# National Vehicle Emission GIS Tool

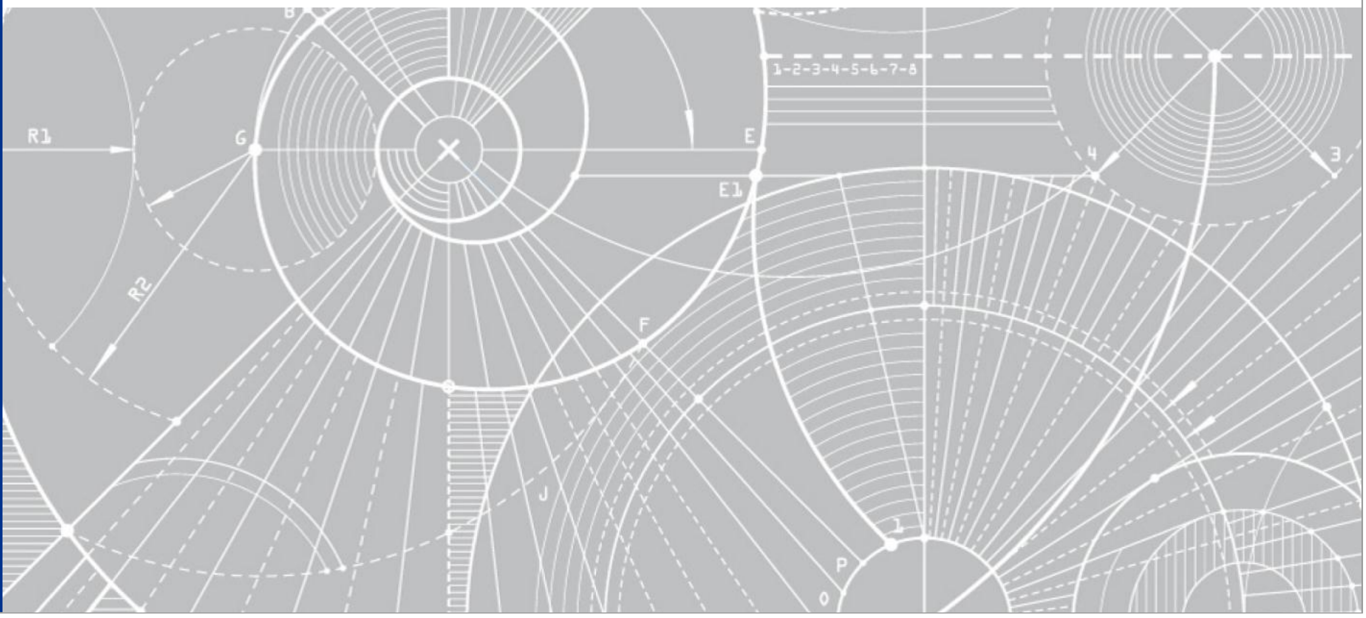
THE TRANSPORT AGENCY

## National Vehicle Emission Dataset 2013

AE04567-IAN-RP-0002 | 0

NZTA NO 14-469

1 Apr 2015



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# National Vehicle Emission GIS Tool

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### Document history and status

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## Contents

# Executive Summary

Estimates of the emissions to air from motor vehicles travelling on the state highway network have been produced for the 2013 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, although there is still some question regarding the reliability of speed data. There was also some limited manual manipulation of data to make it suitable for the automated emission calculation model. This manipulation took place to ensure that there was a correct spatial match between the two NZTA spatial datasets being used.

Methodologies, inputs and outputs are all presented in some detail, as well as some items that may need further consideration in the future..

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The sole purpose of this report and the associated services performed by Jacobs is to identify the inputs and methodology used in building the National 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 build the National Vehicle Emission Dataset for 2013 (NVED2013). This dataset is a spatial dataset representing calculated vehicle emissions for the state highway network in New Zealand. Emissions have been calculated for the pollutants CO, $NO_x$, $PM_{2.5}$ and $PM_{10}$ and for $CO_2$.

This work follows on from a pilot study in 2014 that proved the concept of creating vehicle emission data from GIS data by running through all the requirements for a sample area in Hawkes Bay[1]. The methodology developed in that pilot has been followed very closely for this project.

The NVED2013 is a baseline dataset that can be used to compare against future years datasets as and when new data becomes available.

The GIS tool used to create NVED2013 has been created in such a way as to make creating future emission datasets as straightforward as possible; however, it has not at this stage been created as a completely dynamic tool that enables scenario testing etc. It is assumed that this step would happen in a future stage of the project.

The following report outlines the methodology that has been used to create the NVED2013. It then discusses the input datasets that have been used along with any specific steps that have been taken to ensure the inputs are suitable for creating the NVED2013. The report then carries on to outline the three outputs that have been produced, as well as defining all of the deliverables that have been supplied back to The Transport Agency. The report concludes by raising a few items that may need some further consideration.

[1] Jacobs, Air Emission GIS Interface for State Highways, 2014

# 2. Methodology

The methodology used to calculate emissions was naturally adopted from the pilot project. The key to our 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) Preparing the outputs

The following explains these steps in more detail.

## 2.1 Merging the inputs

We need to merge the information from the three input datasets into one dataset that contains everything.

Because gradient requires the direction of a road to be separated, it is important that the emission calculations are performed on the direction separated road network. The gradient sections are also divided into 10 metre lengths, meaning that they have the greatest resolution of the input datasets. This also means that the traffic count, fleet profile and speed information has to be transferred to the gradient road sections. This transfer is performed on the road sections that are closest to each individual gradient section. Where the RAMM data has a dual carriageway definition it is important to ensure that the SCRIM gradient section is closest to the RAMM carriageway that it is intended to represent. Therefore a manual review and edit process has taken place to ensure this, as discussed in Section 3.1.

## 2.2 Calculating the emissions

Each piece of road section has an average speed, and this can be used to look up its appropriate emission value from the VEPM emission table. This look up uses a combination of the speed, the fleet profile (LV or HV), and the gradient category (-6°, -4°, -2°, 0°, 2°, 4°, 6°) to determine the CO, $CO_2$, $NO_x$, $PM_{2.5}$ & $PM_{10}$ emission factors to apply to each road section.

The emissions are calculated independently for Light Vehicles (LV) and Heavy vehicles (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.

## 2.3 Preparing the outputs

The steps performed up to this point have calculated emissions for the road sections as defined by the SCRIM gradient dataset. This is very good for performing the calculations, but not always ideal when wanting to visualise them.

Because the emissions are calculated independently for the direction of the road, the emission values are split between both sides of the road. Unless the viewer is zoomed in very close, it is unlikely that they will be able to distinguish the two separate directional lines of the road. On casual viewing this may result in the viewer making an assumption that a road's emission is only half of its total.

To remedy this situation, a further step is taken to aggregate the 'directional' results back into the original RAMM based road centrelines, where the roads are mostly represented by a single line. This is achieved through a series of steps that include merging those roads that contain the same RAMM carriageway ID. As the road sections are merged into one road section, the emission values are recalculated using a weighted mean determined by their respective lengths.

A further output is created that represents the emissions in a regular grid pattern. Each grid, sized 1km by 1km, represents the emission values of the roads that pass through that particular grid. This is weighted to make sure that the grid only receives the emission values for the portion of the road that passes through it. This gridded output may have limited value when viewing only the state highway network, but will become a powerful visualisation mechanism when used at a regional level that includes local roads as well.

## 2.4 Using FME

All of 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.

During initial testing of the calculation model very high computer memory usage was observed. This in fact crashed our model. The high memory usage was a result of two main factors. Firstly, the input datasets are very large for the entire state highway network for New Zealand. Secondly, the model was producing three output datasets, which FME handles by processing in parallel which unfortunately increases memory usage considerably. We have taken the following steps to overcome these memory issues.

- Converted the 10m interval SCRIM data into 100m interval data. This has been done by joining up to 10 adjacent lines (but never across intersections) together into one line, and assigning them the average gradient of the lines they replace. This reduces the number of features in the SCRIM dataset from 2,250,000 to 220,000. It was thought that 100m intervals were still a very good calculation resolution for this national dataset.
- Break the model into three separate models. The first of these models performs the emission calculations and produces the SCRIM output. The second and third models produce the RAMM and Grid output. As well as reducing the processing computers memory usage, this also enables the user a little more flexibility in choosing the desired output type, i.e. RAMM or Grid.

As mentioned above, the calculation process has been split into three separate FME models.

1) AirEmissionStage1_1_SCRIM.fmw
this model performs all of the merging and emission calculation steps. Its output is the directionally laned SCRIM dataset, based on 100m intervals. This model must be run before either of the following models can be run.

2) AirEmissionStage1_2_RAMM.fmw
this model transforms the SCRIM output from the first model into a RAMM based output, where emission values are created for each RAMM road section.

3) AirEmissionStage1_3_Grid.fmw
this model transforms the SCRIM output from the first model into a Gridded output. In our initial NVED2013 data supply we have used a 1km x 1km grid size. It is not very practical from a computing point of view to use a finer resolution at this national scale, but this could certainly be done when focussing on regional outputs.

