January-June 2023	https://www.google.com/maps
Land Information New Zealand (LINZ) Toitū Te Whenua	Aerial Imagery Basemap	Aerial imagery	Yes – with restrictions	January-June 2023	https://basemaps.linz.govt.nz/
	NZ Property Titles	Site access	Yes	January-February 2023	https://data.linz.govt.nz/
Herenga ā Nuku	Outdoor Access Map	Site access	Yes	January-February 2023	https://maps.herengaanuku.govt.nz/

8.0 APPENDIX 1 – NOISE LOGGING SITE DETAILS

8.1 Christchurch Site A

Project site number	19	
Site name	Wigram	
State Highway	76	
Location	RS	11
	Road ID	3318
	Distance	2424
	Logger side of road	Decreasing
	NZTM coordinates	1564284, 5176575
	Bearing from road to logger (ref. true north)	336
	Google Maps	https://goo.gl/maps/Dg6uvWhntP1bsP1z9
Traffic lanes	4 (2 each direction)	
Speed	Posted speed limit	100 km/h
	Measured average speed	96.1 km/h Sampled over 10 minutes around 1630 hours on a Friday
CPX	Acquired	Yes
	Acquisition date	21/06/2022
Surface	Surface	OGPA14
	Surface year	2014
	Source	MobileRoad
Topography	Flat road	Yes
	Flat berms	Yes
	Straight road	Slight concave curve (from logger perspective)
Extraneous noise	<ul style="list-style-type: none"> None anticipated 	
Logger location	<ul style="list-style-type: none"> Fixed to cycle path fence line. Logger distance from nearest traffic lane 13 metres 	
Equipment	Convergence Instruments NSRTW Mark 3 Serial Number: CnjcDNWS+30XiptwT4jZnD – AES #8 Laboratory calibrated: 20 th of May 2021 <i>The analyser was field calibrated before measurements, and the calibration checked after measurements. No significant change (+/- 0.1 dB) was noted.</i>	
Period	Start:	Thursday 2 nd February 2023, 1440 hours
	End:	Thursday 9 th February 2023, 1540 hours

Weather station	<i>Data service</i>	NIWA CliFlo
	<i>NIWA agent number</i>	17244
	<i>NIWA agent name</i>	Rangiora EWS
Traffic count	07610013 – E of Dunbars overbridge Inc 07620013 – E of Dunbars overbridge Dec	
Overall reliability score	Green	

8.1.1 CHCA location map



8.1.2 CHCA photos

Looking in increasing direction (left) and decreasing direction (right)

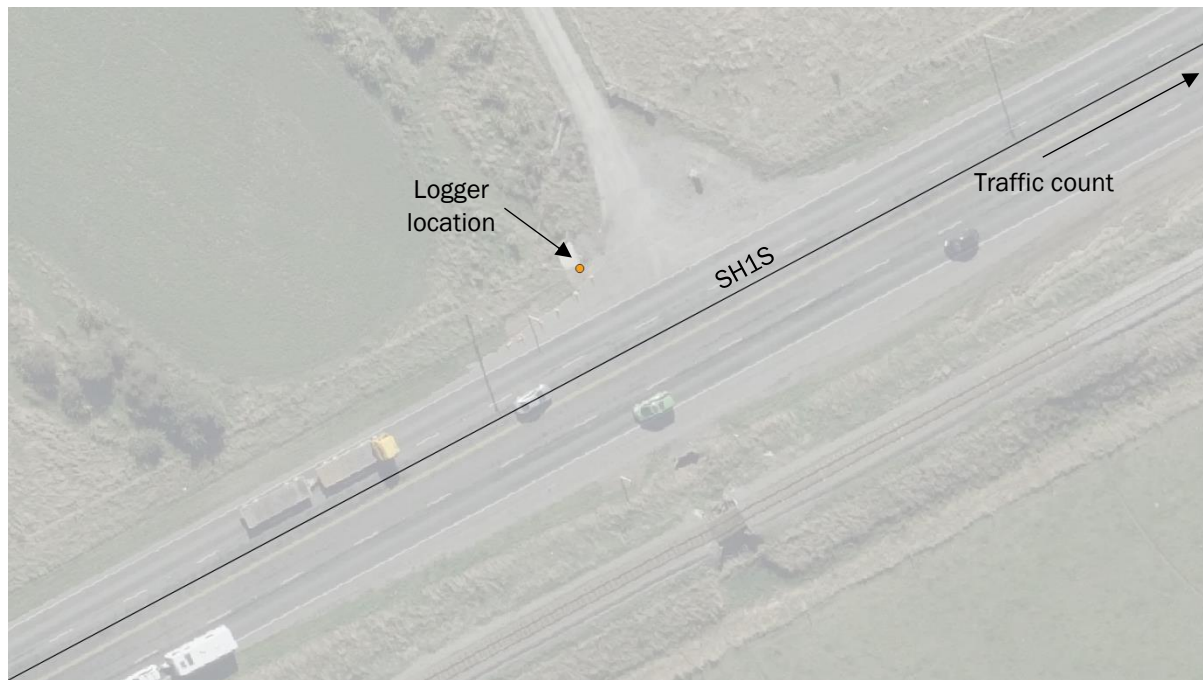


8.2 Christchurch Site B

Project site number	21	
Site name	Dunsandel	
State Highway	01S	
Location	RS	381
	Road ID	663
	Distance	2253
	Logger side of road	Decreasing
	NZTM coordinates	1536308, 5166240
	Bearing from road to logger (ref. true north)	334
	Google Maps	https://goo.gl/maps/VgGD7nGiQdpCHYAh8
Traffic lanes	4 (2 each direction)	
Speed	Posted speed limit	100 km/h
	Measured average speed	95.8 km/h Sampled over 10 minutes around 1130 hours on a Friday
CPX	Acquired	Yes
	Acquisition date	07/03/2019
Surface	Surface	2CHIP 3/5
	Surface year	02/2023 – Recent resurfacing at time of measurement
	Source	MobileRoad
Topography	Flat road	Yes
	Flat berms	Yes
	Straight road	Yes
Extraneous noise	<ul style="list-style-type: none"> Trains Central rumble strip – not sides 	
Logger location	<ul style="list-style-type: none"> Fixed to a post, just above a culvert, west side of the road. Logger distance from nearest traffic lane 6 metres 	
Equipment	Convergence Instruments NSRT Mark 3 Serial Number: AFF+J90S2deVKjvgwwh5vD – AES #23 Laboratory calibrated: 21 st of June 2022 <i>The analyser was field calibrated before measurements, and the calibration checked after measurements. No significant change (+/- 0.1 dB) was noted.</i>	
Period	Start:	Friday 3 rd February 2023, 1135 hours
	End:	Thursday 9 th February 2023, 0145 hours

Weather station	<i>Data service</i>	NIWA CliFlo
	<i>NIWA agent number</i>	39661
	<i>Name</i>	Chertsey CWS
Traffic count	01S00376 Burnham - Sth of Burnham Rd	
Overall reliability score	Green	

