Local Authority Vehicle Emission GIS Mapping

THE TRANSPORT AGENCY

Prototype Development for Four Local Authorities

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Document history and status

Revision	Date	Description	By	Review	Approved
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Contents

Executive Summary

Estimates of the emissions to air from motor vehicles travelling on all roads in the territorial local authorities (TLAs) of Tasman, Nelson, Marlborough and Gisborne have been produced for the 2015 year.

The estimates have been produced through collation of available input data from The Transport Agency systems into a format that is able to be processed within a spatial framework to calculate and produce a visual representation of total emissions across the highway network.

The input data used to obtain traffic counts, fleet profile and gradients is considered to be suitable for providing a baseline vehicle emission dataset. A comparison of the results has been made with the TLA air emission inventories and the results, with the more recent studies, show good agreement. A comparison has also been made with the existing National Vehicle Emission Dataset 2013 (NVED2013) for state highways, and this also shows good agreement.

There was some limited manual manipulation of data to ensure that the categorisation between one way and two way roads was applied correctly, along with ensuring the direction of one way roads was applied correctly. While this was a small task for this prototype dataset, it would expand considerably when extending the prototype to cover the rest of New Zealand. Some future discussion is recommended to ensure the correct path forward is chosen.

Important note about your report

The sole purpose of this report and the associated services performed by Jacobs is to identify the inputs and methodology used in building a Local Authority Vehicle Emission Dataset as well as presenting and reviewing the outputs in accordance with the scope of services set out in the contract between Jacobs and the Client. That scope of services, as described in this report, was developed with the Client.

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1. Introduction

Jacobs has been engaged by The Transport Agency to develop a prototype of a Local Authority Vehicle Emission Dataset (LAVED). This prototype dataset is a spatial dataset representing calculated vehicle emissions for the local road and state highway network in four local authorities in New Zealand. The four local authorities used in the prototype are Tasman, Nelson, Marlborough and Gisborne. Emissions have been calculated for the pollutants CO, NO_x, $PM_{2.5}$, PM_{10}, PM_{BT} and for CO_2.

This work follows on from the creation of the NVED2013 in 2015 that only included state highways. The methodology developed in this previous work has been followed for this project where appropriate, however, new input datasets have now become available.

The following report outlines the methodology that has been used to create the LAVED. It then discusses the input datasets that have been used along with any specific steps that have been taken to ensure the inputs were suitable. It then outlines and gives findings for three separate validation steps. The report finally outlines the outputs that have been produced, as well as defining all of the deliverables that have been supplied back to The Transport Agency.

2. Methodology

The methodology used to develop the prototype dataset is very similar to that used to create the state highway NVED2013 dataset. The key to the methodology is being able to gather all of the required emission parameters (traffic count, fleet profile, speed and gradient) into the same road sections. Once a road section contains all the necessary information then the appropriate emission factors can be applied to calculate its emission values. These results are then organised into suitable outputs for further analysis and visualisation.

The methodology can be broken down into three steps:

1) Merging the inputs
2) Calculating the emissions
3) Writing the outputs

The following sections explain these steps in more detail.

2.1 Merging the inputs

Jacobs has used three datasets as inputs for the LAVED: two road centrelines supplied by Core Logic, and a national Digital Elevation Model (DEM) derived from LINZ topographic data.

Core Logic provides a routable road centreline that includes speed information. This dataset is called TilRdCentreline. They also have an ongoing contract to supply the Transport Agency, and most of the TLAs, with another road centreline dataset that combines the agencies RAMM centreline data, and spatially aligns it to their own TilRdCentreline dataset. This new road centreline data is referred to as RAMM_ONRC.

While the two centrelines have been spatially aligned, the features themselves have different start and end points. This is because they have two separate uses, one is a routable network while the other is an asset database. When bringing the speed data across from the TilRdCentreline, care has to be taken to find all the individual TilRdCentreline road sections that overlap an individual RAMM_ONRC road section, and then use a weighted mean calculation to find the speed based on the length of the overlap. This merged road centreline dataset is called the Merged_ONRC.

The Merged_ONRC is then overlaid over the DEM to determine gradients. Before this takes place, all two way roads are separated into distinct directional road centrelines. The direction of one way roads is also very important, and a manual process was completed to ensure this. The roads are then split into 25 metre lengths, to match the resolution of the DEM, and each individual 25m length receives a gradient.

2.2 Calculating the emissions

Each 25m length of road section has a speed, and this can be used to look up its appropriate emission factor from the VEPM emission table. This look up uses a combination of the speed, the ratio of Light Vehicles (LV) to Heavy Vehicles (HV), and the gradient category (-6°, -4°, -2°, 0°, 2°, 4°, 6°) to determine the CO, CO_2, NO_x, $PM_{2.5}$ & PM_{BT} emission factors to apply to each road section.

The emissions are calculated independently for LV and HV. The Fleet Profile ratio is applied to the traffic volume to obtain LV and HV traffic volumes. These volumes are then multiplied by the appropriate emission factor to get LV emissions and HV emissions (g/km/day) for each road section. These are then added together to obtain the combined emission rate (g/km/day) for each road section. The PM_{10} emission rate is calculated by adding together the $PM_{2.5}$ and PM_{BT} emission rates.

2.3 Writing the Outputs

Once the emissions have been calculated they are written to the output file called Raw_Emissions. This contains the emission values (g/km/day) for each 25m section of road.

The individual 25m sections are then aggregated back into the RAMM_ONRC road sections based on their unique RAMM asset identifiers. As they are aggregated the emission values are added together using a weighted mean based on the component lengths. This output file is called ONRC_Emissions.

2.4 Using FME

The above steps take place in models created within the Feature Manipulation Engine (FME) software. Models can be created in FME that allow the user to fully automate the processes involved with calculating the emissions. As well as the FME model being very flexible and fully repeatable, it is a graphical tool that clearly illustrates, and documents, the workflow that is taking place.

The FME models have been built so that, within certain constraints, the input datasets can be exchanged easily. These constraints mainly relate to the attribute names that the FME model is expecting to find in the input data. As shown with the alignment steps discussed in Section 3.1 there is also an expectation that the input datasets can be meaningfully spatially matched.

The calculation process has been split into two separate FME models.

1) LAVED_CombineRoadCentrelines.fmw
   This model merges the speed data from the TilRdCentreline dataset on to the RAMM_ONRC dataset. It uses a series of spatial and table joins, and then assigns the speeds using a weighted mean. The output of this model is the Merged_ONRC dataset, and this is effectively a replica of the RAMM_ONRC dataset with the addition of the speed attribute.
2) LAVED_AssignEmissionsToRoads.fmw
   This model transforms the Merged_ONRC dataset into two outputs, the Raw_Emissions and the ONRC_Emissions. The Merged_ONRC roads are first overlain over the DEM to assign gradients, and then the emissions are calculated to produce the Raw_Emissions dataset. The Raw_Emissions are then aggregated to produce the ONRC_Emissions dataset.

A manual checking process has been undertaken between the two FME models which ensures that the one way roads have been tagged correctly, and that their directionality is correct. This has highlighted some issues with the input RAMM_ONRC dataset that are discussed in Section 7.

3. Inputs

3.1 Spatial Data

To calculate vehicle emissions using VEPM we require four pieces of information from the road network. These are traffic counts, fleet profile, average speed and road gradient.

This information has been gathered from three different data sources obtained from The Transport Agency, as outlined in Table 1.

Table 1 Input data for LAVED Prototype

Parameter	Source	Database layer	Database field used	Date	Notes
Traffic Count	Core Logic	RAMM_ONRC	trafficVolume	2015	This attribute is provided from Core Logic's RAMM_ONRC dataset, but is brought directly through from the Transport Agency or TLAs own RAMM databases. It represents the average daily traffic count of a particular road section.
Fleet Profile	Core Logic	RAMM_ONRC	hvyVehicleVolume	2015	This attribute is provided from Core Logic's RAMM_ONRC dataset, but is brought directly through from the Transport Agency or TLAs own RAMM databases. It represents the average daily traffic count for heavy vehicles of a particular road section, and is used in conjunction with the trafficVolume attribute to calculate the light/heavy vehicle ratio.
Speed	Core Logic	TilRdCentreLine	routableSpeed	2015	This attribute is provided from Core Logic's Road Network dataset. It represents a realistic speed that a vehicle can traverse the road segment, and incorporates speed constraints such as surface type, intersections, roundabouts etc.
Gradient	LINZ	Nidem_25nztm.img	*derived*		This is a raster dataset that has an elevation value every 25 metres. The road centrelines are overlaid over this elevation surface to derive the gradient of a particular road section.