# 3. Inputs

To calculate vehicle emissions for the state highway network we require four pieces of information from the highway 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 NVED2013**

| Parameter | Database | Database layer | Database field used | Date | Notes |
|---|---|---|---|---|---|
| **Traffic Count** | RAMM | Carriageway | trafficADTEst or trafficADTCount | 2013 | The field *trafficADTCount* is based on actual traffic counts, and has been used where available; otherwise the field *trafficADTEst* has been used, which is estimated from modelling. The road alignment is based on 2014 data; however the traffic counts are from 2013. |
| **Fleet Profile** | RAMM | Carriageway | loadingPCHeavy | 2013 | The field *loadingPCHeavy* represents the percentage of heavy vehicles for each particular road section. The road alignment is based on 2014 data; however the fleet profile information is from 2013. |
| **Speed** | EfficiencyNet | Spreadsheet | USED Free flow speed | 2014 | This spreadsheet has a modelled free flow speed derived from the Electronic Road User Charge (ERUC) database maximum speed, or when not available from factored speed limits. This data can be joined directly to the RAMM dataset by the CarriagewayID attribute. |
| **Gradient** | SCRIM | HSDGeometryCentreline | gradient | 2013 | This spatial dataset is divided into 10 metre lengths with direction separated into 2 lines. |

Appendices F – I illustrate the inputs nationally as maps.

## 3.1 Aligning Spatial Inputs

With the need to use three different datasets to provide the required information for calculating emissions, we have to address any situations where these datasets do not easily match. Any road sections that do not have all of the required four pieces of input information will end up as gaps in the output emission dataset. To avoid this happening we have to ensure the best possible transfer of information from all of the inputs when we merge them into the one merged input dataset. The following steps have been taken to ensure this happens:

- The SCRIM dataset, used to obtain gradients, has two notable omissions when comparing against the RAMM dataset. These are the Taupo bypass and a section of SH 76 near Whangamomona. In these cases gradient data has been interpolated to avoid completely missing out large sections of road in the emission calculations. The interpolation has been achieved by creating parallel lines either side of the RAMM centreline, and then overlaying these new lines over a 20m resolution Digital Elevation Model (DEM) to obtain the gradients. These gradients are considered not to be as accurate as those that are provided by the SCRIM dataset, but deemed better than the alternative of completely missing data. It should also be noted that gradient plays almost no part in the emission calculations for light vehicles, which comprise around 93% of the total fleet.

- We have undertaken some spatial realignment of SCRIM gradient data to more closely follow the RAMM road pattern. This was occasionally necessary at dual carriageway sections of the RAMM data so that the individual SCRIM road sections would be joined to the correct RAMM carriageway section during the emission calculation process. Figures 1 and 2 show a typical adjustment that has been made where one of the SCRIM alignments (shown in orange) has been moved (shown in blue) to make sure it is closest to the RAMM dual carriageway line that we want it to join to.

**Figure 1 Original SCRIM alignment**

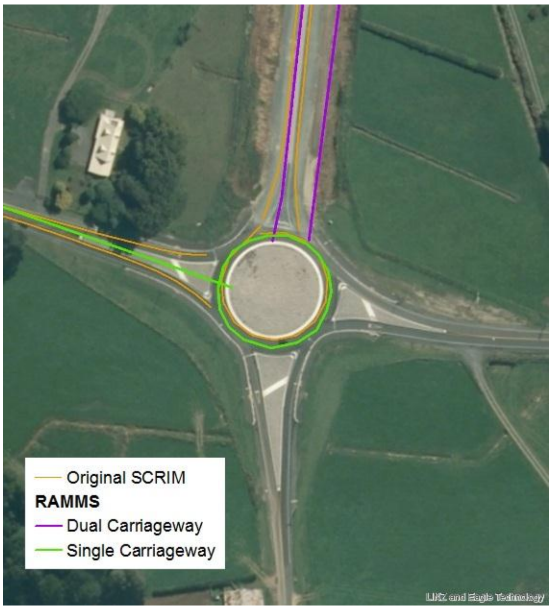
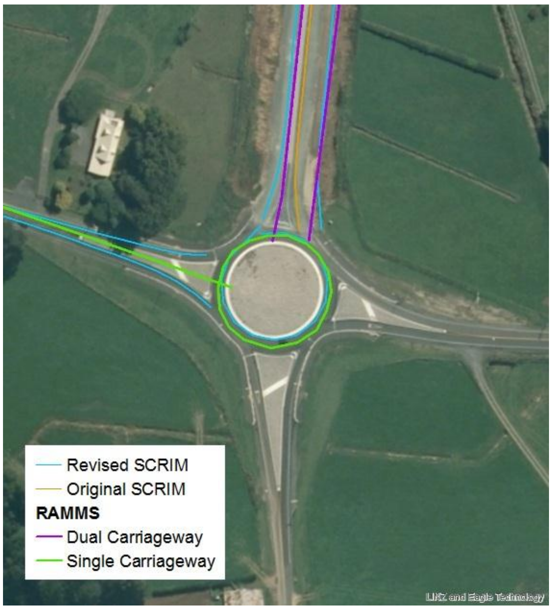



**Figure 2 Revised SCRIM alignment**




- RAMM has inconsistent data around the Ngaruawahia bypass, and differs in alignment with the SCRIM data. The RAMM dataset comprises the new bypass alignment, but contains very small traffic count figures for this. This is possibly a reflection of the bypass not being complete and only being partially used throughout 2013. The older alignment has been completely removed from the new RAMM data, as this alignment is from 2014, even though it was still being used during the 2013 study period. The SCRIM data only reflects the old alignment. The RAMM dataset we have used for the pilot project agrees very well with the SCRIM data, and has traffic count information from June 2013. We have therefore substituted in the RAMM data from the pilot project to give a better representation of the traffic counts at that time.

- The EfficiencyNet speed data misses around 300 road sections when it is joined to the RAMM using the Carriageway ID attribute. In some instances this is because the road alignments between the RAMM dataset we are using and the RAMM dataset that was used in the creation of EfficiencyNet are likely to be from different years. We have managed to join many of the missing EfficiencyNet road sections back to the older 2012 RAMM version, and then transferred the speed data through to the newer replacement RAMM road sections. This has covered most of the gaps, but there are still around 100 outstanding road sections that we have interpolated manually by averaging the speed value of the two adjoining road sections on either side of it.

## 3.2 VEPM

We have created a table that has emission rate values for CO, $CO_2$, $NO_x$, $PM_{2.5}$ and $PM_{10}$ for every combination of speed, fleet profile and gradient using the Vehicle Emissions Prediction Model (VEPM) version 5.0. We have used the batch run functionality within the model to produce this table.

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 |
|---|---|---|---|---|
| 2013 | 10 km/h | 100 km/h | 1 km/h | 9.8 km |

The average trip length of 9.8 km used in the VEPM calculations is taken from the New Zealand Household Travel Survey 2011-2014 produced by the Ministry of Transport. This survey does not include travel by professional drivers, e.g. taxi, courier or truck drivers.

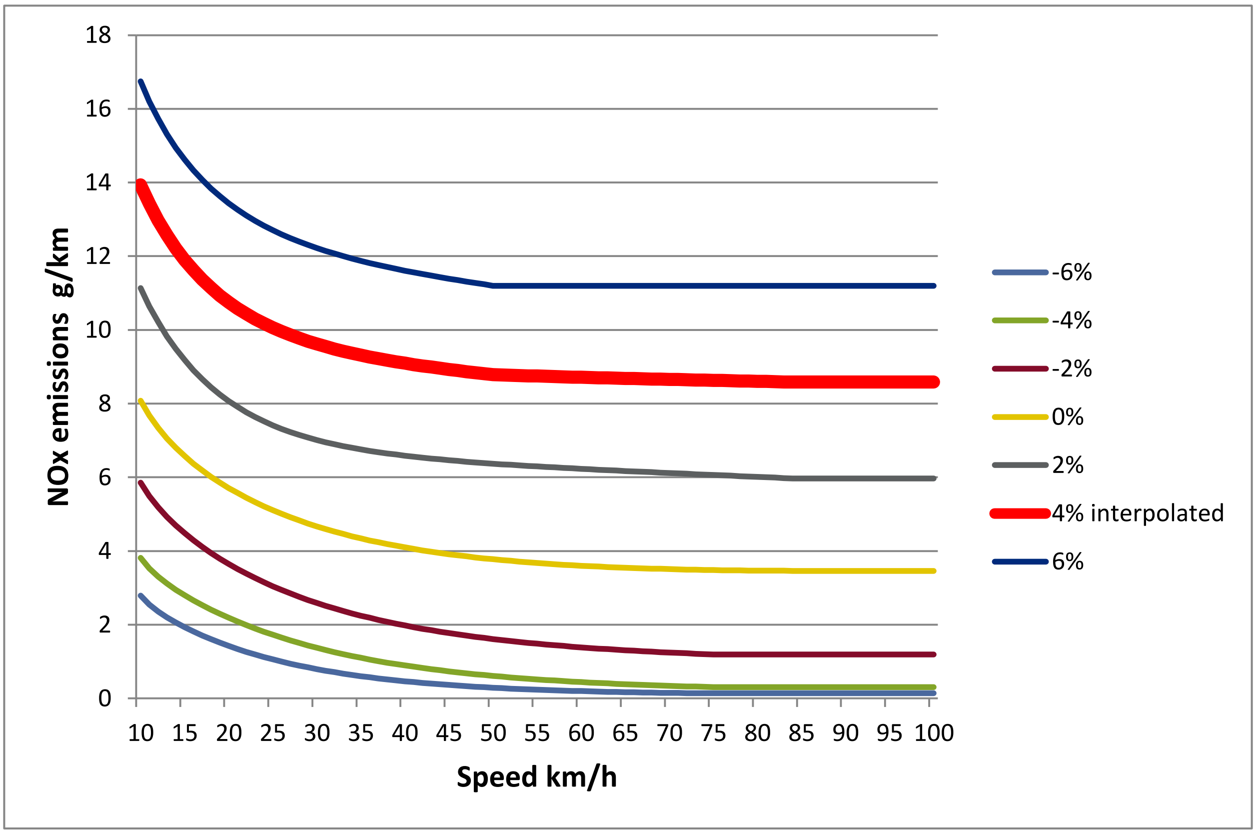
The fleet profile used in the calculations is VEPM's default profile for 2013, and is shown in Table 3.