8.2.1 CHCB location map



8.2.2 CHCB photos

Looking in increasing direction

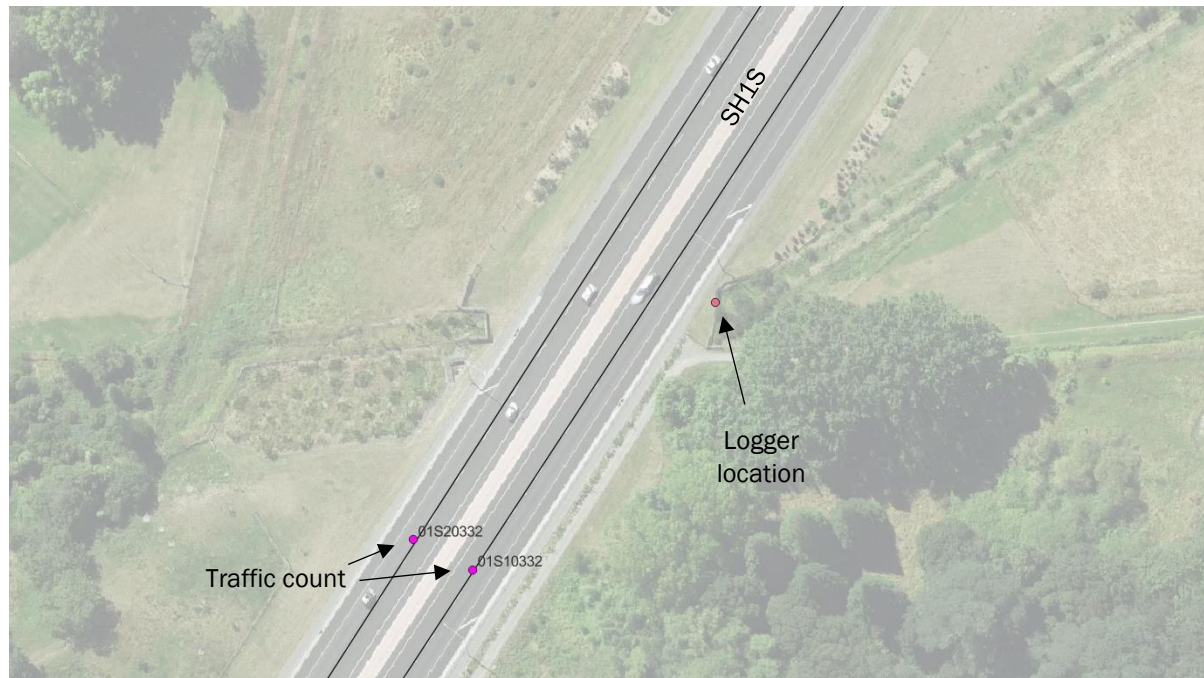


8.3 Christchurch Site C

Project site number	23	
Site name	Northwood	
State Highway	01S	
Location	RS	327
	Road ID	1716
	Distance	5285
	Logger side of road	Increasing
	NZTM coordinates	1568775, 5189476
	Bearing from road to logger (ref. true north)	121
	Google Maps	https://goo.gl/maps/NqGrQhGvVWgnM3C4A
Traffic lanes	4 (2 each direction)	
Speed	Posted speed limit	100 km/h
	Measured average speed	100.5 km/h Sampled over 10 minutes around 1600 hours on a Friday
CPX	Acquired	Yes
	Acquisition date	21/06/2022
Surface	Surface	EPA7
	Surface year	2018
	Source	MobileRoad
Topography	Flat road	Yes
	Flat berms	Yes
	Straight road	Yes
Extraneous noise	<ul style="list-style-type: none"> Large trees to the south of the logger location 	
Logger location	<ul style="list-style-type: none"> Fixed to a timber fence, east side of the road. Logger distance from nearest traffic lane 7.5 metres 	
Equipment	Convergence Instruments NSRTW Mark 3 Serial Number: AnnUJVWQOXe3KhlgR4pxtD – AES #9 Laboratory calibrated: 5 th of May 2021 <i>The analyser was field calibrated before measurements, and the calibration checked after measurements. No significant change (+/- 0.1 dB) was noted.</i>	
Period	Start:	Thursday 2 nd February 2023, 1540 hours
	End:	Wednesday 8 th February 2023, 2315 hours

Weather station	<i>Data service</i>	NZTA MetConnect
	<i>Station name</i>	Christchurch Aero AWS
Traffic count	01S10332 CHCH W Mway Btwn Belfast ramps and Groynes Inc 01S20332 CHCH W Mway Btwn Belfast ramps and Groynes Dec	
Overall reliability score	Green	

8.3.1 CHCC location map



8.3.1 CHCC photos

Looking in decreasing direction

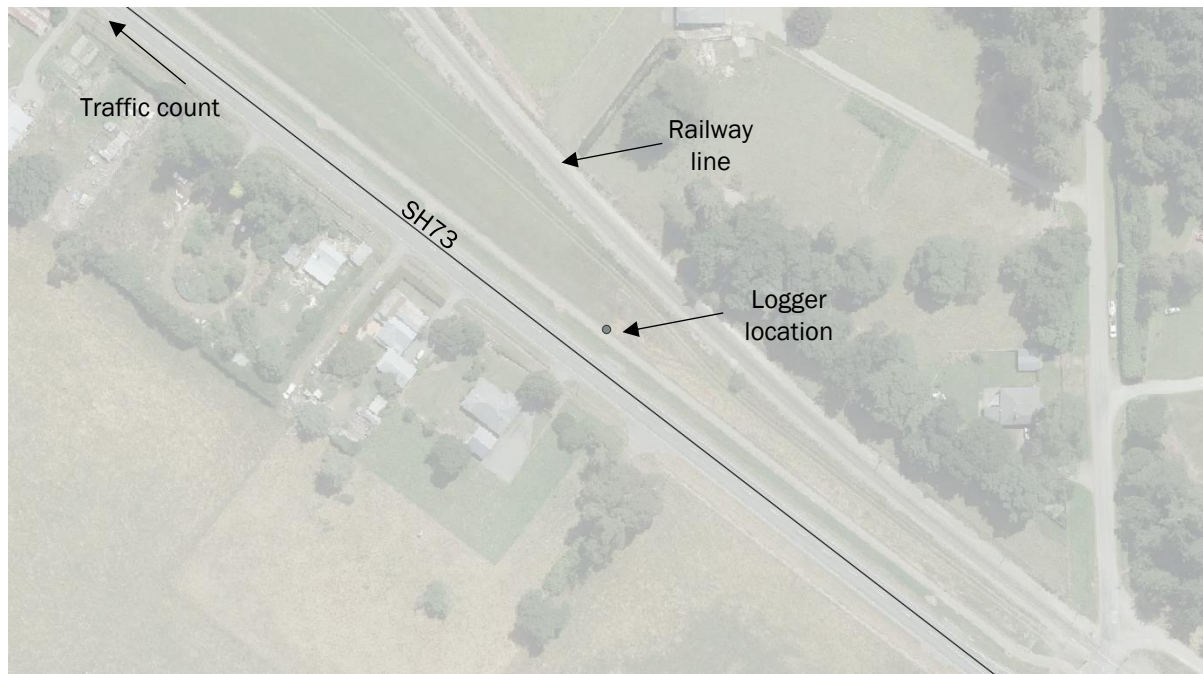


8.4 Christchurch Site D

Project site number	49	
Site name	Springfield	
State Highway	73	
Location	RS	52
	Road ID	679
	Distance	9867
	Logger side of road	Increasing
	NZTM coordinates	1514022, 5200577
	Bearing from road to logger (ref. true north)	56
	Google Maps	https://goo.gl/maps/Jpx5fvsRwKdTaMJr7
Traffic lanes	2 (1 each direction)	
Speed	Posted speed limit	100 km/h
	Measured average speed	95.0 km/h Sampled over 10 minutes around 1300 hours on a Friday
CPX	Acquired	Yes
	Acquisition date	05/03/2019
Surface	Surface	1CHIP 5
	Surface year	2011
	Source	MobileRoad
Topography	Flat road	Yes
	Flat berms	Yes
	Straight road	Yes
Extraneous noise	<ul style="list-style-type: none"> Trains 20 m to the northwest of the logger location Pedestrians on the path in front of the logger Cars accessing the driveways across the road 	
Logger location	<ul style="list-style-type: none"> Fixed to the fence line, north side of the road, between the road and the railway line Logger distance from nearest traffic lane 9.3 metres 	
Equipment	Convergence Instruments NSRT Mark 3 Serial Number: CPT2J12aOd2XqJPi50LRFD – AES #25 Laboratory calibrated: 21 st of June 2022 <i>The analyser was field calibrated before measurements, and the calibration checked after measurements. No significant change (+/- 0.1 dB) was noted.</i>	
Period	Start:	Friday 3 rd February 2023, 1235 hours
	End:	Friday 10 th February 2023, 1235 hours

Weather station	Data service	NZTA MetConnect
	Station name	Methven
Traffic count	07300064 SPRINGFIELD - Telemetry Site 11 - West of Township	
Overall reliability score	Green	

8.4.1 CHCD location map



8.4.2 CHCD photos

Looking in decreasing direction (left) and increasing direction (right)

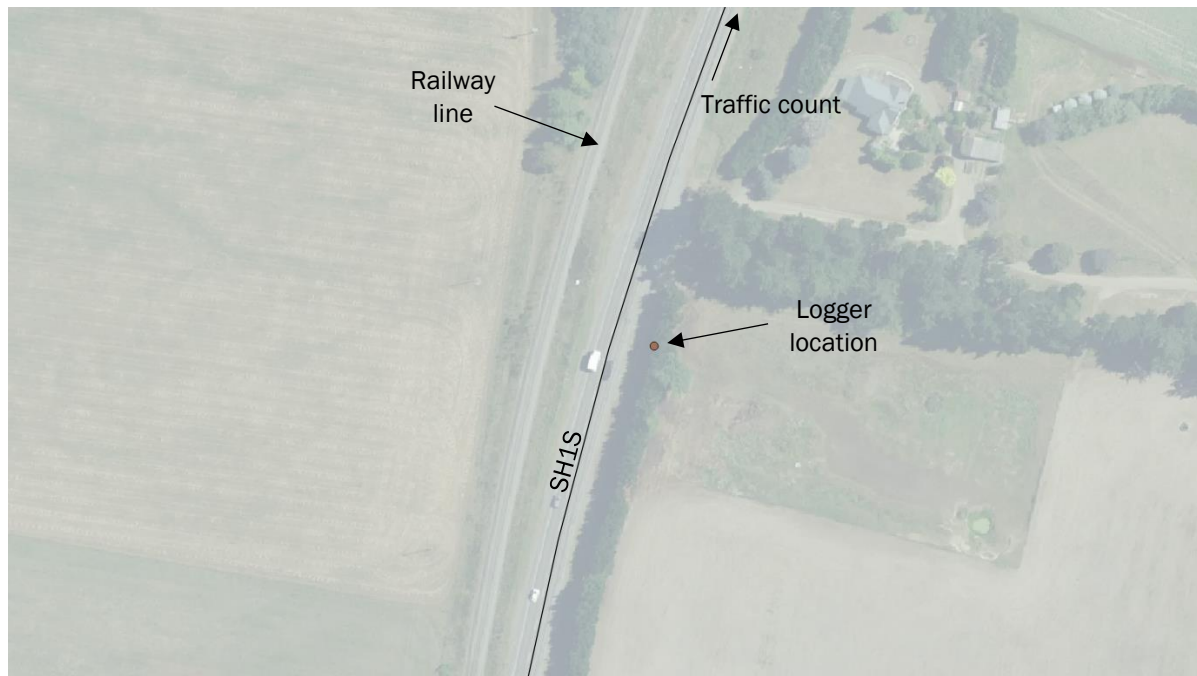


8.5 Christchurch Site E

Project site number	50	
Site name	Waipara	
State Highway	01S	
Location	RS	284
	Road ID	608
	Distance	2556
	Logger side of road	Increasing
	NZTM coordinates	1579008, 5229563
	Bearing from road to logger (ref. true north)	105
	Google Maps	https://goo.gl/maps/Gtip6tkHRnDk4F7t5
Traffic lanes	2 (1 each direction)	
Speed	Posted speed limit	100 km/h
	Measured average speed	90.7 km/h Sampled over 10 minutes around 1500 hours on a Friday
CPX	Acquired	No
	Acquisition date	-
Surface	Surface	2CHIP 2/4
	Surface year	2018
	Source	MobileRoad
Topography	Flat road	Yes
	Flat berms	Yes
	Straight road	Slight concave curve (from logger perspective)
Extraneous noise	<ul style="list-style-type: none"> Trains 35 m to the west Shelterbelt trees around logger 	
Logger location	<ul style="list-style-type: none"> Fixed to the fence line, east side of the road Logger distance from nearest traffic lane 9.9 metres 	
Equipment	Convergence Instruments NSRT Mark 3 Serial Number: AnD+LF0QUV2XIpNC64jZID – AES #24 Laboratory calibrated: 21 st of June 2022 <i>The analyser was field calibrated before measurements, and the calibration checked after measurements. No significant change (+/- 0.1 dB) was noted.</i>	
Period	Start:	Friday 3 rd February 2023, 1435 hours
	End:	Friday 10 th February 2023, 1445 hours