The input datasets are further illustrated in Appendices F – I of this report.

3.2 VEPM

Jacobs has created a table that has emission rate values for CO, CO_2, NO_x, $PM_{2.5}$ and PM_{BT} for every combination of speed, fleet profile and gradient using the Vehicle Emissions Prediction Model (VEPM) version 5.1. We have used the batch run functionality within the model to produce this table. PM_{10} values have been calculated by adding together the values for $PM_{2.5}$ & PM_{BT}.

The parameters used in the VEPM emission rate calculations are shown in Table 2. The minimum and maximum speeds are set by the VEPM model and values outside this range are corrected to either the minimum or maximum value allowed.

Table 2 Input parameters used in VEPM to develop emission factors

Year	Minimum Speed	Maximum Speed	Speed step size	Average trip length
2015	10 km/h	100 km/h	1 km/h	9.1 km

The average trip length of 9.1 km used in the VEPM calculations is taken from the Household Travel Survey 2010 produced by the Land Transport Safety Authority (LTSA), and all other VEPM optional inputs except the gradient have used the VEPM defaults.

The fleet profile used in the calculations is VEPM's default profile for 2015, and is shown in Table 3.

Table 3 VEPM fleet profile

Light Vehicle	Car petrol	68.80%
	Car diesel	8.00%
	Car hybrid	0.80%
	Light commercial petrol	2.90%
	Light commercial diesel	12.90%
	Light commercial hybrid	0.20%
Heavy Vehicle	Bus	0.60%
	Heavy commercial 3.5-7.5 tonne	1.40%
	Heavy commercial 7.5-12 tonne	0.70%
	Heavy commercial 12-15 tonne	0.20%
	Heavy commercial 15-20 tonne	0.30%
	Heavy commercial 20-25 tonne	1.10%
	Heavy commercial 25-30 tonne	1.00%
	Heavy commercial >30 tonne	1.20%

4. Validation

4.1 Comparisons to Air Emission Inventories

Jacobs has sourced air emission inventories from Tasman, Nelson, Marlborough and Gisborne TLAs. These inventories provide estimates for contaminant emissions for specific areas within each of the TLA boundaries. In order to compare with the inventory emission data, the LAVED prototype data has been clipped using the same Census Area Unit (CAU) boundaries that have been used in the inventories, and then emissions from all roads within the areas have been summed.

The inventories reviewed for the comparison with LAVED in chronological order were as follows:

- Air Emission Inventory for the Gisborne District, 2005, Endpoint
- Air Emission Inventory – Richmond, 2010, Environet Ltd
- Blenheim Air Emission Inventory, 2012, Environet Ltd
- Assessment of PM_{10} Richmond emissions by meshblock 2013 estimate, Environet Ltd
- Nelson Air Emission Inventory 2014, Environet Ltd

Tables 4 - 7 have been produced to compare the results between the inventories and the LAVED prototype.

Table 4 Gisborne Air Emission Inventory 2005 comparison with LAVED

	Area (Ha)	PM_{10} (kg/day)	CO (kg/day)	CO_2 (t/day)	NO_X (kg/day)
Gisborne Air Emission Inventory 2005	835,500	150	12,736	445	2,041
LAVED prototype 2015	838,560	50		288	894

Table 5 Richmond Air Inventory 2010 comparison with LAVED

	Area (Ha)	PM_{10} (kg/day)	CO (kg/day)	CO_2 (t/day)	NO_X (kg/day)
Richmond Air Emission Inventory 2010	1368	28	1534	84	296
Richmond Air Emission Update 2013	1368	8			
LAVED prototype 2015	1368	6	556	38	97

Table 6 Blenheim Air Emission Inventory 2012 comparison with LAVED

	Area (Ha)	PM_{10} (kg/day)	CO (kg/day)	CO_2 (t/day)	NO_X (kg/day)
Blenheim Air Emission Inventory 2012	1,930	12	1,123	52	152
LAVED prototype 2015	1,930	9	858	53	147

Table 7 Nelson Air Emission Inventory 2014 comparison with LAVED

	Area (Ha)	PM_{10} (kg/day)	CO (kg/day)	CO_2 (t/day)	NO_X (kg/day)
Nelson Air Emission Inventory 2014 (Total)	**9,316**	**29**	**3,381**	**160**	**469**
Airshed A	998	7	835	44	116
Airshed B1	758	4	463	24	64
Airshed B2	2,898	10	1,198	63	166
Airshed C	4,662	8	885	29	123
LAVED prototype 2015 (Total)	**9,412**	**30**	**2,760**	**188**	**478**
Airshed A	940	5	455	30	72
Airshed B1	699	5	428	29	74
Airshed B2	2,908	11	1,037	71	184
Airshed C	4,865	9	840	58	148

The available inventories from the TLAs were for different years, ranging from 2005 to 2014, whereas the year for the LAVED prototype is for 2015.

There have been large differences in the data sources over the years for which the inventories have been produced. However, the calculation has always been of the same general form, involving an estimate of the vehicle kilometres travelled and derivation of an estimate for the emission factor generally applied across the whole area based on an average speed.

In the earlier inventories, such as the Gisborne inventory, the emission factors were based on the Ministry of Transport's NZTER emission factor data base with level of service e.g. suburban road as a surrogate for speed.

The Vehicle Emissions Prediction Model (VEPM) Version 3.0 was in use by 2010 with the Richmond Inventory and the VEPM 5.0 in use by the 2012 Blenheim inventory.

Various approaches have been used for VKT estimation including Ministry of Transport data, transport models and projections based on population. The more recent inventories, such as Richmond 2013 and Nelson 2014, use data from the Transport Agency. It can be assumed that input data reliability has improved over time due to better data capture and would more closely align to the data in the LAVED.

Jacobs considers that there are too many variables in data inputs and quality to make meaningful comparisons with the LAVED prototype estimates for the older inventories. Since 2012, when the VEPM 5.0 was used with the inventories reviewed, a reasonable alignment of the results to the LAVED predictions appears to have been achieved bearing in mind that emissions per VKT are generally predicted to decrease with time due to changes in vehicle engine technology.

We also note that Environet has adjusted the emission factor model for the local wintertime average temperature, which affects the cold start (increases emissions with colder temperatures). The LAVED (and NVED) do not account for ambient temperature but use the model default, which is based on the average Auckland wintertime temperature. The temperature variable could be investigated to account for regional differences in the future.

Environet does not state any assumptions in relation to gradient, but we would assume this has not been incorporated in the TLA inventories based on the aggregated nature of the input data. We note that both the Environet and LAVED studies both make adjustments to the default fleet profile based on local data. LAVED, however, does this adjustment based on road section, so is able to show the contribution locally such as on roads with high percentages of heavy vehicles such as around ports.

We note that we had some difficulty spatially matching the airsheds described in the Nelson TLA inventory. This has resulted in slightly different reported areas as shown in Table 7. However, LAVED has achieved fairly consistent estimates for 2015 compared to those reported in the Nelson inventory. Overall we can conclude that the tool, with relatively consistent inputs, gives very similar result to those achieved with traditional inventory approaches.

4.2 Comparison to NVED2013

A random sample of state highway road sections (5 for each district) has been compared against the existing NVED2013 dataset. Values for CO_2 have been used and the results presented in Table 7.