**Table 3 VEPM fleet profile**

| | | |
|---|---|---|
| Light Vehicle | Car petrol | 69.80% |
| | Car diesel | 7.60% |
| | Car hybrid | 0.50% |
| | Light commercial petrol | 3.30% |
| | Light commercial diesel | 12.20% |
| | Light commercial hybrid | 0.10% |
| 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% |

An observation was made when running the calculations in the VEPM spreadsheet that there is an omission in calculating $NO_x$ emissions for heavy vehicles at a 4% gradient. It is not understood what causes this error. A graph of $NO_x$ emissions against speed at the differing gradients clearly shows a very consistent pattern. We have therefore interpolated the $NO_x$ emissions for the 4% gradient by taking the mean of the 2% and 6% values. Figure 3 shows the $NO_x$ emission factor curves for heavy vehicles.

**Figure 3 Interpolated NOx emission factors for heavy vehicles at 4% gradient**



# 4. Outputs

There are three output datasets created as part of the NVED2013. These represent directional SCRIM emissions, RAMM emissions and Grid emissions.

Appendices A – E illustrate the Emission_RAMM outputs nationally as maps.

## 4.1 Emission_SCRIM

Figure 4 shows an example of the SCRIM emission output near Thames. This output represents a separate emission value for each direction of the state highway. This represents the spatial resolution at which the actual calculations have been made. It is also the same spatial definition as the 100 m resolution SCRIM dataset.

**Figure 4 Example of Emission_SCRIM output**

Table 4 summarises the attribute definitions for the Emission_SCRIM output.

**Table 4 Emission_SCRIM attribute definitions**

| Field Name | Field Type | Description |
|---|---|---|
| carrWayNo | Long Integer | Unique identifier that represents road section in RAMMS |
| 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 |
| Gradient_degrees | Double | Gradient of road section in degrees (from SCRIM) |
| Speed_km_h | Double | Average speed in km/hr (from EfficiencyNet free flow speed) |
| 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) |
| HV_Percent | Double | Percentage of Heavy Vehicles in Average Daily Traffic count (from RAMMS) |

## 4.2 Emission_RAMM

Figure 5 shows an example of the RAMM emission output near Thames. This output represents an emission value for each RAMM road section. This has been aggregated from the separate directional Emission_SCRIM dataset.

**Figure 5 Example of Emission_RAMM output**

Table 5 summarises the attribute definitions for the Emission_RAMM output.

**Table 5 Emission_RAMM attribute definitions**

| Field Name | Field Type | Description |
|---|---|---|
| carrWayNo | Long Integer | Unique identifier that represents road section in RAMMS |
| 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 |

## 4.3 Emission_Grid

Figure 6 shows an example of the Grid emission output. This output represents an emission value for every 1km square grid throughout New Zealand. This has been aggregated from the separate directional Emission_SCRIM dataset.

**Figure 6 Example of Emission_Grid output**

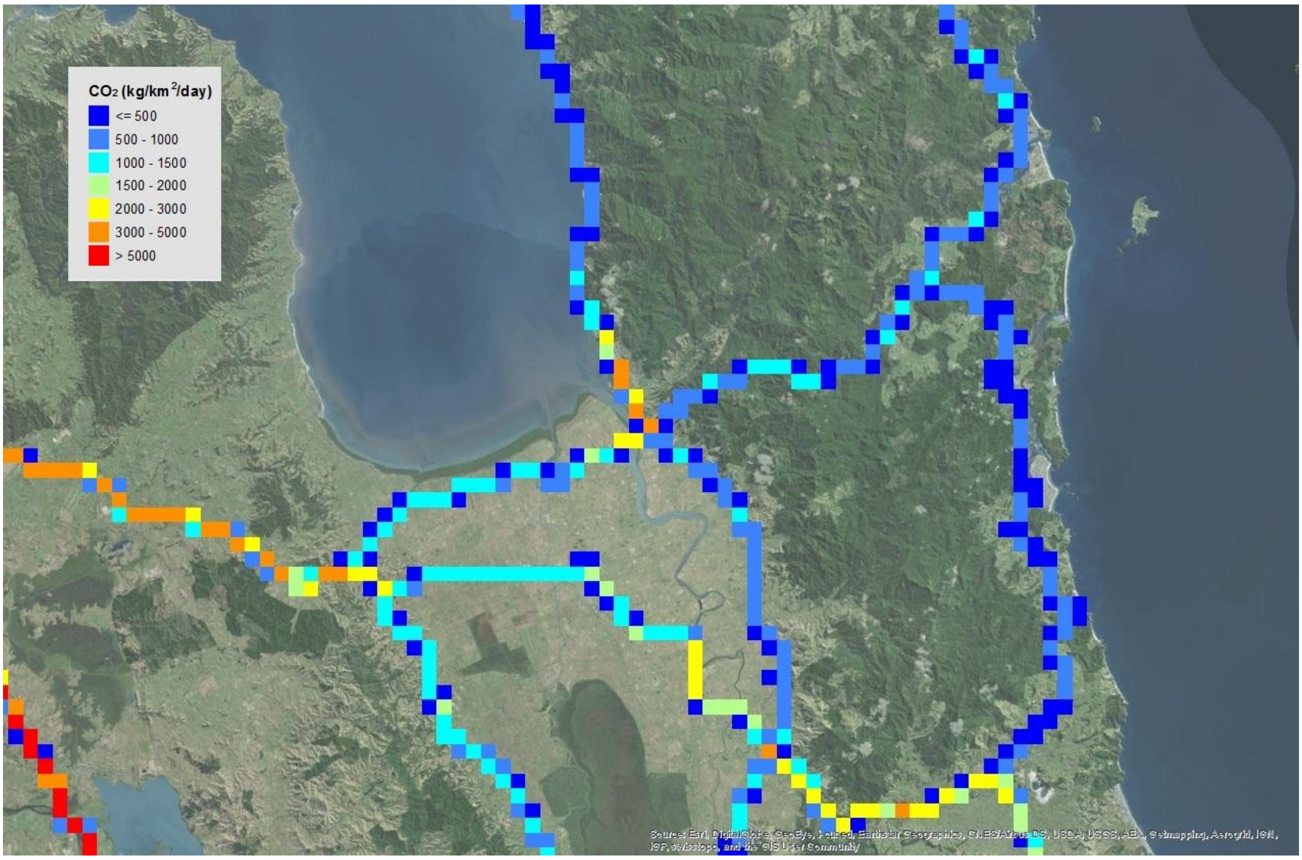



Table 6 summarises the attribute definitions for the Emission_Grid output.

**Table 6 Emission_Grid attribute definitions**

| Field Name | Field Type | Description |
|---|---|---|
| ID | Long Integer | Unique identifier that represents each 1km grid square |
| CO_g_day | Double | CO emissions in grams/day |
| CO2_g_day | Double | $CO_2$ emissions in grams/day |
| NOx_g_day | Double | $NO_x$ emissions in grams/day |
| PM10_g_day | Double | $PM_{10}$ emissions in grams/day |
| PM25_g_day | Double | $PM_{2.5}$ emissions in grams/day |

# 5. Data Deliverables

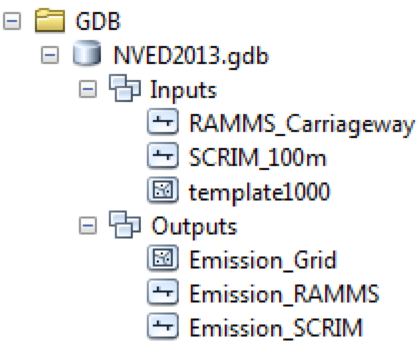
There are four components to the data that is delivered as part of this project. These are:

- the NVED2013 database
- the FME model
- the VEPM2013 spreadsheet
- the EfficiencyNet spreadsheet

## 5.1 NVED2013 database

This is 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 7 shows the storage structure of the geodatabase when viewed from within the ArcCatalog software.

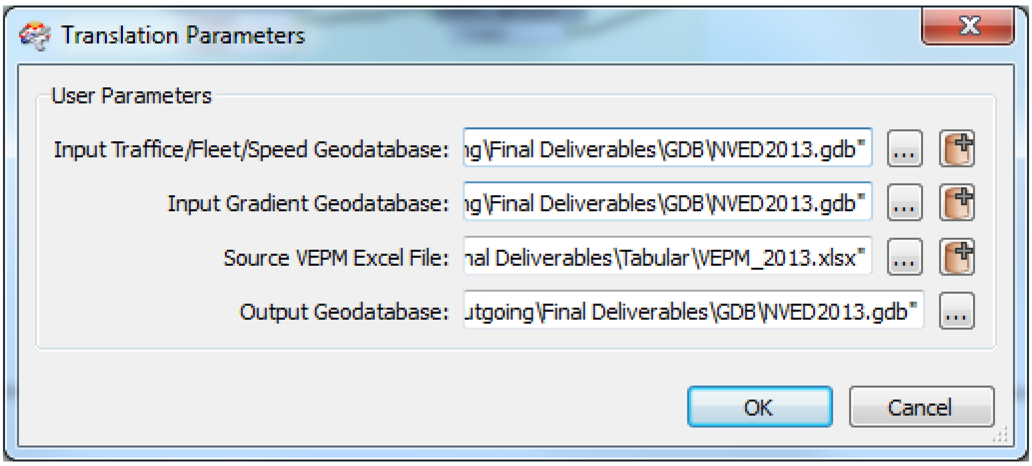
**Figure 7 NVED2013 Geodatabase storage structure**




## 5.2 FME model

The FME model is provided as three FME Workbench files (.fmw). These can be opened and run in FME versions 2014 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 NZTA structure when running the model for the first time as shown in Figure 8.