Weather station	<i>Data service</i>	NIWA CliFlo
	<i>NIWA agent number</i>	26607
	<i>Name</i>	Waipara West EWS
Traffic count	01S00285 WAIPARA - Telemetry Site 52 -(WIM Site)	
Overall reliability score	Green	

8.5.1 CHCE location map



8.5.2 CHCE photos

Looking in decreasing direction (left) and increasing direction (right)

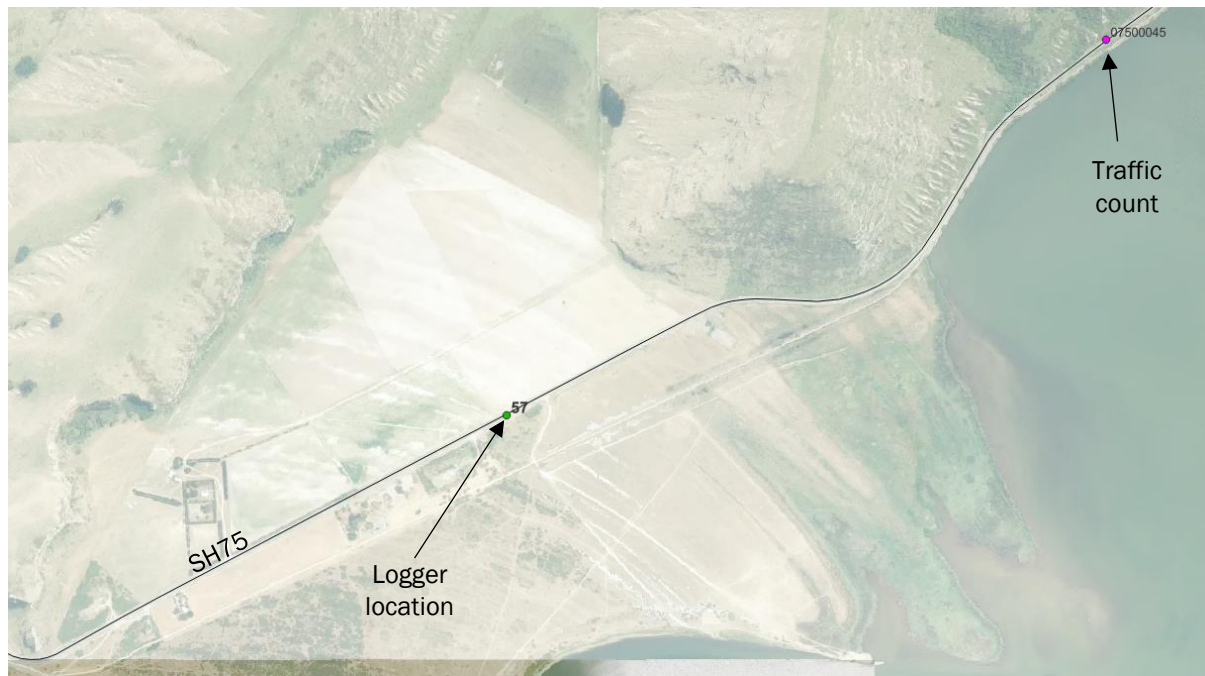


8.6 Christchurch Site F

Project site number	57	
Site name	Little River	
State Highway	75	
Location	RS	35
	Road ID	693
	Distance	8343
	Logger side of road	Decreasing
	NZTM coordinates	1576858, 5149142
	Bearing from road to logger (ref. true north)	120
	Google Maps	https://goo.gl/maps/EeCp7pqfrED1tiwU9
Traffic lanes	2 (1 each direction)	
Speed	Posted speed limit	80 km/h
	Measured average speed	80.3 km/h Sampled over 10 minutes around 1100 hours on a Friday
CPX	Acquired	No
	Acquisition date	-
Surface	Surface	2CHIP 2/4
	Surface year	2017
	Source	MobileRoad
Topography	Flat road	Yes
	Flat berms	Yes
	Straight road	Yes
Extraneous noise	<ul style="list-style-type: none"> None anticipated 	
Logger location	<ul style="list-style-type: none"> Fixed to the fence line, east side of the road Logger distance from nearest traffic lane 10.0 metres 	
Equipment	Convergence Instruments NSRT Mark 3 Serial Number: CPD0hvW68%3iDvSQ8rxHD – AES #22 Laboratory calibrated: 21 st of June 2022 <i>The analyser was field calibrated before measurements, and the calibration checked after measurements. No significant change (+/- 0.1 dB) was noted.</i>	
Period	Start:	Friday 3 rd February 2023, 1025 hours
	End:	Thursday 9 th February 2023, 2230 hours

Weather station	Data service	NZTA MetConnect
	Station name	Cooptown
Traffic count	07500045 Motukarara - East of McQueens Valley Rd	
Overall reliability score	Green	

8.6.1 CHCF location map



8.6.2 CHCF photos

Looking in decreasing direction (left) and increasing direction (right)

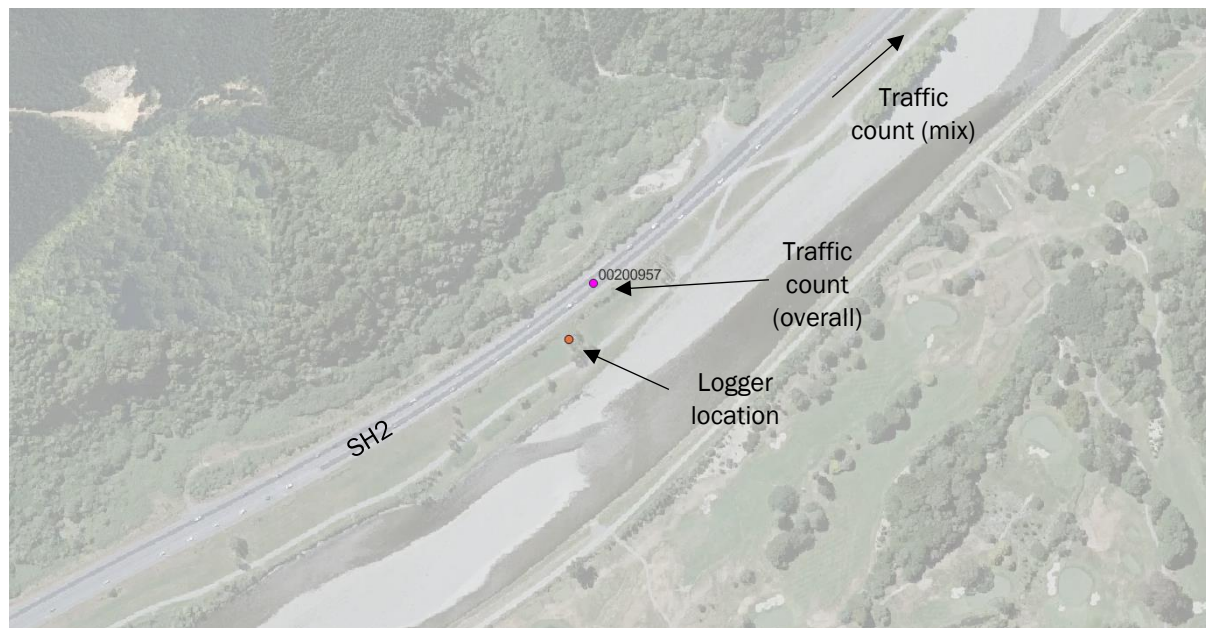


8.7 Wellington Site A

Project site number	42	
Site name	Trentham	
State Highway	2	
Location	RS	946
	Road ID	3276
	Distance	10860
	Logger side of road	Increasing
	NZTM coordinates	1769407, 5444526
	Bearing from road to logger (ref. true north)	140
	Google Maps	https://goo.gl/maps/p9jgv2HuavQwVT616
Traffic lanes	2 (1 each direction)	
Speed	Posted speed limit	100 km/h
	Measured average speed	91.7 km/h Sampled over 10 minutes around 1200 hours on a Thursday
CPX	Acquired	Yes
	Acquisition date	30/03/2023
Surface	Surface	OGPA10
	Surface year	01/2021
	Source	MobileRoad
Topography	Flat road	Yes
	Flat berms	West side is hilly bush. East side descends in elevation towards the river
	Straight road	Yes
Extraneous noise	<ul style="list-style-type: none"> River and tree noise 	
Logger location	<ul style="list-style-type: none"> Fixed to a tree on the east side of the road. Ground level at the tree was in the order of 2.5 metres below the height of the road surface. Logger mounted as high as practical on the tree (~2.0 metres above ground level) Logger distance from nearest traffic lane 26 metres 	
Equipment	Convergence Instruments NSRTW Mark 3 Serial Number: AnnUJVWQ0Xe3KhlgR4pxtD – AES #9 Laboratory calibrated: 5 th of May 2021 <i>The analyser was field calibrated before measurements, and the calibration checked after measurements. No significant change (+/- 0.1 dB) was noted.</i>	
Period	Start:	Wednesday 22 nd February 2023, 1150 hours
	End:	Thursday 2 nd March 2023, 1145 hours