Table 8 NVED2013 comparison with LAVED

	NVED2013 CO_2 kg/km/day	LAVED 2015 CO_2 kg/km/day	% difference
Nelson			
1	5089	5240	2.88%
2	3687	3749	1.65%
3	4604	4999	7.90%
4	2584	2588	0.15%
5	3499	3526	0.77%
Tasman			
1	2762	2803	1.46%
2	2209	2265	2.47%
3	1261	1272	0.86%
4	2720	2761	1.48%

5	3150	3300	4.55%
Marlborough			
1	1695	1731	2.08%
2	734	744	1.34%
3	3142	3343	6.01%
4	1326	1454	8.80%
5	1096	1073	-2.14%
Gisborne			
1	620	600	-3.33%
2	615	627	1.91%
3	3757	4045	7.12%
4	624	678	7.96%
5	356	328	-8.54%

All comparisons of the LAVED against the NVED2013 were shown to be within 10%, reflecting the similar methodology used for the two datasets. It is likely that the small differences between the results are mainly a result of the change in input data. The new RAMM_ONRC dataset, while in essence derived from the Transport Agency's RAMM centreline for the state highway component, has different road sections and definitions in numerous places when compared with the input dataset used for NVED2013. The resulting change in these definitions has meant that traffic counts may not always represent exactly the same length of road, and therefore may have been adjusted up or down relative to the NVED2013 traffic counts. At an individual road level, this variation ends up being a significant influence on the comparison results, and is likely to be a bigger factor than changes in emission factors between 2013 and 2015.

The key reason for this comparison was to make sure that by using different inputs, and a slightly different methodology, that the LAVED still provided comparable results to NVED2013. As these results are recorded on a road by road basis, they eliminate any averaging over larger areas that may tend to even out any errors. It has therefore acted as a good double check to ensure errors have not been introduced during the LAVED emission estimates.

5. Outputs

There are three output datasets created as part of the LAVED prototype. The first of these, the Merged_ONRC dataset, is a working dataset that has been created by merging the two input datasets provided by Core Logic. This merged dataset is then used to create the final two output datasets which comprise of the Raw Emissions as they are calculated, and the ONRC Emissions that have been averaged to conform to the ONRC road sections.

Appendices A – E of this report illustrate the ONRC_Emissions outputs as maps.

5.1 Merged_ONRC

Figure 1 shows an example of the Merged ONRC output in Nelson. This dataset is in effect a replica of the Core Logic supplied RAMM_ONRC dataset, with the unnecessary attributes being removed and the speed attribute added.

Figure 1 Example of Merged ONRC output

Table 9 summarises the attribute definitions for the Merged_ONRC output.

Table 9 Merged_ONRC output attribute definitions

Field Name	Field Type	Description
assetCarriageWayID	Long Integer	RAMM ID that represents the road section uniquely for each authority
assetRoadID	Long Integer	RAMM ID that represents the road uniquely for each authority
ONRCClass	Text	One Network Road Classification, e.g. primary collector, arterial, low volume
hvyVehicleTrafficVolume	Double	Average Daily Traffic count for heavy vehicles (from RAMMS)
trafficVolume	Double	Average Daily Traffic count (from RAMMS)
Speed	Long Integer	Average speed in km/hr
LaneFlow	Text	Indicates whether road is ‘One way’ or ‘Two way’

5.2 Raw_Emission

Figure 2 shows an example of the Raw Emission output in Nelson. This output represents a separate emission value for each direction of the road. This represents the spatial resolution at which the actual calculations have been made, which in this case has been 25 metres.

Figure 2 Example of Raw_Emission output

Table 10 summarises the attribute definitions for the Raw_Emission output.

Table 10 Raw_Emission output attribute definitions

Field Name	Field Type	Description
assetCarriageWayID	Long Integer	RAMM ID that represents the road section uniquely for each authority
assetRoadID	Long Integer	RAMM ID that represents the road uniquely for each authority
ONRCClass	Text	One Network Road Classification, e.g. primary collector, arterial, low volume
CO_g_km_day	Double	CO emission rate in grams/kilometre/day
CO2_g_km_day	Double	CO_2 emission rate in grams/kilometre/day
NOx_g_km_day	Double	NO_x emission rate in grams/kilometre/day
PM10_g_km_day	Double	PM_{10} emission rate in grams/kilometre/day
PM25_g_km_day	Double	$PM_{2.5}$ emission rate in grams/kilometre/day
PMBT_g_km_day	Double	PM Brake/Tyre emission rate in grams/kilometre/day
Gradient	Double	Gradient of road section in degrees (from SCRIM)
Speed	Double	Average speed in km/hr
ADT	Double	Average Daily Traffic count (from RAMMS)
LV_ADT	Double	Light Vehicle Average Daily Traffic count (calculated from ADT & HV_Percent)
HV_ADT	Double	Heavy Vehicle Average Daily Traffic count(calculated from ADT & HV_Percent)
LaneFlow	Text	Indicates whether road is ‘One way’ or ‘Two way’

5.3 ONRC_Emissions

Figure 3 shows an example of the ONRC emission output in Nelson. This output represents an emission value for each ONRC road section. The emission output has been aggregated from the separate directional Raw_Emission dataset.

Figure 3 Example of ONRC_Emission output

Table 11 summarises the attribute definitions for the ONRC_Emission output.

Table 11 ONRC_Emission output attribute definitions

Field Name	Field Type	Description
assetCarriageWayID	Long Integer	RAMM ID that represents the road section uniquely for each authority
assetRoadID	Long Integer	RAMM ID that represents the road uniquely for each authority
ONRCClass	Text	One Network Road Classification, e.g. primary collector, arterial, low volume
CO_g_km_day	Double	CO emission rate in grams/kilometre/day
CO2_g_km_day	Double	CO_2 emission rate in grams/kilometre/day
NOx_g_km_day	Double	NO_x emission rate in grams/kilometre/day
PM10_g_km_day	Double	PM_{10} emission rate in grams/kilometre/day
PM25_g_km_day	Double	$PM_{2.5}$ emission rate in grams/kilometre/day
PMBT_g_km_day	Double	PM Brake/Tyre emission rate in grams/kilometre/day
Speed	Double	Average speed in km/hr
ADT	Double	Average Daily Traffic count (from RAMMS)
LaneFlow	Text	Indicates whether road is ‘One way’ or ‘Two way’

6. Data Deliverables

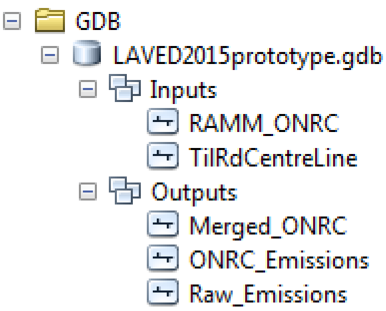
There are three components to the data that is delivered as part of this project. These are:

- the LAVED prototype database
- the FME model
- the VEPM2015 spreadsheet

6.1 LAVED prototype database

The LAVED prototype database is stored as an ESRI File Geodatabase. It has two Feature Datasets. The first dataset contains all of the input data that is required by the FME model. In some instances the input data has been modified to make it more suitable for emission calculations. The second dataset contains the three output datasets produced by the FME model. Figure 4 shows the storage structure of the geodatabase when viewed from within the ArcCatalog software.

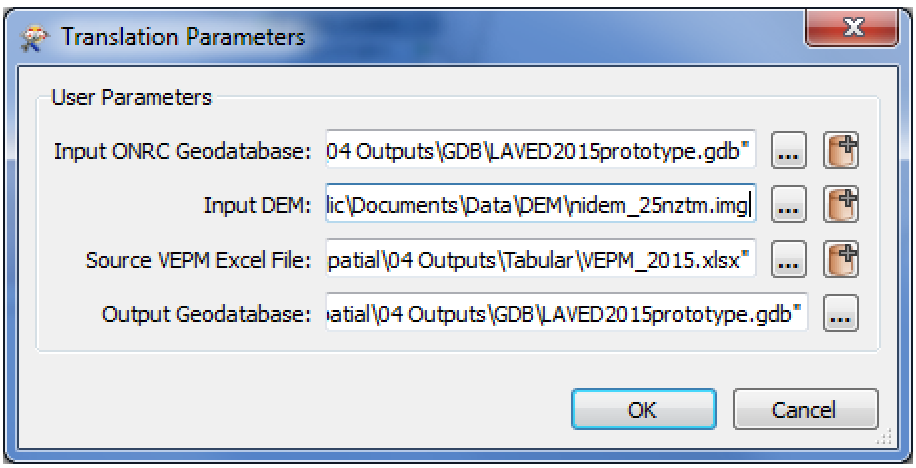
Figure 4 LAVED Prototype Geodatabase storage structure



6.2 FME model

The FME model is provided as two FME Workbench files (.fmw). These can be opened and run in FME versions 2015 and later. Initially the inputs will be set up according to the Jacobs project directory structure, but these can be changed very easily to the Transport Agency's structure when running the model in 'Prompt and Run' mode  for the first time as shown in Figure 5.