**Figure 8 FME parameter dialog**




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

## 5.3 VEPM2013 spreadsheet

The VEPM2013 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.

## 5.4 EfficiencyNet spreadsheet

The EfficiencyNet spreadsheet supplied in the deliverables of this project is a subset of the full spreadsheet supplied to Jacobs. It only contains the fields that are required to join the free flow speed data on to the RAMMS dataset. This join has been performed in ArcGIS prior to the FME model being run, and this spreadsheet is not used directly by the FME model.

# 6. Corollary

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

## 6.1 Average Trip Length

We have adopted an average trip length of 9.8 km from the New Zealand Household Survey 2011-2014 produced by the Ministry of Transport. We believe this distance is likely to be too low when considering just the state highway network, as the original distance is derived from surveys covering all roads. However, currently there is no official alternative figure available for use on the state highway network.

While the full effect of using a lower average trip length is not completely understood, we consider the emission values calculated during this project will be conservative. This is because the impact of cold starts on the VEPM calculations will be greater than we believe they should be.

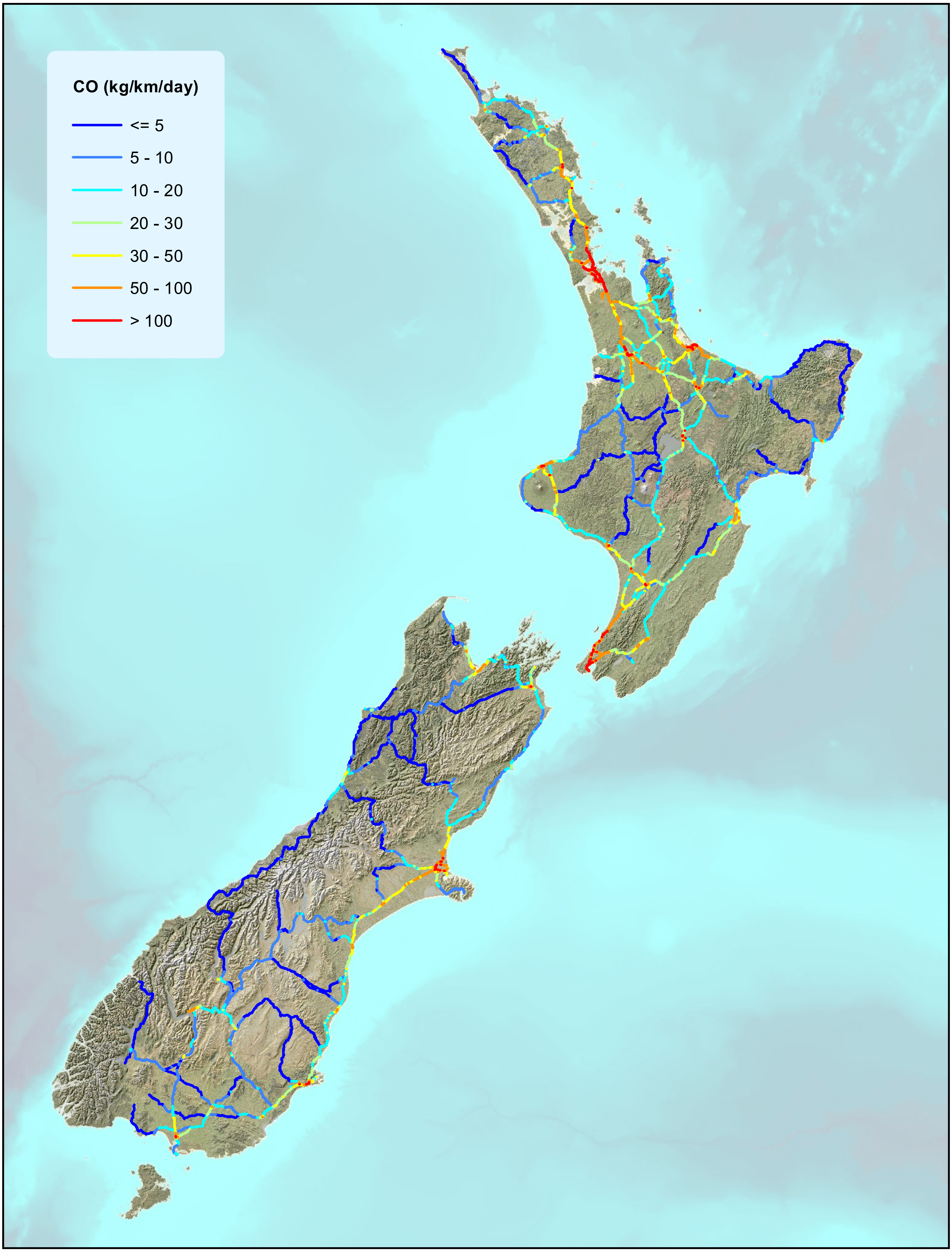
## 6.2 Speed Data

The inputs used for speed are considered the least reliable of the data sources. These inputs are derived from the ERUC maximum speeds, or when this was not available from a factored speed limit. We have obtained this data from the EfficiencyNet dataset, and after discussions with the author of EfficiencyNet it was pointed out that they thought the ERUC data was not particularly reliable. They also mentioned that they were looking to incorporate different speed sources for future versions of EfficiencyNet.

## 6.3 FME interactivity

While the FME models used to create NVED2013 are designed with the flexibility of data inputs in mind, they cannot at this stage be used as an interactive scenario modeller. This will require further development of the FME models, as well as a more thorough appreciation of how different scenarios/parameters may want to be analysed.

# Appendix A. Daily Vehicle Emissions CO




# Calculated Daily CO Emissions

## NVED2013 Data Outputs

1:6,000,000

N W E S

Date: 20/03/2015

NZ TRANSPORT AGENCY WAKA KOTAHI

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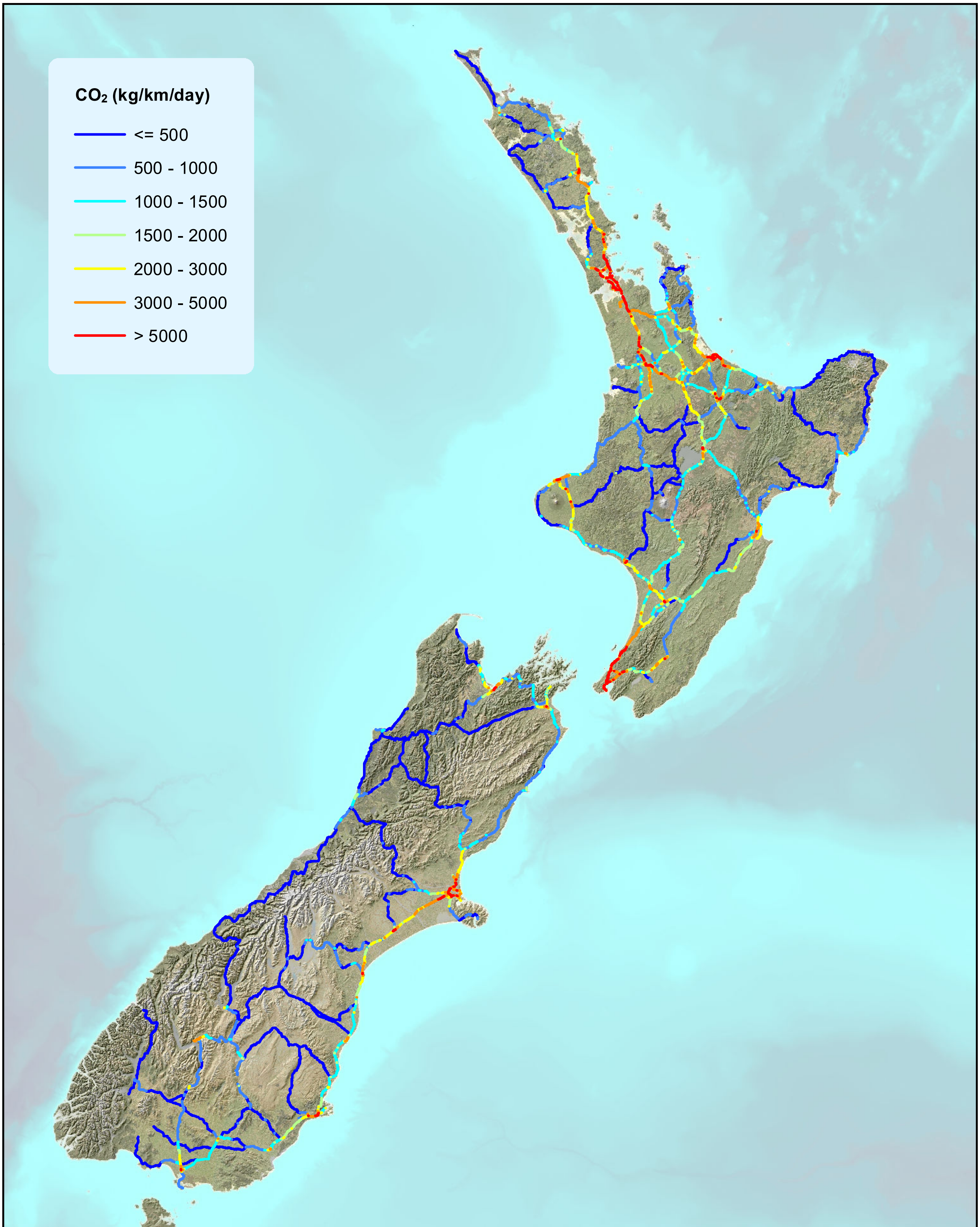
I:\AENVW\Projects\AE04567\Technical (controlled)\Spatial\ArcGIS\MXD (final)\Stage 1\OutputCO.mxd