Weather station	<i>Data service</i>	NIWA CliFlo
	<i>NIWA agent number</i>	40750
	<i>NIWA agent name</i>	Upper Hutt, Trentham EWS
Traffic count	<i>Overall counts source</i>	00200957 – Sth of Craigs Flat
	<i>Traffic mix (% HV) source</i>	00200954 – Sth of Whakatiki St HV data for the actual logging period was not available from this site due to a fault with the count station. Therefore, averaged historical data of weekday and weekend day %HV was used from a two month period over Feb-Mar 2019
Overall reliability score	Orange (Due to historical traffic mix)	

8.7.1 WLGA location map



8.7.2 WLGA photos

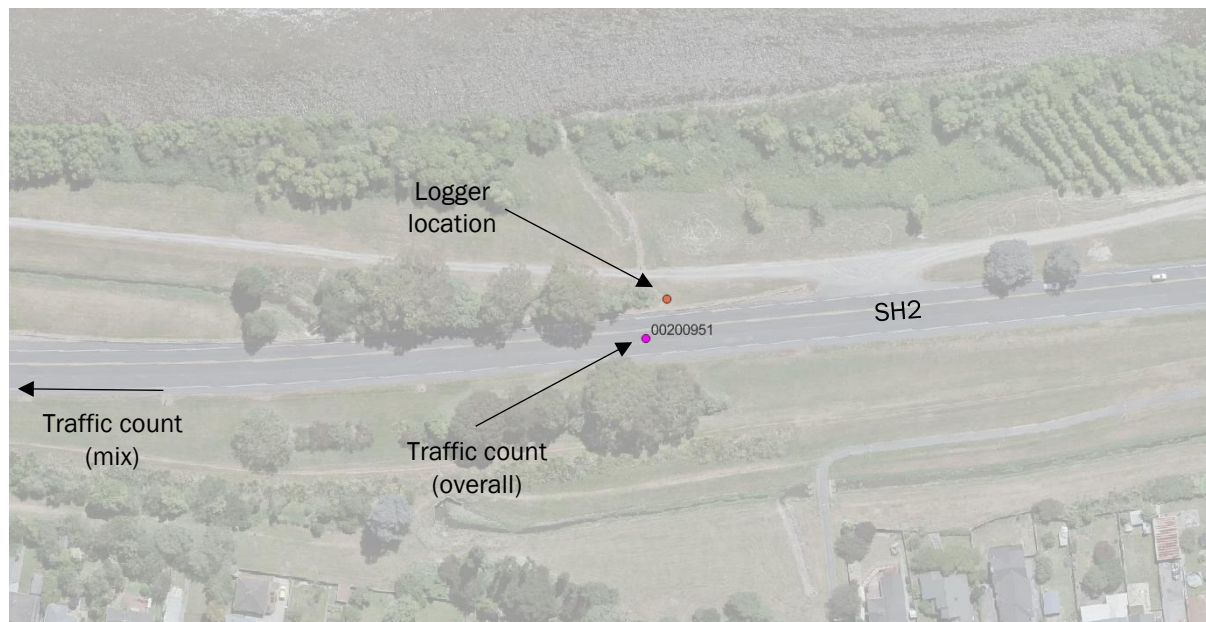


8.8 Wellington Site B

Project site number	43	
Site name	Upper Hutt	
State Highway	2	
Location	<i>RS</i>	946
	<i>Road ID</i>	1199
	<i>Distance</i>	5362
	<i>Logger side of road</i>	Increasing
	<i>NZTM coordinates</i>	1774313, 5446312
	<i>Bearing from road to logger (ref. true north)</i>	356
	<i>Google Maps</i>	https://goo.gl/maps/9raPnTHrCs5V26678
Traffic lanes	3 (1 decreasing/northbound, 2 increasing/southbound)	
Speed	<i>Posted speed limit</i>	100 km/h
	<i>Measured average speed</i>	90.4 km/h Sampled over 10 minutes around 1115 hours on a Thursday
CPX	<i>Acquired</i>	Yes
	<i>Acquisition date</i>	30/03/2023
Surface	<i>Surface</i>	OGPA10
	<i>Surface year</i>	2014
	<i>Source</i>	MobileRoad
Topography	<i>Flat road</i>	Yes
	<i>Flat berms</i>	South side has a slight elevation gain to the pedestrian path (located on a berm)
	<i>Straight road</i>	Yes
Extraneous noise	<ul style="list-style-type: none"> Tree noise 	
Logger location	<ul style="list-style-type: none"> Logger fixed to a waratah post cable tied to the traffic count box (northern side of the road) Logger distance from nearest traffic lane 4 metres 	
Equipment	Convergence Instruments NSRTW Mark 3 Serial Number: CnjcDNWS+30XiptwT4jZnD – AES #8 Laboratory calibrated: 20 th of May 2021 <i>The analyser was field calibrated before measurements, and the calibration checked after measurements. No significant change (+/- 0.1 dB) was noted.</i>	
Period	<i>Start:</i>	Wednesday 22 nd February 2023, 1100 hours
	<i>End:</i>	Thursday 2 nd March 2023, 1115 hours

Weather station	<i>Data service</i>	NIWA CliFlo
	<i>NIWA agent number</i>	40750
	<i>NIWA agent name</i>	Upper Hutt, Trentham EWS
Traffic count	<i>Overall counts source</i>	00200951 – Sth of Totara Park
	<i>Traffic mix (% HV) source</i>	00200954 – Sth of Whakatiki St HV data for the actual logging period was not available from this site due to a fault with the count station. Therefore, averaged historical data of weekday and weekend day %HV was used from a two month period over Feb-Mar 2019
Overall reliability score	Orange (Due to historical traffic mix from a different site)	

8.8.1 WLGB location map



8.8.2 WLGB photos

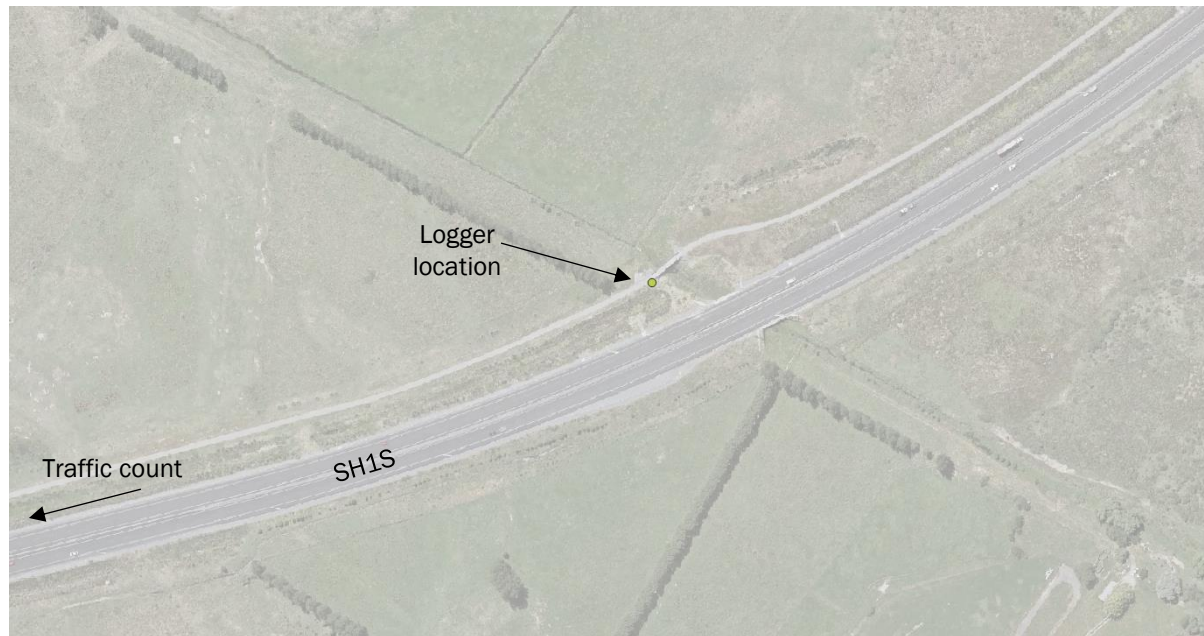


8.9 Wellington Site C

Project site number	23	
Site name	Peka Peka	
State Highway	01N	
Location	RS	1011
	Road ID	3564
	Distance	1616
	Logger side of road	Decreasing
	NZTM coordinates	1775248, 5476190
	Bearing from road to logger (ref. true north)	333
	Google Maps	https://goo.gl/maps/8eT1f32nTktSawt5
Traffic lanes	4 (2 each direction)	
Speed	Posted speed limit	100 km/h
	Measured average speed	99.0 km/h Sampled over 10 minutes around 1500 hours on a Thursday
CPX	Acquired	Yes
	Acquisition date	30/03/2023
Surface	Surface	OGPA10
	Surface year	2018
	Source	MobileRoad
Topography	Flat road	Yes
	Flat berms	Yes
	Straight road	Slight concave curve (from logger perspective)
Extraneous noise	<ul style="list-style-type: none"> Pedestrian noise from the pathway 	
Logger location	<ul style="list-style-type: none"> Fixed to the sign post, south side of the pedestrian bridge. Logger distance from nearest traffic lane 22 metres 	
Equipment	Convergence Instruments NSRT Mark 3 Serial Number: AnD+LF0QUV2XlpNC64jZID – AES #24 Laboratory calibrated: 21 st of June 2022 <i>The analyser was field calibrated before measurements, and the calibration checked after measurements. No significant change (+/- 0.1 dB) was noted.</i>	
Period	Start:	Wednesday 22 nd February 2023, 1445 hours
	End:	Thursday 2 nd March 2023, 1500 hours