Figure 5 FME parameter dialog



Illustrations of the FME models are provided in Appendices J, K & L of this report.

6.3 VEPM2015 spreadsheet

The VEPM2015 spreadsheet supplied in the deliverables of this project is a data only version of the batch outputs derived from the VEPM calculation spreadsheet. It combines both LV & HV calculations, and has some revised field names that enable direct reading and processing by the FME model. This spreadsheet has been stripped of all formatting and macros.

7. Corollary

During the course of this project we have noted a few items for future consideration.

An important step of the emission estimation process is to assign gradients to the individual road sections. To do this it is important to know whether a road section is one way or two way.

The vast majority of roads are two way roads, and these are separated into two in the FME model, and the gradient assigned separately for each direction. The traffic count is then halved and applied to both sides of the road separately.

One way roads occur less frequently, and are predominantly related to motorways and urban areas. It is important to know the direction of the one way road so that the correct gradient can be applied to it.

Unfortunately the RAMM_ONRC dataset supplied by Core Logic does not contain an attribute that distinguishes between one way and two way roads. The Core Logic TilRdCentreline dataset does contain a lane flow attribute, and during the LAVED_CombineRoadCentrelines FME model this attribute is transferred on to the output Merged_ONRC dataset. There are several instances, particularly on motorways, where the TilRdCentreline dataset has separated the road into distinct one way carriageways, whereas the RAMM_ONRC dataset has represented them as a single two way road. To compensate for this difference Jacobs has had to undertake a manual process, introduced after the first FME model to check the ‘one way’ roads, to reassign the ‘LaneFlow’ attribute where necessary based on the actual situation on the RAMM_ONRC dataset.

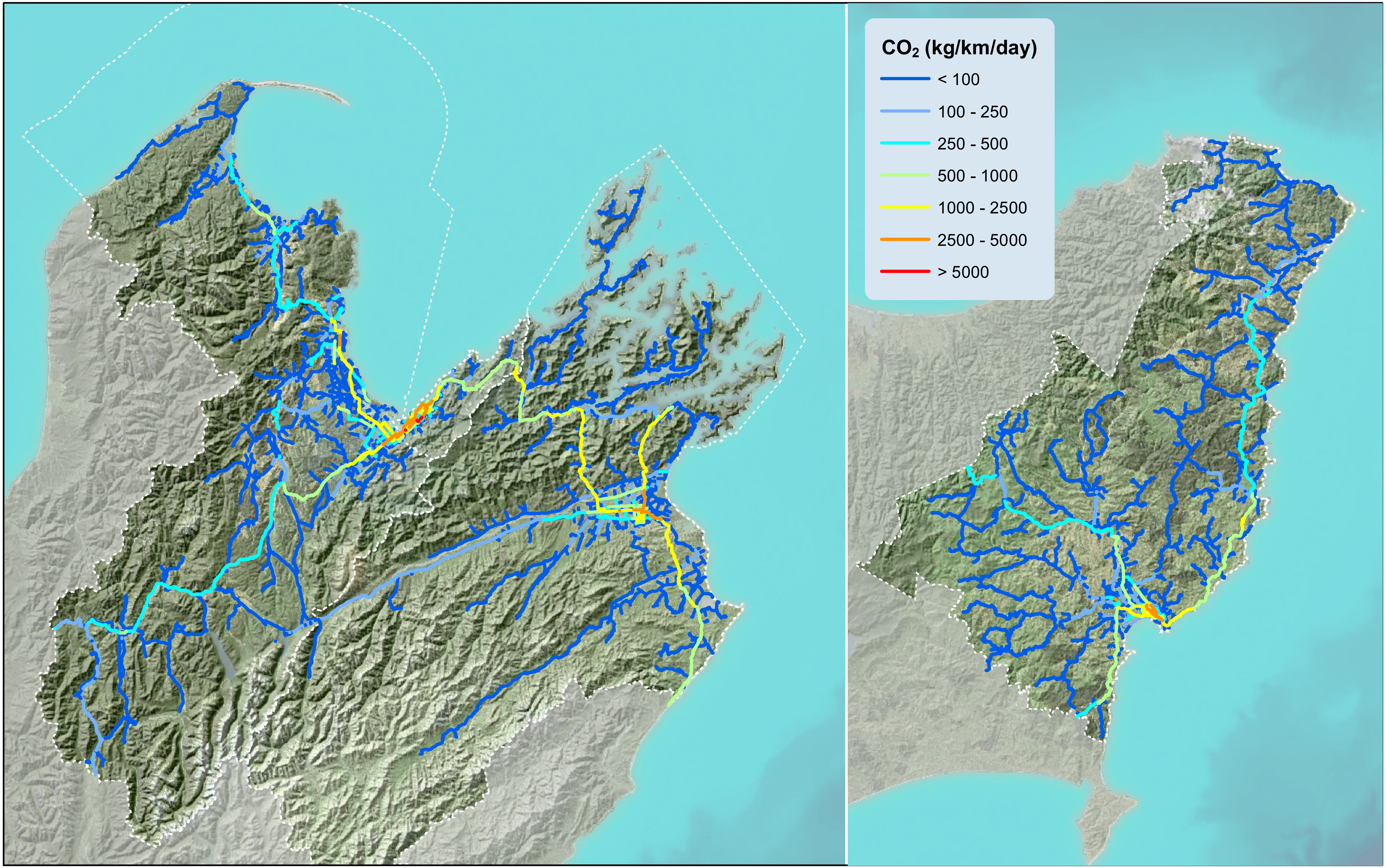
A separate, but related, issue involves the direction of the one way roads in the RAMM_ONRC dataset. The directionality of these one way roads is important to assign the correct gradient, however, the direction of the one way roads in the RAMM_ONRC dataset is essentially random. Therefore another manual process was used to ensure that these one way roads were assigned the correct direction.

Due to the relatively small number of one way roads in this prototype area, the manual processes used to correct the data were not particularly time consuming, however, when extending this method to the all of New Zealand there would be considerable time spent correcting this data, especially in the larger urban areas.

Some discussion will be needed with the Transport Agency’s GIS team to decide how this extra information is treated from the Transport Agency’s perspective, i.e. is it brought into a more core GIS dataset, or left separately as a GIS input into the emission datasets which would need to be updated every time emission outputs were refreshed.

As mentioned in section 4, Environet used different average temperatures for each region, whereas the calculations for LAVED used the default VEPM temperature for all roads. Currently the emission estimation process uses just the one VEPM lookup table, but a possible development for the future would be to incorporate separate lookup tables for separate TLAs.