# Appendix B. Daily Vehicle Emissions $CO_2$




# Calculated Daily $CO_2$ Emissions

NVED2013 Data Outputs

1:6,000,000

N W E S

Date: 20/03/2015

NZ TRANSPORT AGENCY WAKA KOTAHI

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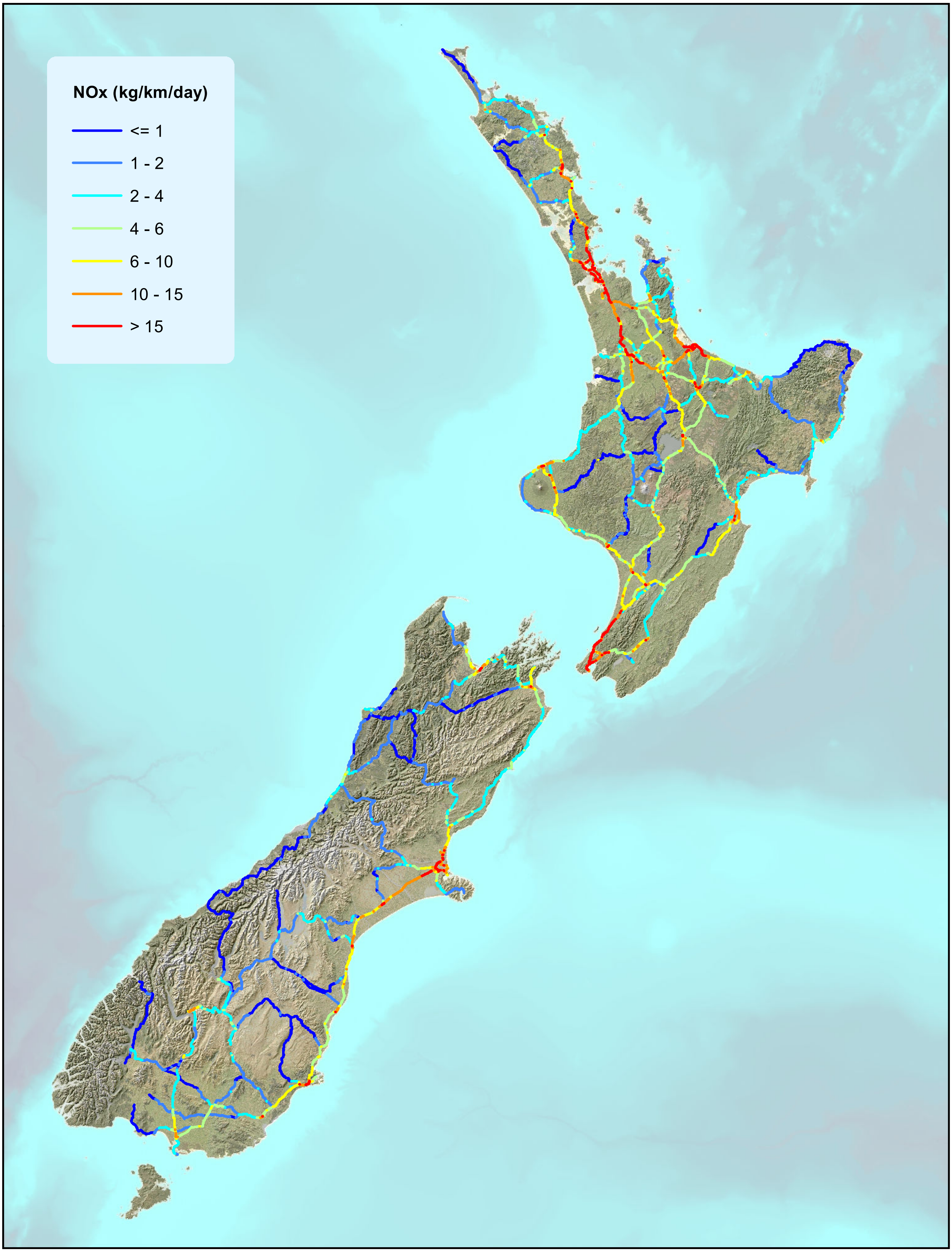
I:\AENVW\Projects\AE04567\Technical (controlled)\Spatial\ArcGIS\MXD (final)\Stage 1\OutputCO2.mxd

# Appendix C. Daily Vehicle Emissions $NO_x$




# Calculated Daily $NO_x$ Emissions

NVED2013 Data Outputs

1:6,000,000

N W E S

Date: 20/03/2015

NZ TRANSPORT AGENCY WAKA KOTAHI

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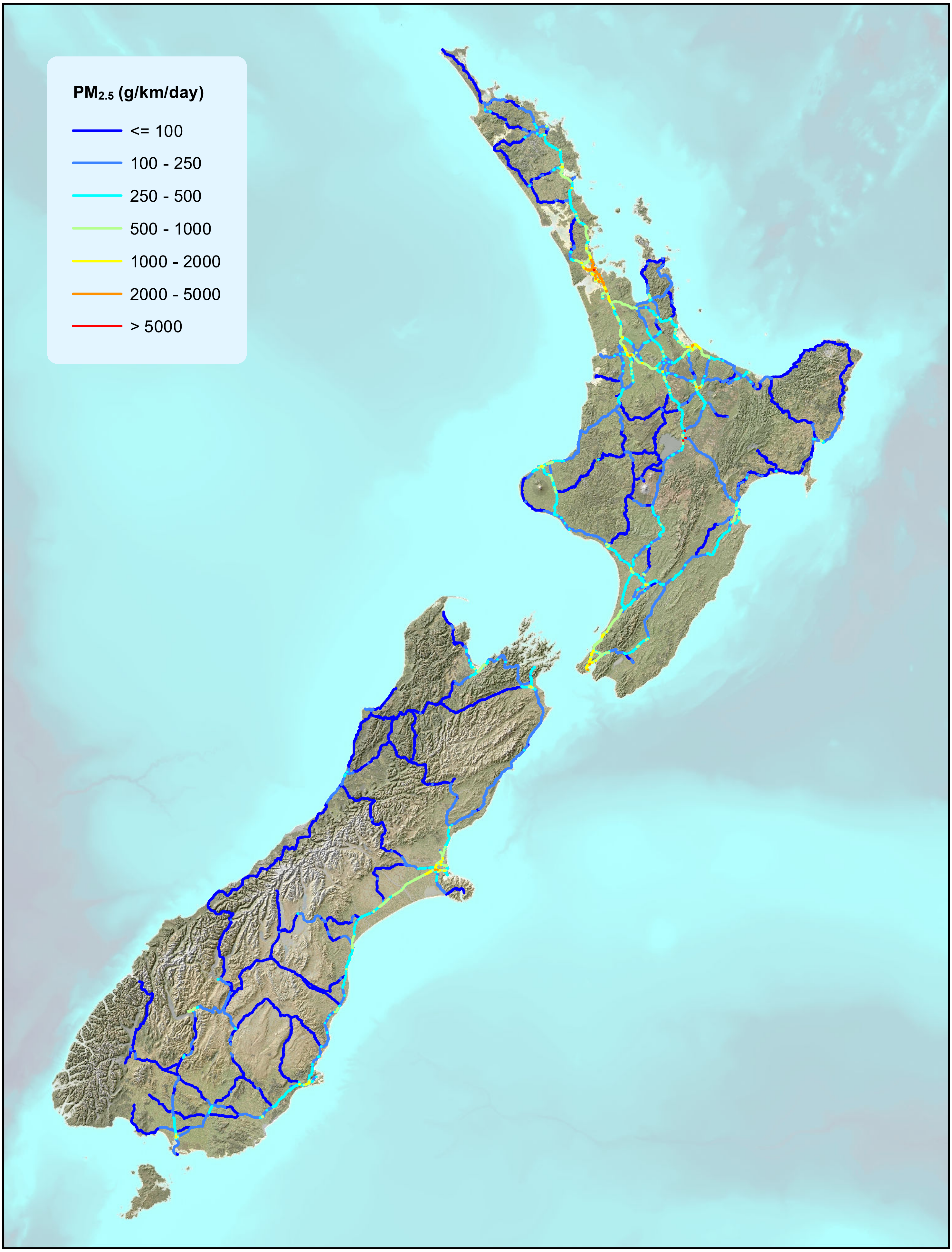
I:\AENVW\Projects\AE04567\Technical (controlled)\Spatial\ArcGIS\MXD (final)\Stage 1\OutputNOx.mxd