Weather station	Data service	NZTA MetConnect
	Station name	Paraparaumu AWS
Traffic count	01K11023 – Kapiti Rd Int Mainline Southbound 01K21023 – Kapiti Rd Int Mainline Northbound	
Overall reliability score	Orange (Due to distance of traffic counter from logger site)	

8.9.1 WLGC location map



8.9.2 WLGC photos

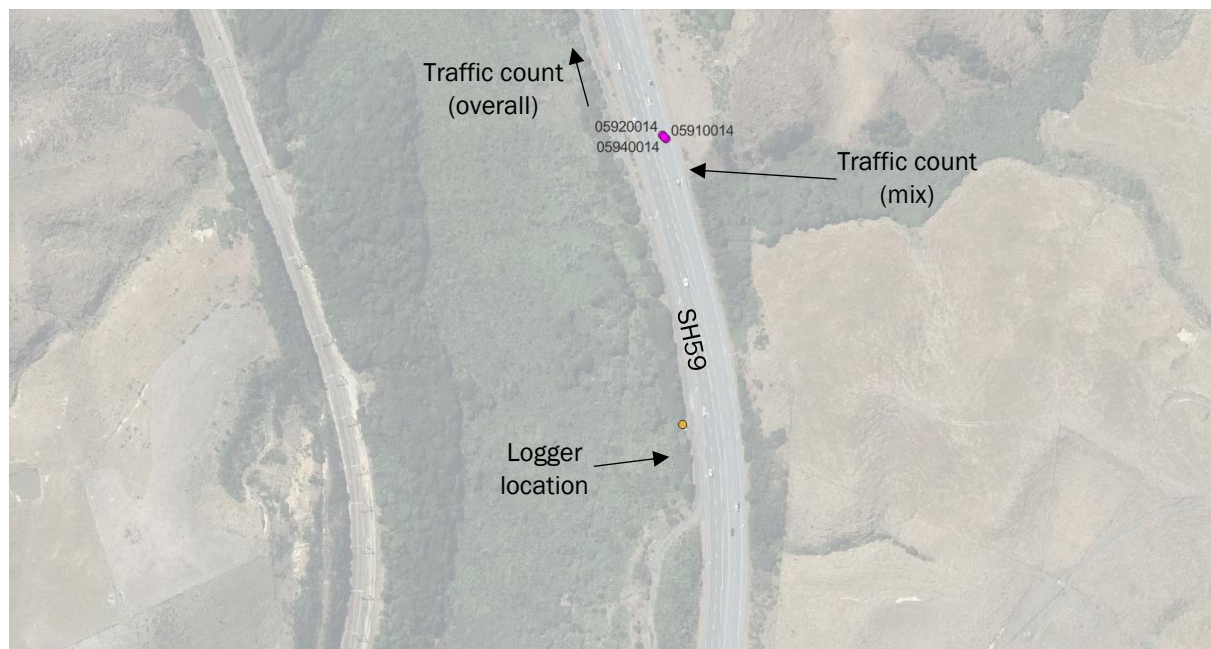


8.10 Wellington Site D

Project site number	51	
Site name	Plimmerton	
State Highway	59	
Location	<i>RS</i>	1035
	<i>Road ID</i>	2694
	<i>Distance</i>	14796
	<i>Logger side of road</i>	Decreasing
	<i>NZTM coordinates</i>	1757730, 5452431
	<i>Bearing from road to logger (ref. true north)</i>	265
	<i>Google Maps</i>	https://goo.gl/maps/gELy9mU2qqi1AZv36
Traffic lanes	4 (2 each direction)	
Speed	<i>Posted speed limit</i>	100 km/h
	<i>Measured average speed</i>	95.4 km/h Sampled over 10 minutes around 1400 hours on a Thursday
CPX	<i>Acquired</i>	Yes
	<i>Acquisition date</i>	30/03/2023
Surface	<i>Surface</i>	Decreasing (northbound): 2CHIP 3/5 (and/or RACK 3/5 – unsure) Increasing (southbound): RACK 3/5
	<i>Surface year</i>	Decreasing (northbound): 2022 Increasing (southbound): 2019
	<i>Source</i>	MobileRoad
Topography	<i>Flat road</i>	Yes
	<i>Flat berms</i>	Mostly yes. To the north on the east side of the road is a large, steep embankment
	<i>Straight road</i>	Concave curve (from logger perspective)
Extraneous noise	<ul style="list-style-type: none"> Trees behind the logger Pedestrians on the path in front of the logger 	
Logger location	<ul style="list-style-type: none"> Logger fixed to traffic light pole on the west side of the road Logger distance from nearest traffic lane 11 metres 	
Equipment	Convergence Instruments NSRT Mark 3 Serial Number: CPT2J12a0d2XqJPi50LRFD – AES #25 Laboratory calibrated: 21 st of June 2022 <i>The analyser was field calibrated before measurements, and the calibration checked after measurements. No significant change (+/- 0.1 dB) was noted.</i>	
Period	<i>Start:</i>	Wednesday 22 nd February 2023, 1310 hours
	<i>End:</i>	Thursday 2 nd March 2023, 0640 hours

Weather station	<i>Data service</i>	NZTA MetConnect
	<i>Station name</i>	Paraparaumu AWS
Traffic count	<i>Overall counts source</i>	05900011 – Nth of Wairaka Rd (Pukerua Bay)
	<i>Traffic mix (% HV) source</i>	05900014 – Taupo Swamp (averaged February 2023 weight classes) HV data for the actual logging period was not available in full from this site due to a fault with the count station. Therefore, averaged data of weekday and weekend day %HV was used from the available data for Feb 2023
Overall reliability score	Orange (Due to interpolated traffic data)	

8.10.1 WLGD location map



8.10.2 WLGD photos

Looking in increasing direction

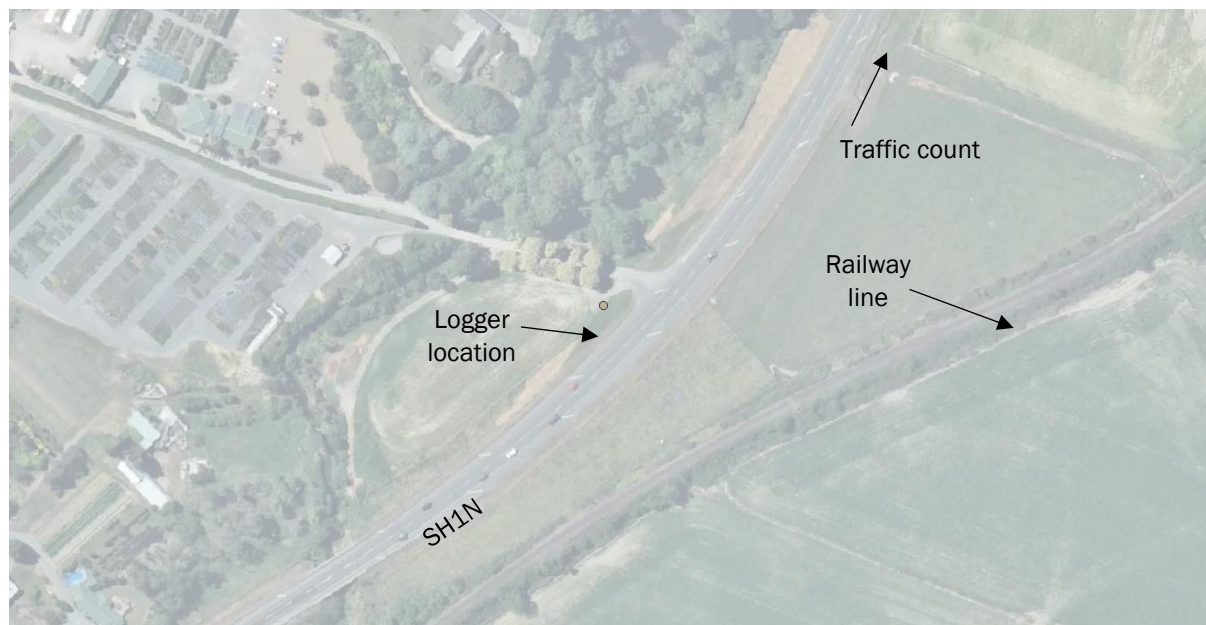


8.11 Wellington Site E

Project site number	72	
Site name	Manakau	
State Highway	01N	
Location	RS	985
	Road ID	1174
	Distance	9838
	Logger side of road	Decreasing
	NZTM coordinates	1786812, 5489420
	Bearing from road to logger (ref. true north)	309
	Google Maps	https://goo.gl/maps/EfLicRHqByhm8EMF9
Traffic lanes	2 (1 each direction)	
Speed	Posted speed limit	100 km/h
	Measured average speed	77.0 km/h Sampled over 10 minutes around 1415 hours on a Thursday
CPX	Acquired	Yes
	Acquisition date	30/03/2023
Surface	Surface	1CHIP 2
	Surface year	2012
	Source	MobileRoad
Topography	Flat road	Yes
	Flat berms	Mostly yes. To the north on the west side of the road is a small embankment
	Straight road	Concave curve (from logger perspective)
Extraneous noise	<ul style="list-style-type: none"> Vehicles turning into the garden centre Rail noise (~80 m away) 	
Logger location	<ul style="list-style-type: none"> Fixed to the fence line, west side of the road Logger distance from nearest traffic lane 16 metres 	
Equipment	Convergence Instruments NSRT Mark 3 Serial Number: AFF+J90S2deVKjvgwwh5vD – AES #23 Laboratory calibrated: 21 st of June 2022 <i>The analyser was field calibrated before measurements, and the calibration checked after measurements. No significant change (+/- 0.1 dB) was noted.</i>	
Period	Start:	Thursday 23 rd February 2023, 1145 hours
	End:	Thursday 2 nd March 2023, 1415 hours