Appendix A. Daily Vehicle Emissions CO



Calculated Daily CO_2 Emissions

LAVED 2015 Prototype Outputs

NZ TRANSPORT AGENCY
WAKA KOTAHI

JACOBS

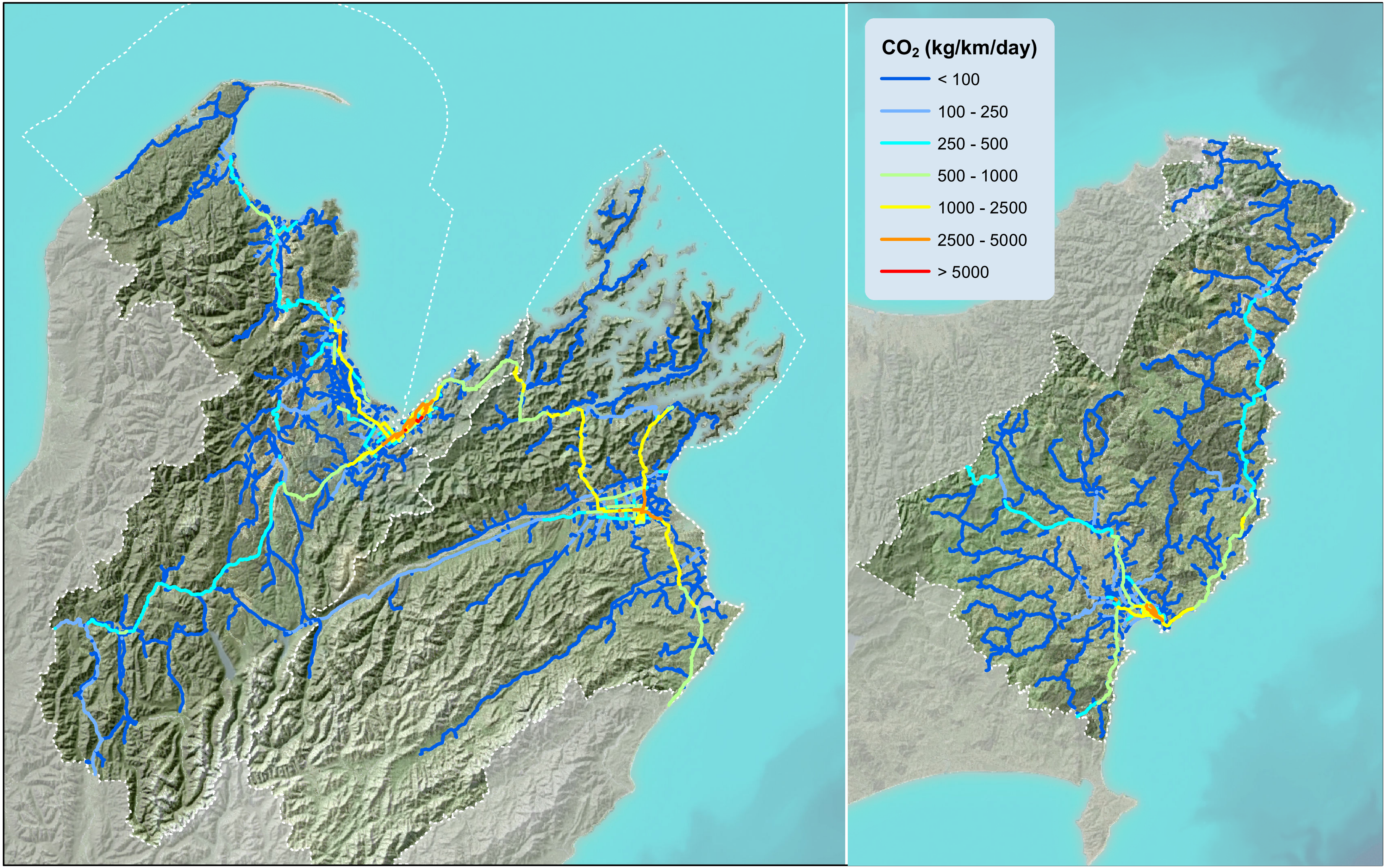
1:1,250,000

N W E S

Date: 21/09/2016

J:\IE\Projects\02_New Zealand\IZ013700\06 Technical\01 Spatial\01 MXD\Outputs.mxd

Appendix B. Daily Vehicle Emissions CO_2



Calculated Daily CO_2 Emissions

LAVED 2015 Prototype Outputs

NZ TRANSPORT AGENCY
WAKA KOTAHI

JACOBS

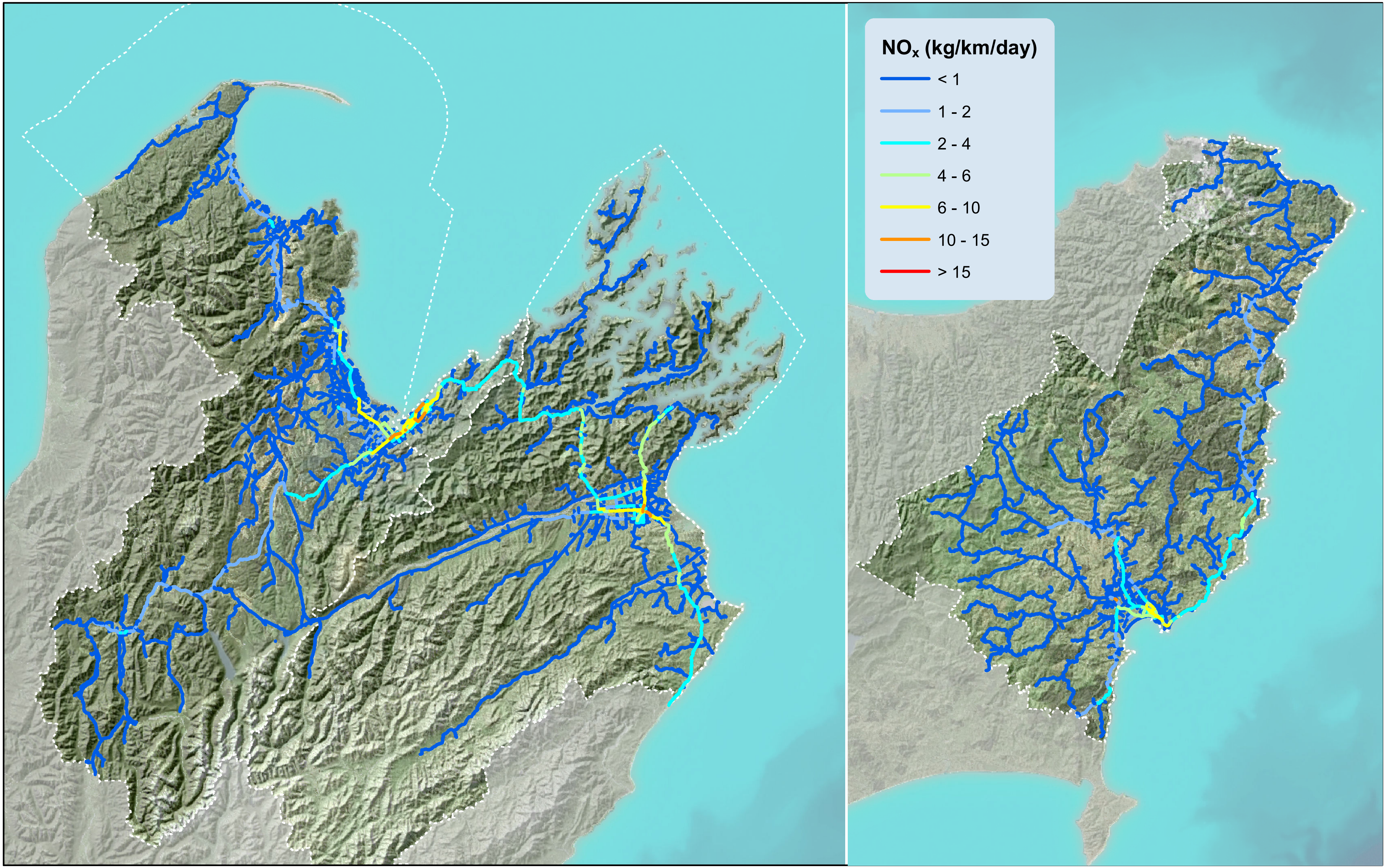
1:1,250,000

N
W E
S

Date: 21/09/2016

J:\IE\Projects\02_New Zealand\IZ013700\06 Technical\01 Spatial\01 MXD\Outputs.mxd