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




# Calculated Daily $PM_{2.5}$ Emissions

NVED2013 Data Outputs

1:6,000,000

N W E S

Date: 23/03/2015

NZ TRANSPORT AGENCY WAKA KOTAHI

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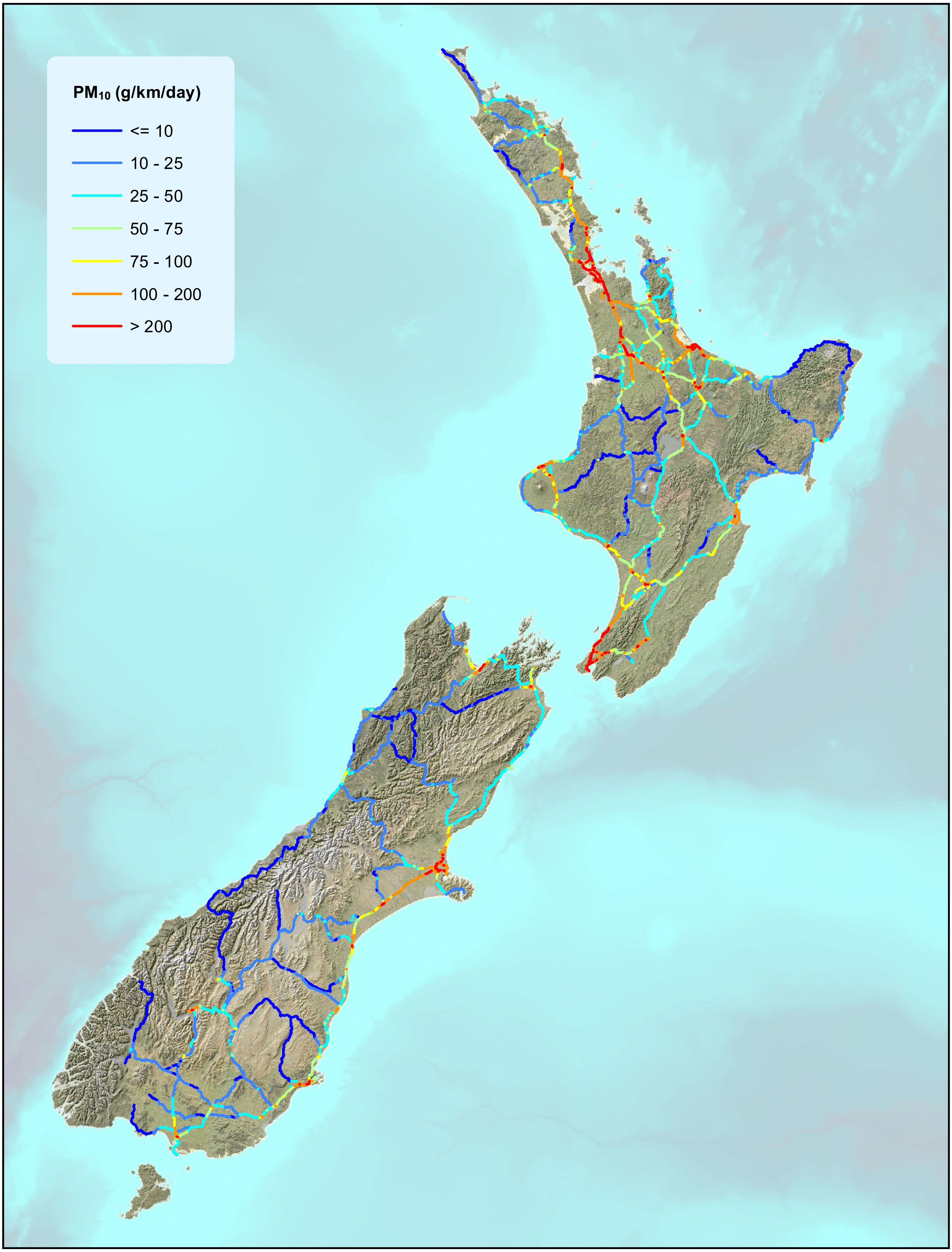
I:\AENVW\Projects\AE04567\Technical (controlled)\Spatial\ArcGIS\MXD (final)\Stage 1\OutputPM25.mxd

# Appendix E. Daily Vehicle Emissions $PM_{10}$




# Calculated Daily $PM_{10}$ Emissions

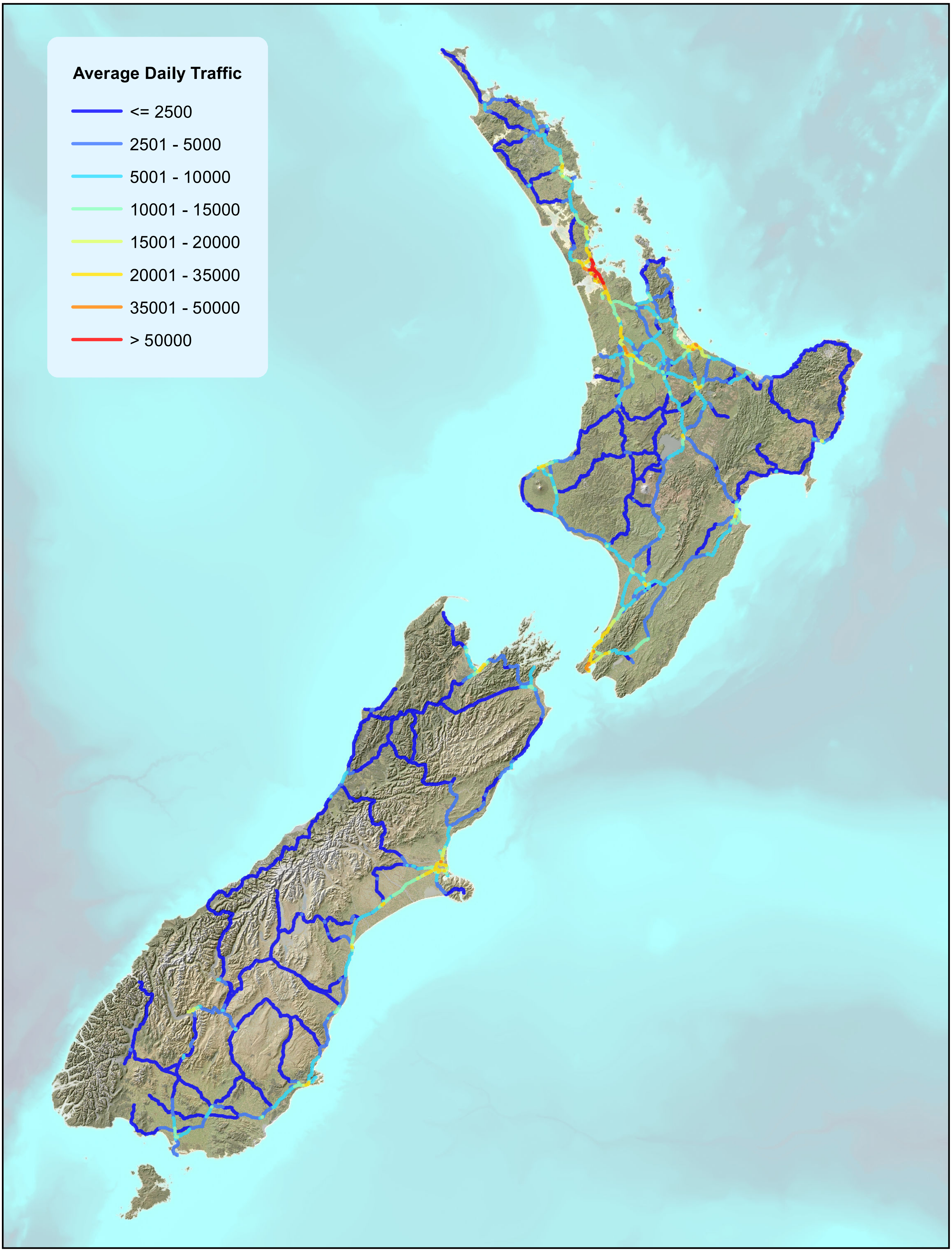
NVED2013 Data Outputs

1:6,000,000

Date: 20/03/2015

I:\AENV\WProjects\AE04567\Technical (controlled)\Spatial\ArcGIS\MXD (final)\Stage 1\OutputPM10.mxd

# Appendix F. Average Daily Traffic Input




# RAMMS Average Daily Traffic

## NVED2013 Data Inputs

1:6,000,000

N W E S

Date: 9/03/2015

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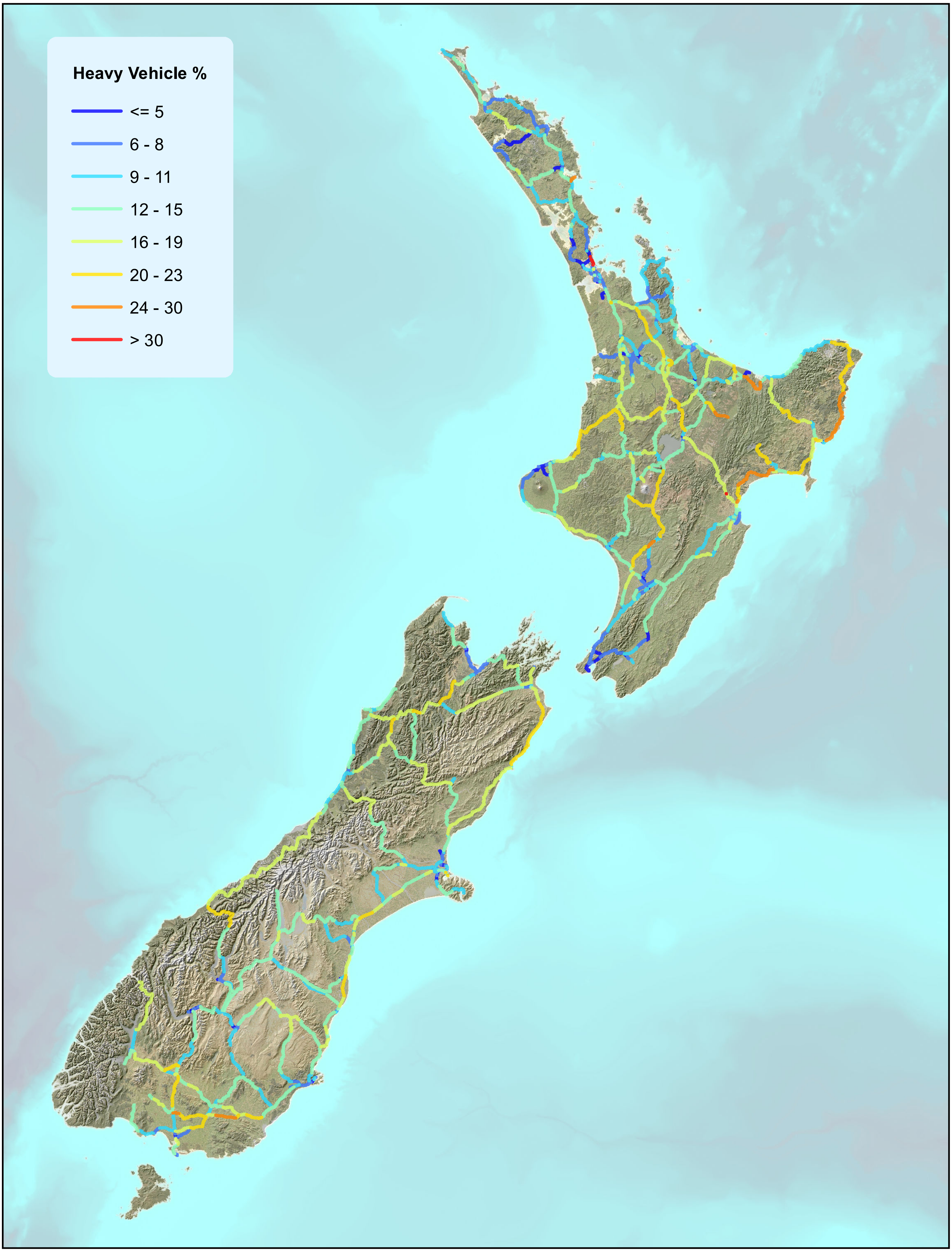
I:\AENVW\Projects\AE04567\Technical (controlled)\Spatial\ArcGIS\MXD (final)\Stage 1\InputTraffic.mxd