Weather station	<i>Data service</i>	NIWA CliFlo
	<i>NIWA agent number</i>	41352
	<i>Name</i>	Levin EWS
Traffic count	01N00988 OHAU - Telemetry Site 56 Traffic data for the actual logging period was not available from this site due to a fault with the count station. Therefore, averaged data of weekday and weekend day traffic (and traffic mix) was used from the available data for a two month period over Feb-Mar 2019	
Overall reliability score	Orange (Due to interpolated traffic data)	

8.11.1 WLGE location map



8.11.2 WLGE photos

Looking in increasing direction

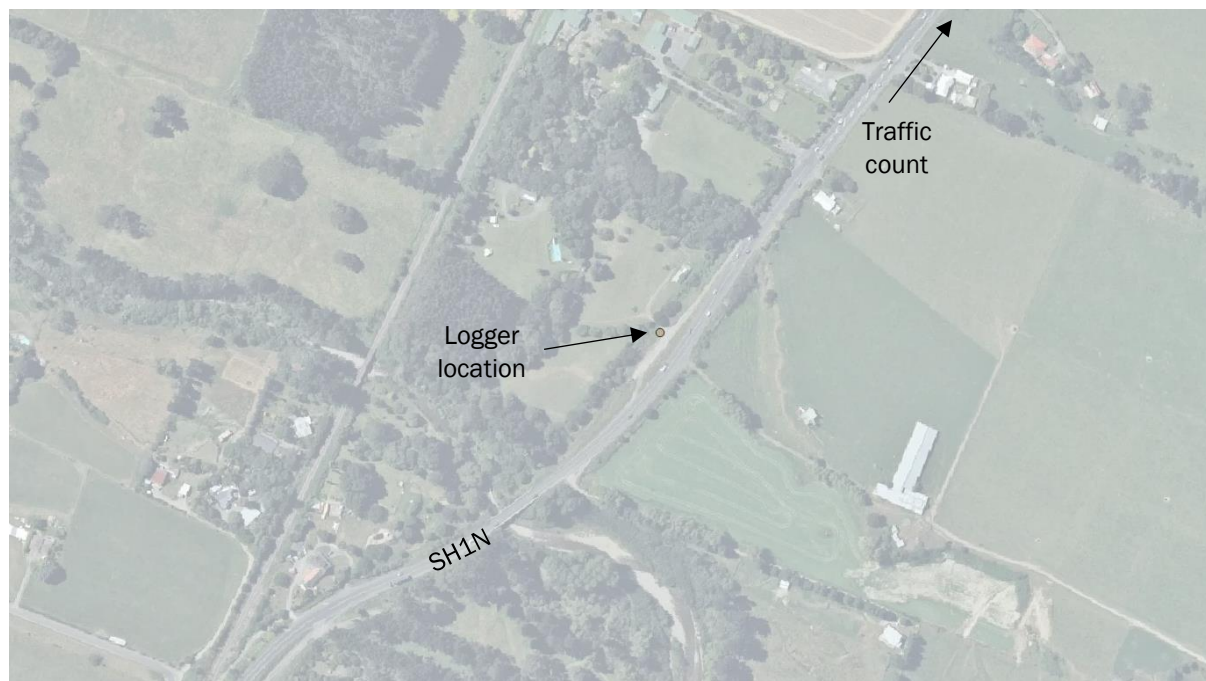


8.12 Wellington Site F

Project site number	73	
Site name	Kuku	
State Highway	01N	
Location	RS	985
	Road ID	1174
	Distance	6351
	Logger side of road	Decreasing
	NZTM coordinates	1788248, 5492483
	Bearing from road to logger (ref. true north)	302
	Google Maps	https://goo.gl/maps/uyUjQ3aooPE4NZbg9
Traffic lanes	2 (1 each direction)	
Speed	Posted speed limit	100 km/h
	Measured average speed	79.0 km/h Sampled over 10 minutes around 1430 hours on a Friday
CPX	Acquired	Yes
	Acquisition date	30/03/2023
Surface	Surface	2CHIP 2/4
	Surface year	2019
	Source	MobileRoad
Topography	Flat road	Some variation
	Flat berms	Some variation
	Straight road	Concave curve (from logger perspective)
Extraneous noise	<ul style="list-style-type: none"> Cars accessing driveways 	
Logger location	<ul style="list-style-type: none"> Fixed to the power pole (just to the south of the driveway to number 850) Logger distance from nearest traffic lane 20.0 metres 	
Equipment	Convergence Instruments NSRT Mark 3 Serial Number: CPD0hvW68% c3iDvSQ8rxHD – AES #22 Laboratory calibrated: 21 st of June 2022 <i>The analyser was field calibrated before measurements, and the calibration checked after measurements. No significant change (+/- 0.1 dB) was noted.</i>	
Period	Start:	Thursday 23 rd February 2023, 1220 hours
	End:	Thursday 2 nd March 2023, 1435 hours

Weather station	<i>Data service</i>	NIWA CliFlo
	<i>NIWA agent number</i>	41352
	<i>Name</i>	Levin EWS
Traffic count	01N00988 OHAU - Telemetry Site 56 Traffic data for the actual logging period was not available from this site due to a fault with the count station. Therefore, averaged data of weekday and weekend day traffic (and traffic mix) was used from the available data for a two month period over Feb-Mar 2019	
Overall reliability score	Orange (Due to interpolated traffic data)	