Appendix C. Daily Vehicle Emissions NO_x



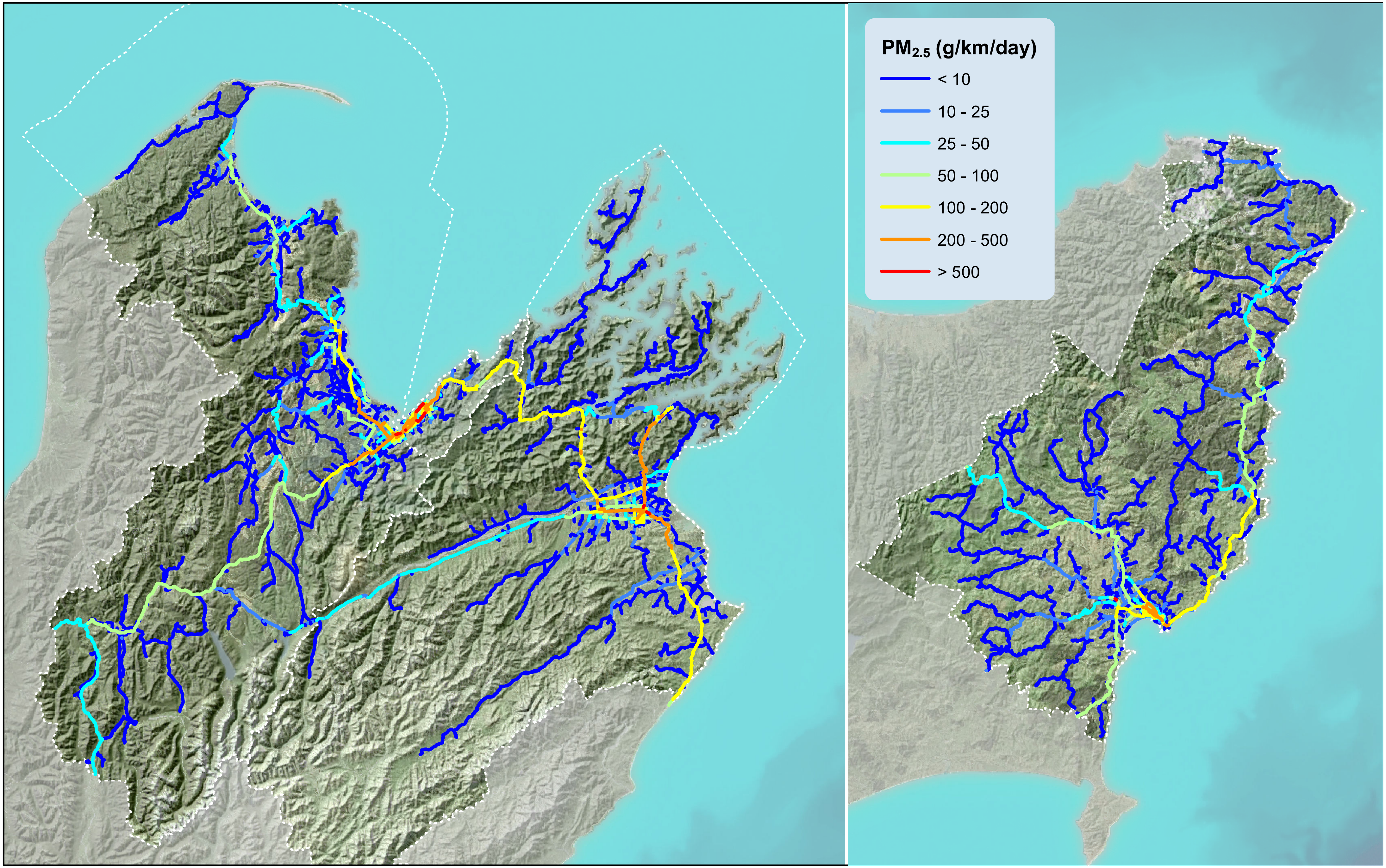
Calculated Daily NO_x Emissions

LAVED 2015 Prototype Outputs

1:1,250,000

Date: 21/09/2016

Appendix D. Daily Vehicle Emissions $PM_{2.5}$



Calculated Daily PM$_{2.5}$ Emissions

LAVED 2015 Prototype Outputs

NZ TRANSPORT AGENCY
WAKA KOTAHI

JACOBS

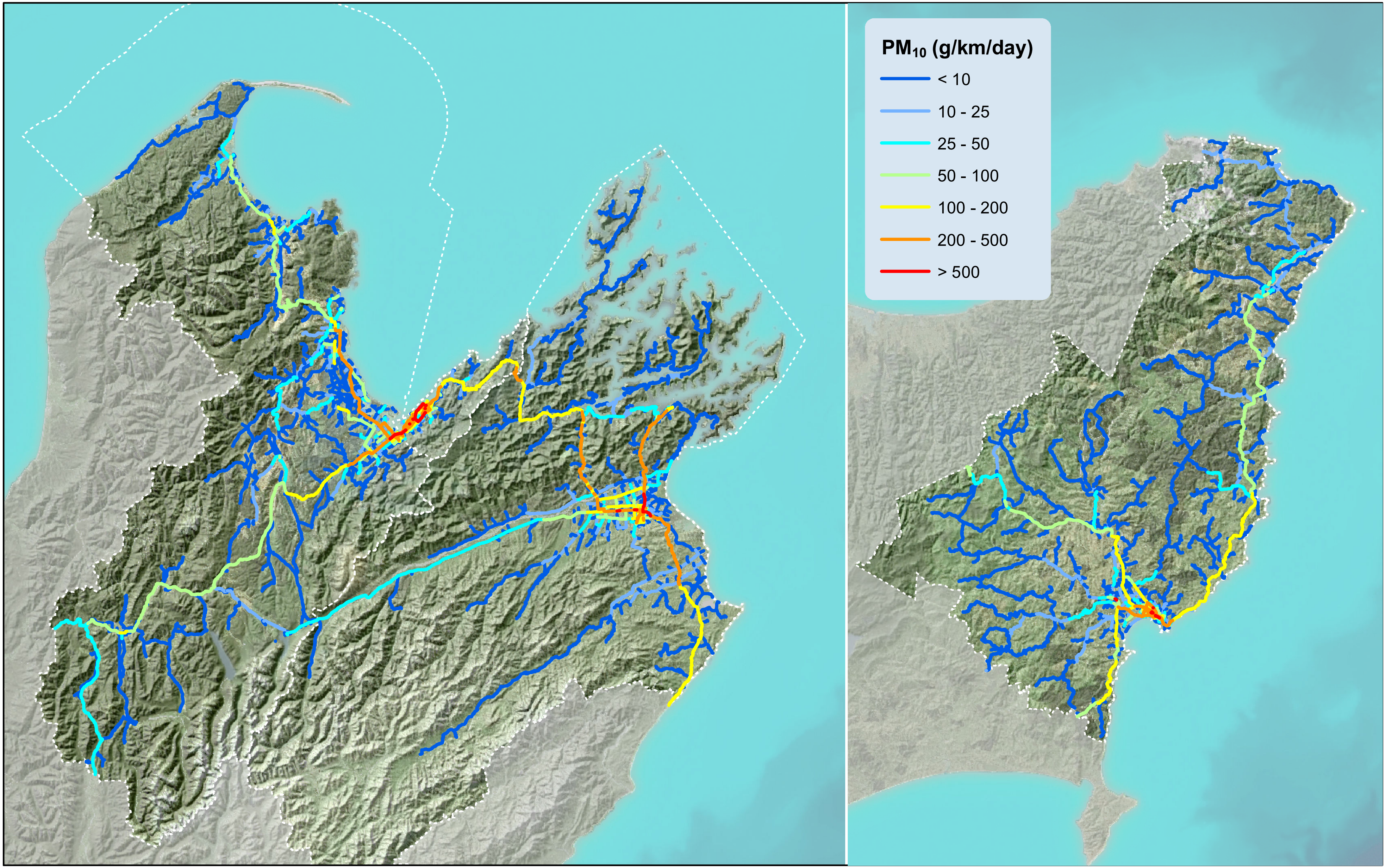
1:1,250,000

N
W E
S

Date: 21/09/2016

J:\IE\Projects\02_New Zealand\IZ013700\06 Technical\01 Spatial\01 MXD\Outputs_PM2-5.mxd