# Appendix G. Fleet Profile Input




# RAMMS Fleet Profile

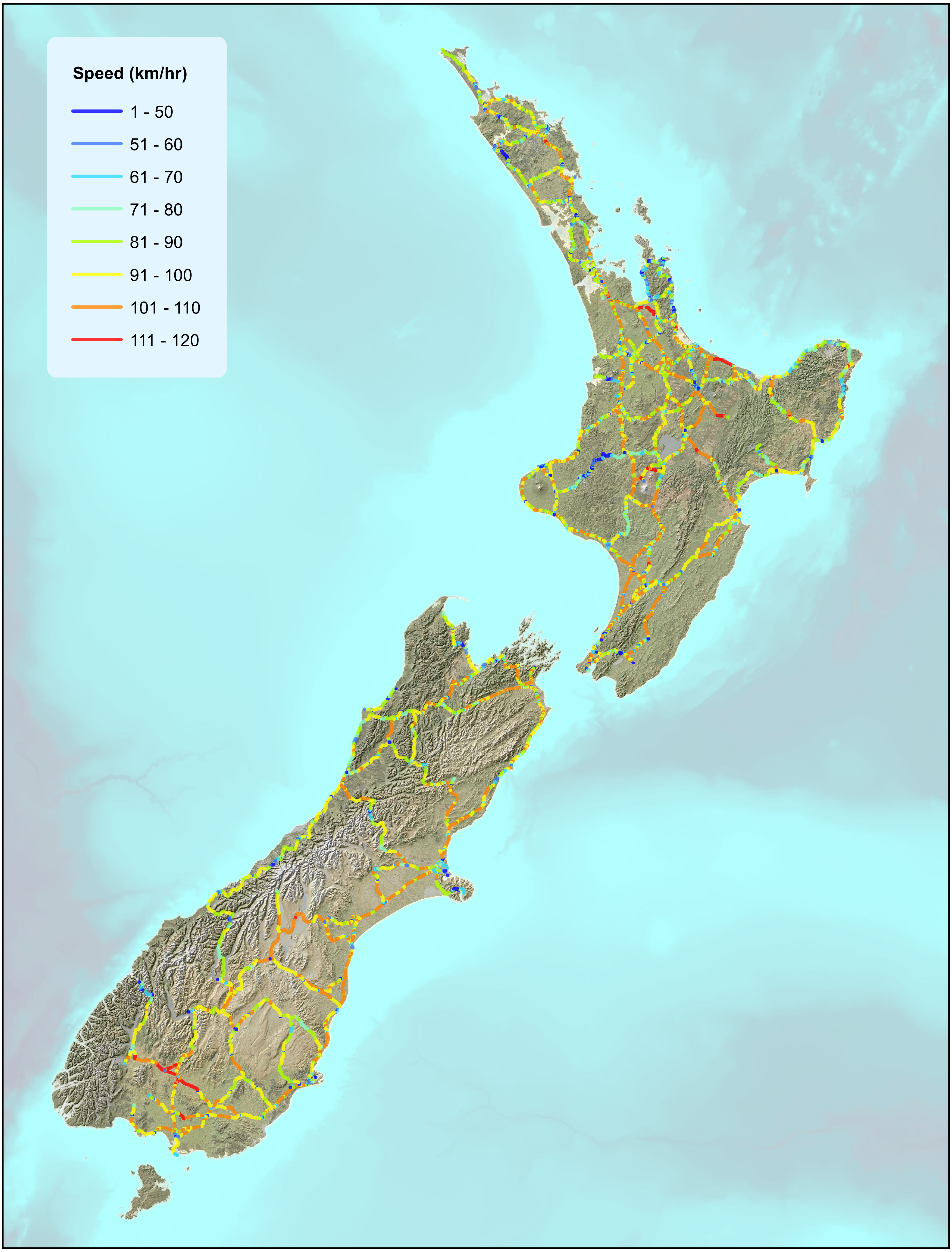
## NVED2013 Data Inputs

1:6,000,000

Date: 9/03/2015

I:\AENVW\Projects\AE04567\Technical (controlled)\Spatial\ArcGIS\MXD (final)\Stage 1\InputFleetProfile.mxd

# Appendix H. Speed Input




I:\AENVW\Projects\AE04567\Technical (controlled)\Spatial\ArcGIS\MXD (final)\Stage 1\InputSpeed.mxd

# EfficiencyNet Free Flow Speed

NVED2013 Data Inputs

1:6,000,000

N W E S

Date: 9/03/2015

NZ TRANSPORT AGENCY WAKA KOTAHI

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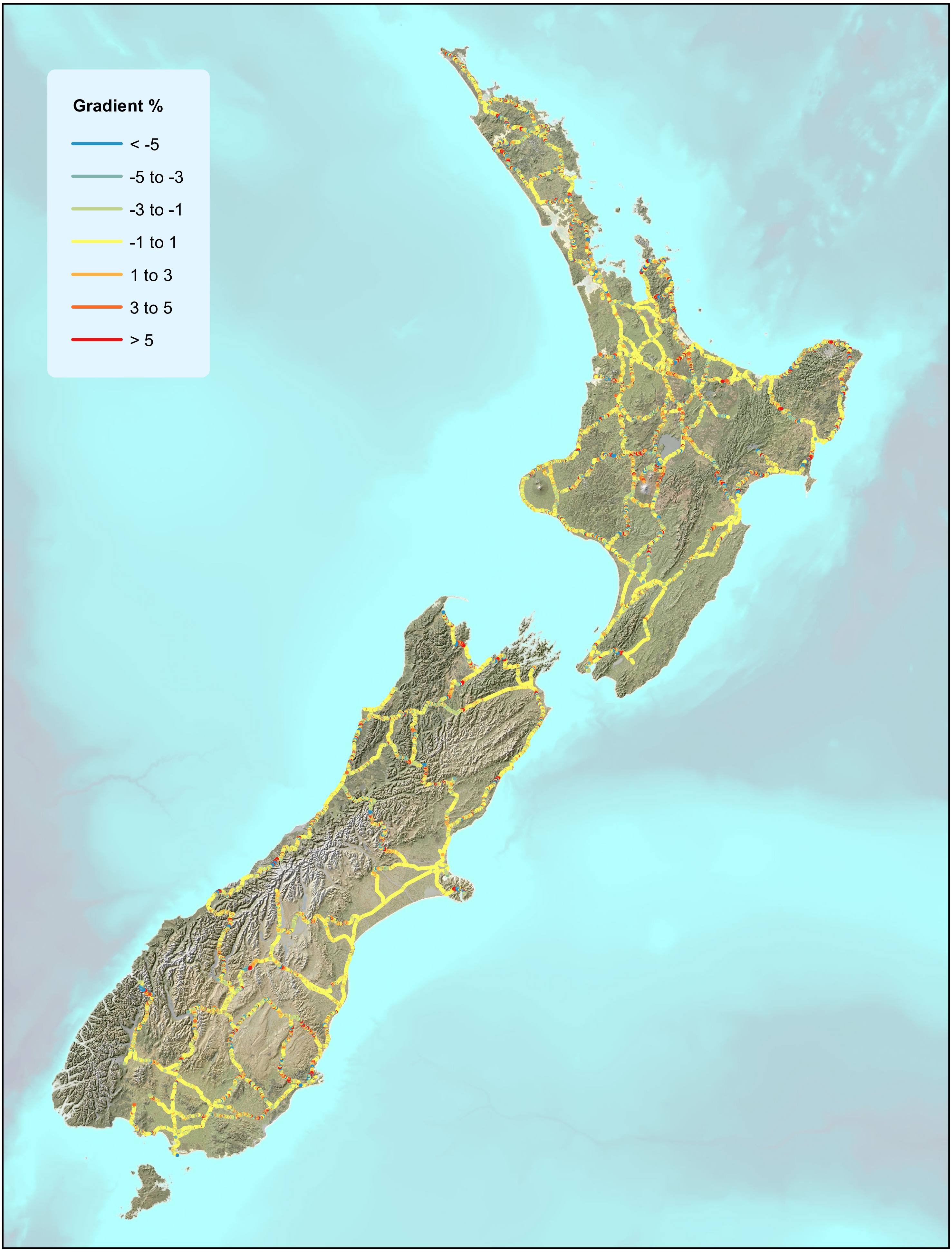
# Appendix I. Gradient Input