8.12.1 WLGF location map



8.12.2 WLGF photos

Looking in decreasing direction

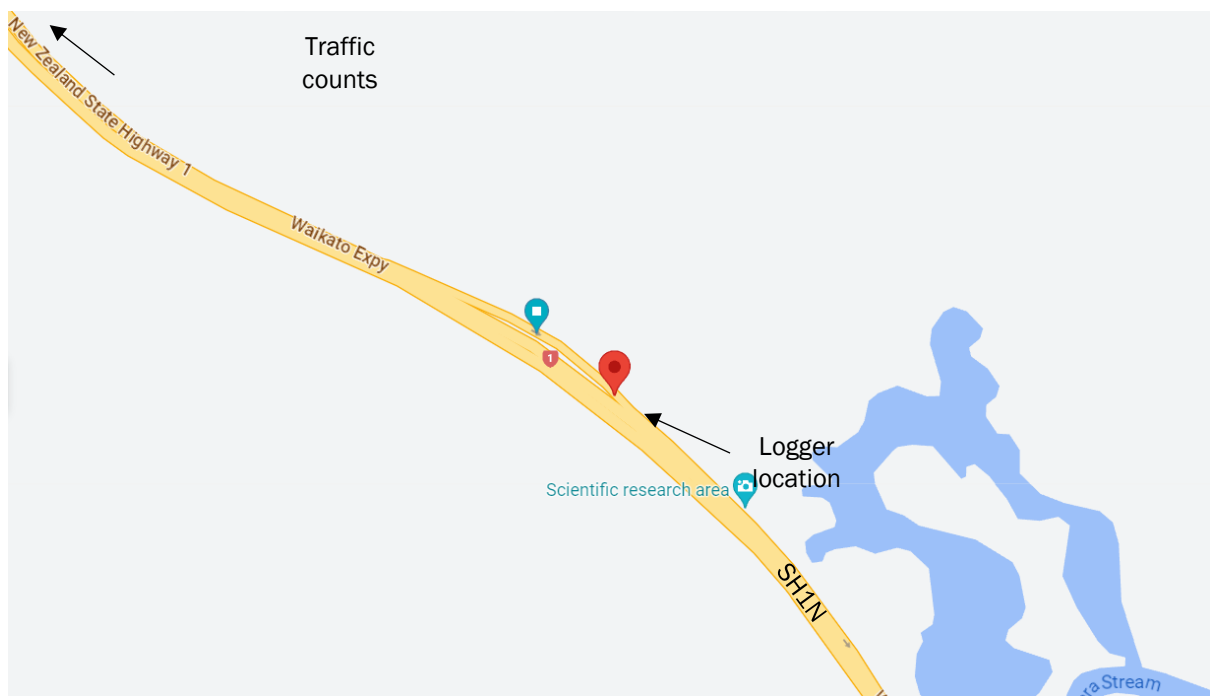


8.13 Auckland Site A

Project site number	5	
Site name	Huntly	
State Highway	01N	
Location	RS	513
	Road ID	3740
	Distance	11152
	Logger side of road	Increasing
	NZTM coordinates	1793908, 5837728
	Bearing from road to logger (ref. true north)	038
	Google Maps	https://goo.gl/maps/wdL3nxdNjjaribb87
Traffic lanes	4 (2 each direction), plus 1 southbound merging lane / on ramp	
Speed	Posted speed limit	100 km/h
	Measured average speed	101.5 km/h Sampled over 10 minutes around 1430 hours on a Friday
CPX	Acquired	Yes
	Acquisition date	21/06/2022
Surface	Surface	SMA10
	Surface year	2020
	Source	MobileRoad
Topography	Flat road	Yes
	Flat berms	Some variation
	Straight road	Convex curve, from logger perspective
Extraneous noise	<ul style="list-style-type: none"> Accelerating and merging vehicles Rumble strips (sides and centre strips) Vegetation 	
Logger location	<ul style="list-style-type: none"> On the east side of the road, just south of the 'Scientific Reserve' carpark. Mounted on the traffic barrier fence posts near the 100 kph sign on the on ramp (for vehicles leaving the Reserve) Logger distance from nearest traffic lane 13 metres 	
Equipment	Convergence Instruments NSRTW Mark 3 Serial Number: CnjcDNWS+30XiptwT4jZnD – AES #8 Laboratory calibrated: 20 th of May 2021 <i>The analyser was field calibrated before measurements, and the calibration checked after measurements. No significant change (+/- 0.1 dB) was noted.</i>	
Period	Start:	Thursday 9 th March 2023, 1430 hours
	End:	Friday 17 th March 2023, 1240 hours

Weather station	<i>Data service</i>	NIWA CliFlo
	<i>NIWA agent number</i>	26117
	<i>NIWA agent name</i>	Hamilton, Ruakura 2 EWS
Traffic count	<i>Overall counts source</i>	01N20477 – SH1 SH2 Interchange NB 01N10477 – SH1 SH2 Interchange SB The traffic site that we ended up using for overall traffic counts was in Pokeno (55 km north of the noise logger location). No closer traffic data was able to be found due to faults with traffic counters nearby to the logger.
	<i>Traffic mix (% HV) source</i>	01N20459 – Rosehill - Telemetry Site 7 - NB (Park Estate) 01N10459 – Rosehill - Telemetry Site 7 - SB (Park Estate) HV data for the actual logging period was not available from the Pokeno site. Therefore, alternative traffic mix data was sourced from the Rosehill Telemetry site. Due to technical issues, actual (real time data) was not available from this site, so averaged historical data of weekday and weekend day %HV was used from a one month period over Mar 2019.
Overall reliability score	Red (Due to distance of traffic count sites from logger location, historical traffic mix)	

8.13.1 AKLA location map



8.13.2 AKLA photos

Looking in decreasing direction (left) and increasing direction (right)

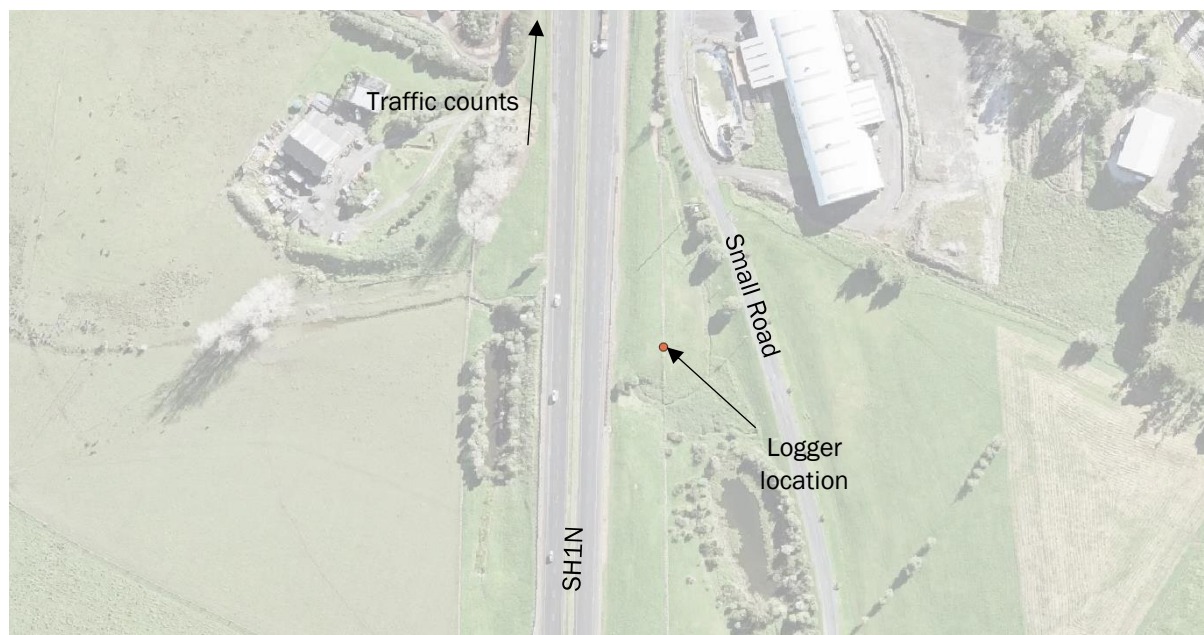


8.14 Auckland Site B

Project site number	54	
Site name	Silverdale	
State Highway	01N	
Location	RS	398
	Road ID	2613
	Distance	854
	Logger side of road	Increasing
	NZTM coordinates	1748671, 5944578
	Bearing from road to logger (ref. true north)	092
	Google Maps	https://goo.gl/maps/Wvta6udxs66C8oT97
Traffic lanes	4 (2 each direction)	
Speed	Posted speed limit	100 km/h
	Measured average speed	85.2 km/h Sampled over 10 minutes around 0940 hours on a Friday
CPX	Acquired	No
	Acquisition date	-
Surface	Surface	OGPA10
	Surface year	Northbound 2018 and 2021 Southbound 2015 and 2018
	Source	MobileRoad
Topography	Flat road	Yes
	Flat berms	East side of SH (logger side) has a small raised bund and swale behind
	Straight road	Yes
Extraneous noise	<ul style="list-style-type: none"> Traffic on Small Road (going to Snow Planet etc.) Accelerating and merging vehicles Rumble strips 	
Logger location	<ul style="list-style-type: none"> Logger fixed to the SH corridor fence, east side of the road, between the SH corridor and Small Road Logger distance from nearest traffic lane 23 metres 	
Equipment	Convergence Instruments NSRTW Mark 3 Serial Number: AnnUJVWQ0Xe3KhlgR4pxtD – AES #9 Laboratory calibrated: 5 th of May 2021 <i>The analyser was field calibrated before measurements, and the calibration checked after measurements. No significant change (+/- 0.1 dB) was noted.</i>	
Period	Start:	Thursday 9 th March 2023, 1000 hours
	End:	Friday 17 th March 2023, 0925 hours

Weather station	Data service	NZTA MetConnect
	Station name	Whangaparaoa AWS
Traffic count	Overall counts source	01N20398 – SH1 Silverdale Interchange NB (N11) 01N10398 – SH1 Silverdale Interchange SB (N11) There were some anomalies with data from the Silverdale Interchange count sites, where zero counts were recorded for certain times of the day (mostly throughout the night time). Therefore, data for March 2023 was averaged (separate weekday and weekend day averages) to synthesise traffic counts for this site
	Traffic mix (% HV) source	01N20391 – SH1 Orewa Off Ramp to Millwater Off Ramp NB 01N10391 – SH1 Orewa On Ramp to Millwater On Ramp SB HV data from the Silverdale Interchange count sites was not available. Therefore, averaged traffic mix data of weekday and weekend day %HV was used for March 2023
Overall reliability score	Orange (Due to historical traffic mix from a different site)	

8.14.1 AKLB location map



8.14.2 AKLB photos

Looking in decreasing direction (left) and increasing direction (right)



8.15 Auckland Site C

Project site number	76	
Site name	Rosehill	
State Highway	01N	
Location	<i>RS</i>	448
	<i>Road ID</i>	1734
	<i>Distance</i>	12592
	<i>Logger side of road</i>	Increasing
	<i>NZTM coordinates</i>	1772693, 5892996
	<i>Bearing from road to logger (ref. true north)</i>	071
	<i>Google Maps</i>	https://goo.gl/maps/kdMUp4eey2mKRVsMA
Traffic lanes	4 (2 each direction)	
Speed	<i>Posted speed limit</i>	100 km/h
	<i>Measured average speed</i>	83.6 km/h Sampled over 10 minutes around 1115 hours on a Friday
CPX	<i>Acquired</i>	No
	<i>Acquisition date</i>	-
Surface	<i>Surface</i>	OGPA10
	<i>Surface year</i>	Northbound 2012 Southbound 2013
	<i>Source</i>	MobileRoad
Topography	<i>Flat road</i>	Yes
	<i>Flat berms</i>	Solid site fences and vegetation on the east side of the road
	<i>Straight road</i>	Yes
Extraneous noise	<ul style="list-style-type: none"> Tree noise Rumble strips 	
Logger location	<ul style="list-style-type: none"> Logger fixed to the SH corridor fence, east side of the road, between the SH corridor and the stormwater reserve (off Kilmacrennan Drive) Logger distance from nearest traffic lane 15 metres 	
Equipment	Convergence Instruments NSRT Mark 3 Serial Number: AnD+LF0QUV2XlpNC64jZID – AES #24 Laboratory calibrated: 21 st of June 2022 <i>The analyser was field calibrated before measurements, and the calibration checked after measurements. No significant change (+/- 0.1 dB) was noted.</i>	
Period	<i>Start:</i>	Thursday 9 th March 2023, 1115 hours
	<i>End:</i>	Friday 17 th March 2023, 0045 hours