Appendix E. Daily Vehicle Emissions PM_{10}



Calculated Daily PM_{10} Emissions

LAVED 2015 Prototype Outputs

NZ TRANSPORT AGENCY
WAKA KOTAHI

JACOBS

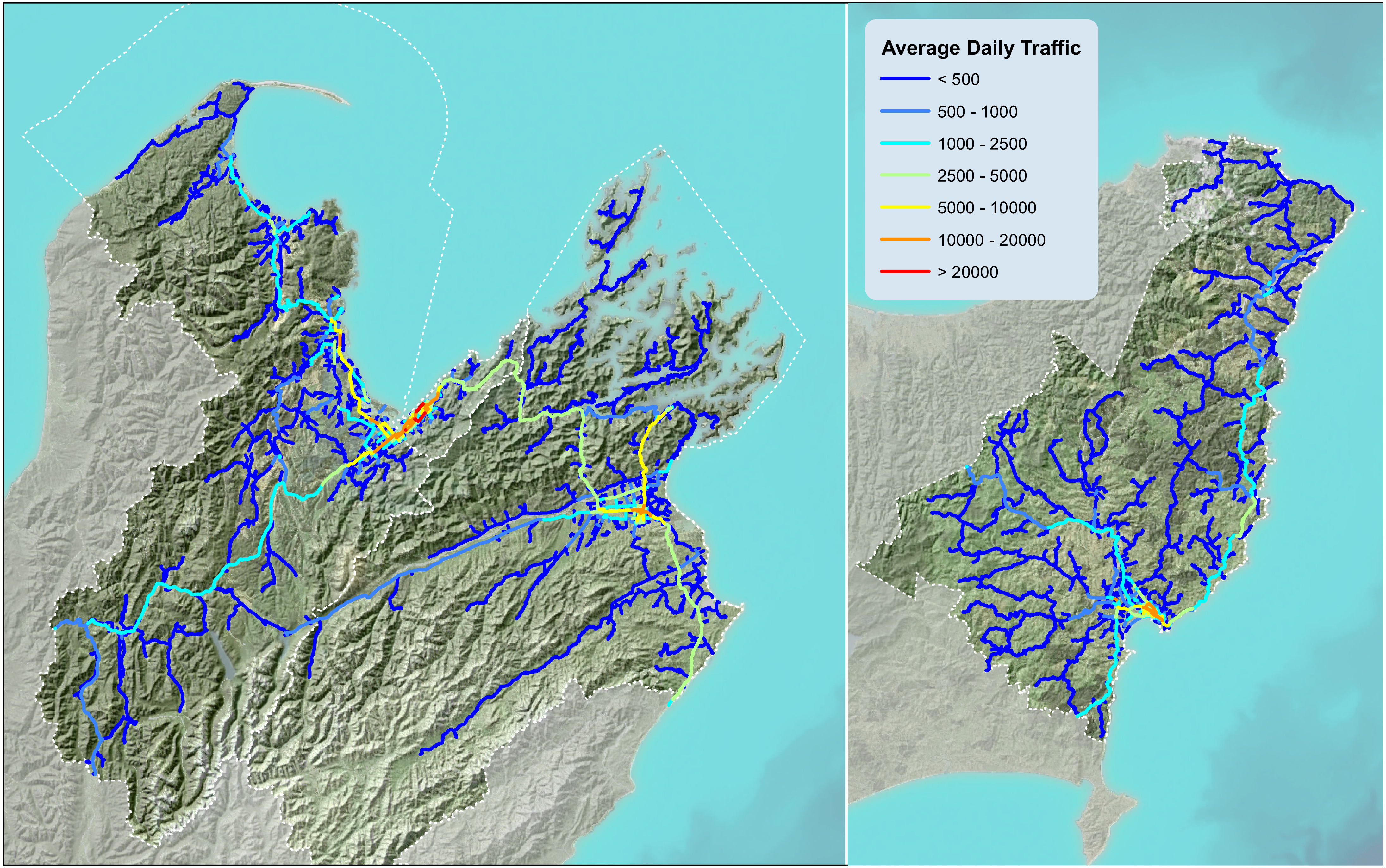
1:1,250,000

N W E S

Date: 21/09/2016

J:\IE\Projects\02_New Zealand\IZ013700\06 Technical\01 Spatial\01 MXD\Outputs_PM10.mxd

Appendix F. Average Daily Traffic Input



ONRC Average Daily Traffic

LAVED 2015 Prototype Inputs

NZ TRANSPORT AGENCY
WAKA KOTAHI

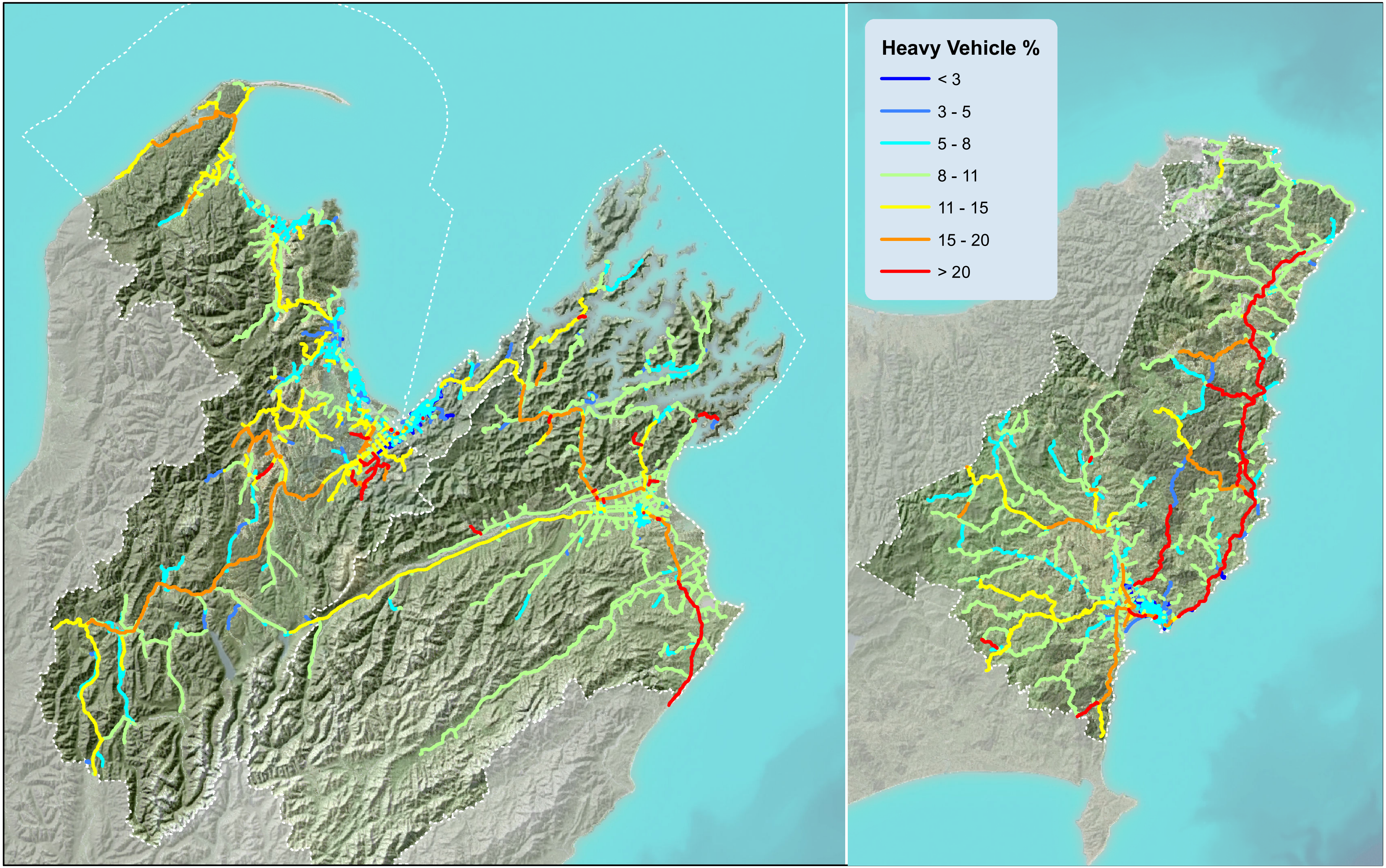
JACOBS

1:1,250,000

Date: 21/09/2016

J:\IE\Projects\02_New Zealand\IZ013700\06 Technical\01 Spatial\01 MXD\Inputs_Traffic.mxd