# SCRIM Gradient

## NVED2013 Data Inputs

1:6,000,000

N
W E
S

Date: 9/03/2015

NZ TRANSPORT AGENCY
WAKA KOTAHI

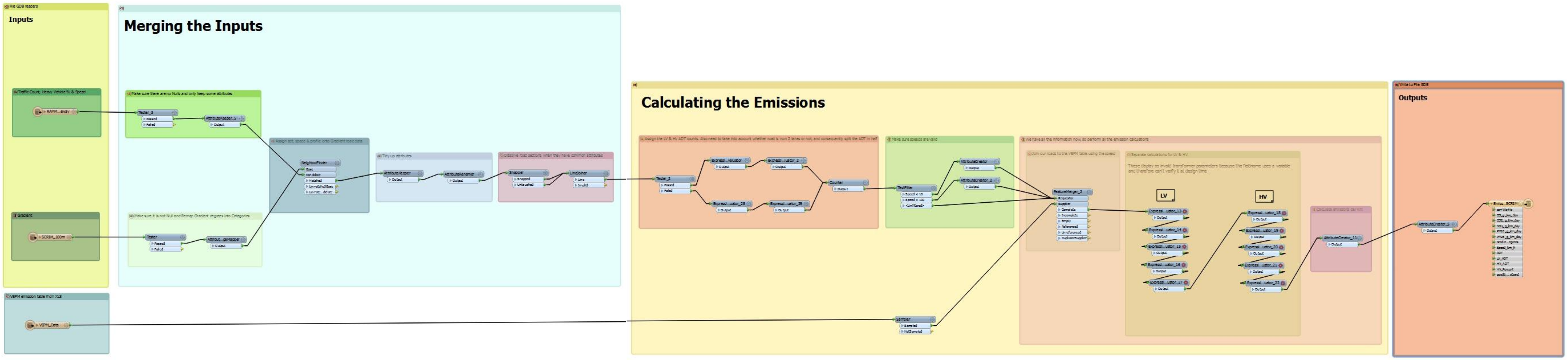
JACOBS

I:\AENVW\Projects\AE04567\Technical (controlled)\Spatial\ArcGIS\MXD (final)\Stage 1\InputGradient.mxd

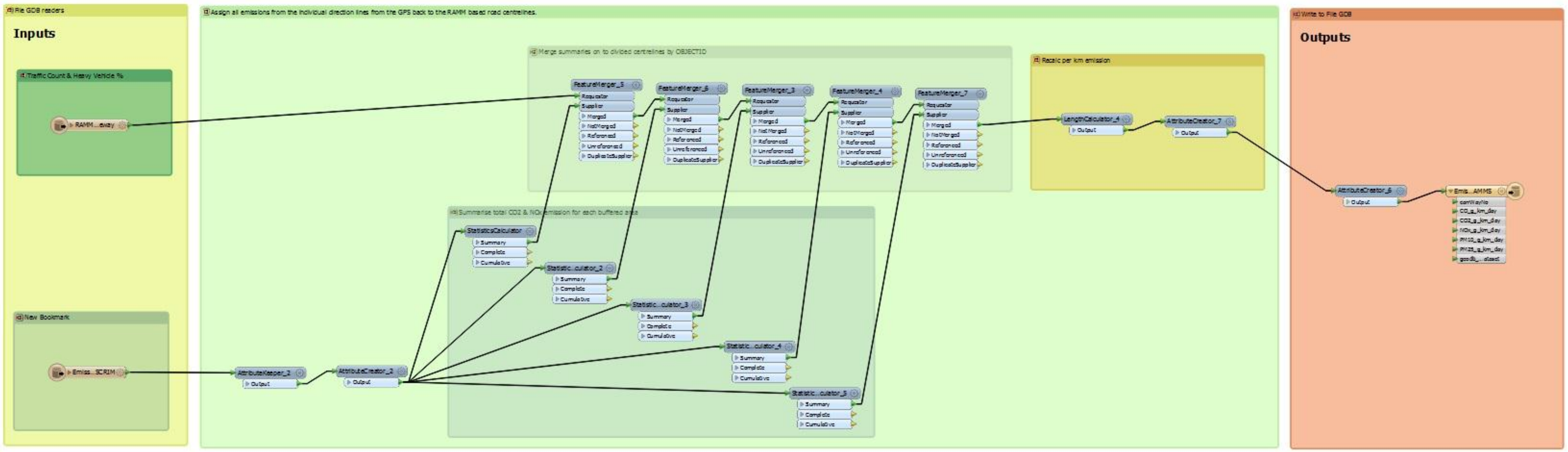
# Appendix J. FME Model 1 – Calculations and output to SCRIM

**Required Input Attributes:**

- TrafficADT (RAMMS)
- loadingPCHeavy (RAMMS)
- FreeFlowSpeed (RAMMS via EfficiencyNet)
- gradient (SCRIM)
- carrWayNo (RAMMS)

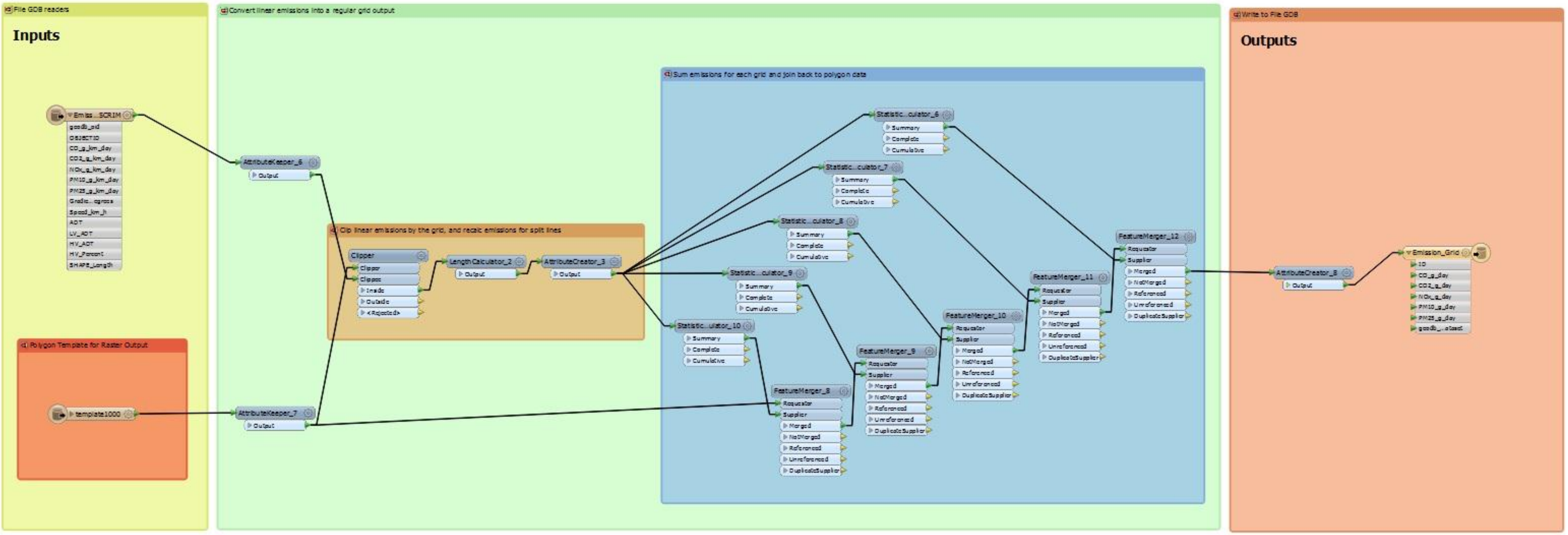


# Appendix K. FME Model 2 – Output to RAMM



File GDB readers
Inputs
Traffic Count & Heavy Vehicle %
RAMM...eway
New Bookmark
Emiss...SCRIM
Assign all emissions from the individual direction lines from the GPS back to the RAMM based road centrelines.
Merge summaries on to divided centrelines by OBJECTID
FeatureMerger_5
FeatureMerger_6
FeatureMerger_3
FeatureMerger_4
FeatureMerger_7
Requestor
Supplier
Merged
NotMerged
Referenced
Unreferenced
DuplicateSupplier
Summarise total CO2 & NOx emission for each buffered area
StatisticsCalculator
Statistic...culator_2
Statistic...culator_3
Statistic...culator_4
Statistic...culator_5
Summary
Complete
Cumulative
AttributeKeeper_2
AttributeCreator_2
Output
Recalc per km emission
LengthCalculator_4
AttributeCreator_7
Write to File GDB
Outputs
AttributeCreator_6
Emis...AMMS
carrWayNo
CO_g_km_day
CO2_g_km_day
NOx_g_km_day
PM10_g_km_day
PM25_g_km_day
geodb_...oteed

# Appendix L. FME Model 3 – Output to Grid


File GDB readers
Inputs
Convert linear emissions into a regular grid output
Sum emissions for each grid and join back to polygon data
Clip linear emissions by the grid, and recalc emissions for split lines
Polygon Template for Raster Output
template1000
AttributeKeeper_6
AttributeKeeper_7
Clipper
LengthCalculator_2
AttributeCreator_3
FeatureMerger_8
FeatureMerger_9
FeatureMerger_10
FeatureMerger_11
FeatureMerger_12
AttributeCreator_8
Emission_Grid
Write to File GDB
Outputs