Weather station	<i>Data service</i>	NZTA MetConnect
	<i>Station name</i>	Paraparaumu AWS
Traffic count	01N20459 – Rosehill - Telemetry Site 7 - NB (Park Estate) 01N10459 – Rosehill - Telemetry Site 7 - SB (Park Estate) Traffic data for the actual logging period was not available from this site due to a fault with the count station. Therefore, averaged data of weekday and weekend day traffic (and traffic mix) was used from the available data for a one month period over March 2019	
Overall reliability score	Orange (Due to historic traffic data)	

8.15.1 AKLC location map



8.15.2 AKLC photos



8.16 Auckland Site D

Project site number	77	
Site name	Paerata	
State Highway	22	
Location	RS	0
	Road ID	1771
	Distance	8478
	Logger side of road	Increasing
	NZTM coordinates	1767544, 5887019
	Bearing from road to logger (ref. true north)	250
	Google Maps	https://goo.gl/maps/67SDJzVtRJWCtp68
Traffic lanes	2 (1 each direction)	
Speed	Posted speed limit	80 km/h
	Measured average speed	70.1 km/h Sampled over 10 minutes around 1230 hours on a Thursday
CPX	Acquired	No
	Acquisition date	-
Surface	Surface	SMA14
	Surface year	2008
	Source	MobileRoad
Topography	Flat road	Yes
	Flat berms	Slight downhill in increasing direction
	Straight road	Some variation, particularly on the eastern (Wesley College) side of the road
Extraneous noise	<ul style="list-style-type: none"> Traffic turning into Puhitahi Hill Road (160 m north), school traffic (including buses) Rumble strips 	
Logger location	<ul style="list-style-type: none"> Logger fixed to the W-barrier on the west side of the road Logger distance from nearest traffic lane 10 metres 	
Equipment	Convergence Instruments NSRT Mark 3 Serial Number: CPD0hvW68%c3iDvSQ8rxHD – AES #22 Laboratory calibrated: 21 st of June 2022 <i>The analyser was field calibrated before measurements, and the calibration checked after measurements. No significant change (+/- 0.1 dB) was noted.</i>	
Period	Start:	Thursday 9 th March 2023, 1220 hours
	End:	Friday 17 th March 2023, 1135 hours

Weather station	<i>Data service</i>	NIWA CliFlo
	<i>NIWA agent number</i>	2006
	<i>Name</i>	Pukekohe EWS
Traffic count	02200008 – SH22 West of Glenbrook Rd	
Overall reliability score	Green	

8.16.1 AKLD location map



8.16.2 *AKLD photos*

Looking in decreasing direction

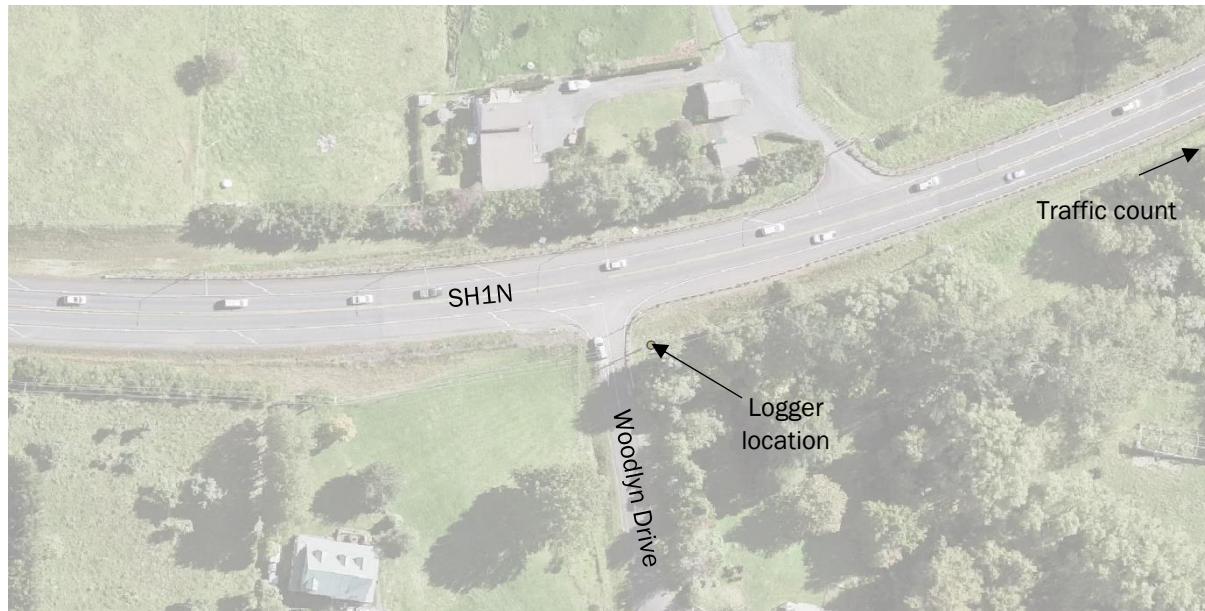


8.17 Auckland Site E

Project site number	80	
Site name	Karaka	
State Highway	22	
Location	<i>RS</i>	0
	<i>Road ID</i>	307
	<i>Distance</i>	3649
	<i>Logger side of road</i>	Increasing
	<i>NZTM coordinates</i>	1770420, 5889662
	<i>Bearing from road to logger (ref. true north)</i>	169
	<i>Google Maps</i>	https://goo.gl/maps/ZtHoEcmaPTzDiFXv6
Traffic lanes	2 (1 each direction)	
Speed	<i>Posted speed limit</i>	80 km/h
	<i>Measured average speed</i>	72.7 km/h Sampled over 10 minutes around 1200 hours on a Friday
CPX	<i>Acquired</i>	No
	<i>Acquisition date</i>	-
Surface	<i>Surface</i>	SMA10
	<i>Surface year</i>	2021
	<i>Source</i>	MobileRoad
Topography	<i>Flat road</i>	At the bottom of a small valley with the road climbing up gradually either side of the logger location. Also, the road looks like it has a slight camber to the south
	<i>Flat berms</i>	Some variation
	<i>Straight road</i>	Slight convex curve from logger perspective
Extraneous noise	<ul style="list-style-type: none"> Vehicles turning into Woodlyn Drive, and the private driveway opposite Tree noise Rumble strips 	
Logger location	<ul style="list-style-type: none"> Fixed to a power pole, south side of the SH, east side of Woodlyn Drive Logger distance from nearest traffic lane 13 metres 	
Equipment	Convergence Instruments NSRT Mark 3 Serial Number: AFF+J90S2deVKjvgwwh5vD – AES #23 Laboratory calibrated: 21 st of June 2022 <i>The analyser was field calibrated before measurements, and the calibration checked after measurements. No significant change (+/- 0.1 dB) was noted.</i>	
Period	<i>Start:</i>	Thursday 9 th March 2023, 1200 hours
	<i>End:</i>	Friday 17 th March 2023, 1110 hours

Weather station	<i>Data service</i>	NIWA CliFlo
	<i>NIWA agent number</i>	2006
	<i>Name</i>	Pukekohe EWS
Traffic count	02200003 – SH22 West of Oira Rd	
Overall reliability score	Green	

8.17.1 AKLE location map



8.17.2 *AKLE photos*

Looking in decreasing direction



8.18 Auckland Site F

Project site number	82	
Site name	Pokeno	
State Highway	2	
Location	RS	0
	Road ID	1774
	Distance	3226
	Logger side of road	Decreasing
	NZTM coordinates	1782049, 5879051
	Bearing from road to logger (ref. true north)	346
	Google Maps	https://goo.gl/maps/m1x7qpomk4SUGaQu9
Traffic lanes	2 (1 each direction)	
Speed	Posted speed limit	90 km/h
	Measured average speed	80.9 km/h Sampled over 10 minutes around 1430 hours on a Friday
CPX	Acquired	No
	Acquisition date	-
Surface	Surface	2CHIP 2/4
	Surface year	2014
	Source	MobileRoad
Topography	Flat road	Yes
	Flat berms	Mostly yes
	Straight road	Yes
Extraneous noise	<ul style="list-style-type: none"> Cars turning into driveways Rumble strips 	
Logger location	<ul style="list-style-type: none"> Fixed to the wooden fence of the Southern Palms site, north side of the road Logger distance from nearest traffic lane 10.0 metres 	
Equipment	Convergence Instruments NSRT Mark 3 Serial Number: CPT2J12aOd2XqJPI50LRFD – AES #25 Laboratory calibrated: 21 st of June 2022 <i>The analyser was field calibrated before measurements, and the calibration checked after measurements. No significant change (+/- 0.1 dB) was noted.</i>	
Period	Start:	Thursday 9 th March 2023, 1540 hours
	End:	Friday 17 th March 2023, 1430 hours

Weather station	<i>Data service</i>	NIWA CliFlo
	<i>NIWA agent number</i>	26117
	<i>Name</i>	Hamilton, Ruakura 2 EWS
Traffic count	00200002 – MANGATAWHIRI - Telemetry Site 74	
Overall reliability score	Green	

8.18.1 AKLF location map



8.18.2 AKLF photos

Looking in decreasing direction (left) and increasing direction (right)