Appendix G. Fleet Profile Input



ONRC Average Daily Traffic

LAVED 2015 Prototype Inputs

NZ TRANSPORT AGENCY
WAKA KOTAHI

JACOBS

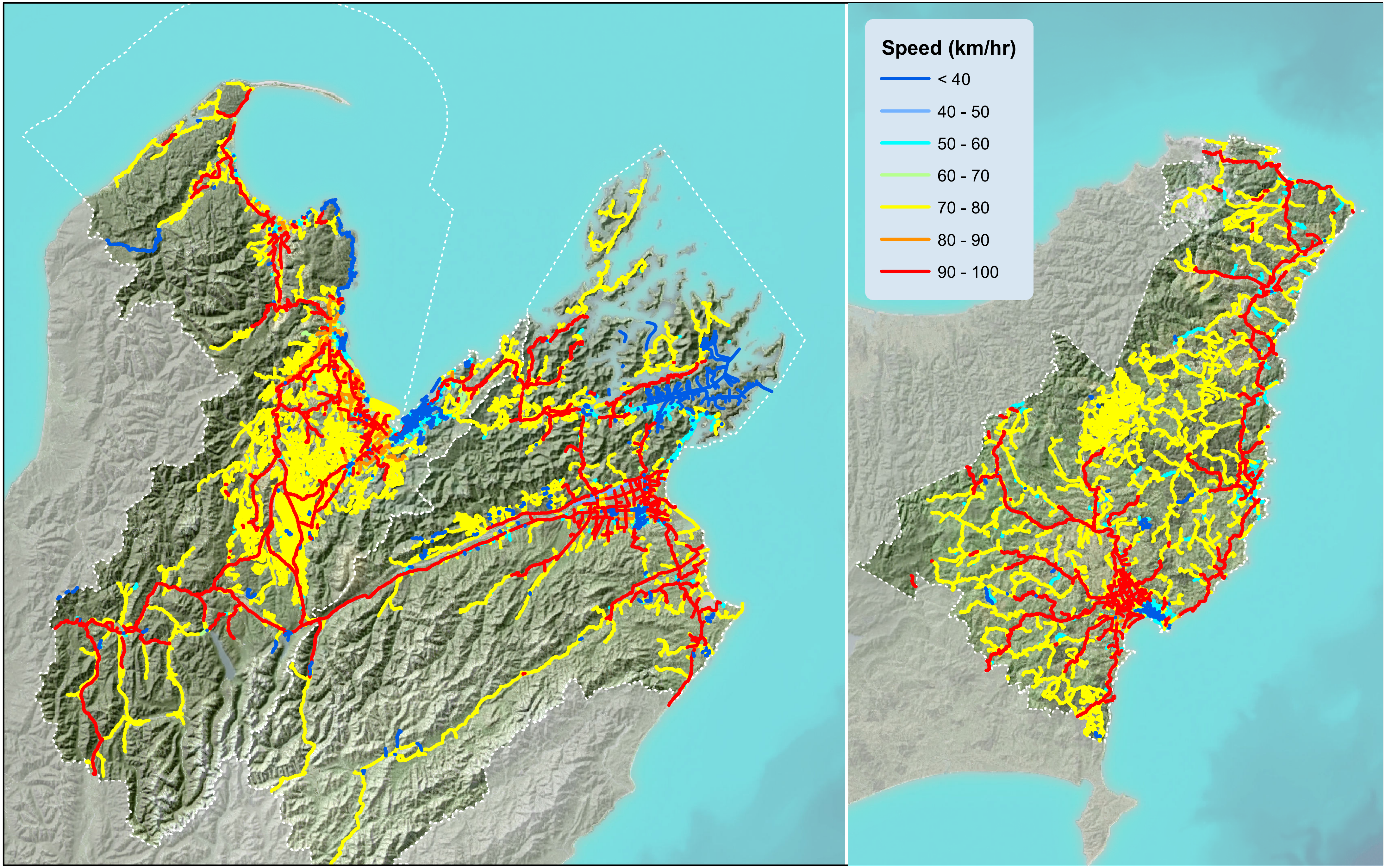
1:1,250,000

N W E S

Date: 21/09/2016

J:\IE\Projects\02_New Zealand\IZ013700\06 Technical\01 Spatial\01 MXD\Inputs_FleetProfile.mxd

Appendix H. Speed Input



TilRdCentreline Routable Speed

LAVED 2015 Prototype Inputs

NZ TRANSPORT AGENCY
WAKA KOTAHI

JACOBS

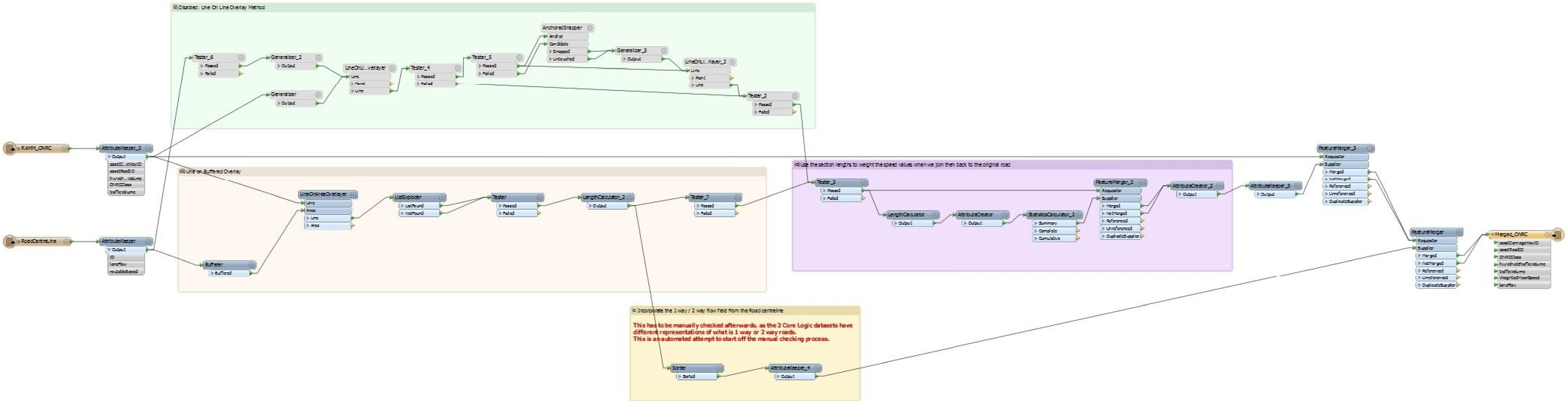
1:1,250,000

N
W E
S

Date: 21/09/2016

J:\IE\Projects\02_New Zealand\IZ013700\06 Technical\01 Spatial\01 MXD\Inputs_Speed.mxd

Appendix I. FME Model 1 – Combine Road Centrelines


Disabled: Line On Line Overlay Method
Tester_6
Generalizer_2
Generalizer
Tester_4
Tester_5
AnchoredSnapper
Generalizer_3
Tester_2
RAMM_ONRC
AttributeKeeper_2
RoadCentreLine
AttributeKeeper
Line on Buffered Overlay
LineOnAreaOverlayer
ListExploder
Tester
LengthCalculator_2
Tester_7
Bufferer
Use the section lengths to weight the speed values when we join then back to the original road
Tester_3
LengthCalculator
AttributeCreator
StatisticsCalculator_2
FeatureMerger_2
AttributeCreator_2
AttributeKeeper_3
FeatureMerger_3
FeatureMerger
Merged_ONRC
Incorporate the 1 way / 2 way flow field from the Road centreline
This has to be manually checked afterwards, as the 2 Core Logic datasets have
different representations of what is 1 way or 2 way roads.
This is an automated attempt to start off the manual checking process.
Sorter
AttributeKeeper_4

Appendix J. FME Model 2 – Assign Emissions To Roads