TODOROSKI AIR SCIENCES

AIR DISPERSION MODELLING

ETHANEDINITRILE

Worksafe New Zealand

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Air Dispersion Modelling
Ethanedinitrile

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1 INTRODUCTION

Todoroski Air Sciences has been engaged by New Zealand WorkSafe to conduct air dispersion modelling of Ethanedinitrile as a potential fumigant for timber used for quarantine and pre-shipment purposes. It is understood in recent years Ethanedinitrile has been introduced as a viable alternative to methyl bromide in timber fumigation.

This report assesses the potential air quality impacts associated with the use of Ethanedinitrile during fumigation activity occurring at the Port of Tauranga (hereafter referred to as the Project).

1.1 Objectives

The purpose of this project is to understand the air quality impacts associated with emissions from Ethanedinitrile during fumigation activity. The key objectives identified for the project include:

1. *Examine whether an approximate 50 metre (m) buffer is adequate for the ventilation of log stacks under tarpaulin covers and from ship holds following fumigation with ethanedinitrile (and if not, what a suitable buffer would be);*
2. *Identify how long the buffer needs to be in place; and,*
3. *Examine whether time of day for ventilation, or log stacks per hour are other factors that can be used to manage impacts on workers.*

2 ASSESSMENT CRITERIA

2.1 Ethanedinitrile

Ethanedinitrile (EDN) is a colourless gas with a pungent bitter almond odour (**APVMA, 2013**). EDN consists of two cyanide molecules bonded together. It hydrolyses to form one molecule of hydrogen cyanide and one of cyanate. EDN is of relatively high acute toxicity to mammals and can cause irritation to the eyes and respiratory systems.

2.2 Air quality criteria

The New Zealand Tolerable Exposure Limits (TELs) and Workplace Exposure Standard as a time weighted average (WES-TWA) are set out for exposure to EDN in New Zealand. The TEL is averaged over a 24-hour period representing a single day and the WES-TWA over an eight hour day is designed to protect workers from excessive exposure to EDN.

The Acute Exposure Guideline Levels (AEGLs) represent threshold exposure limits for the general public below which adverse health effects are not likely to occur. Three levels of AEGLs (AEGL -1, -2 and -3) are established for various exposure periods and are distinguished by varying degrees of severity as a result of short-term exposure.

The first level, AEGL-1, is the airborne concentration above which individuals may experience notable discomfort or irritation. Individuals exposed to concentrations greater than the AEGL-2 recommended criteria may experience long-lasting health effects.

For this assessment we have focused on the TELs, WES-TWA and short-term AEGL-1 criteria. **Table 2-1** summarises the air quality criteria considered in this assessment.

Table 2-1: EDN Air Quality Criteria

Standard	Averaging Period	Criteria	
		ppm	µg/m³
TEL_{air}	24-hour	0.034	72
WES-TWA	8-hour	2	4256
AEGL-1	1-hour	2	4,256
AEGL-1	10-minute	2.5	5,320

Source: **NZ EPA (2018)**

ppm = parts per million, µg/m³ = micrograms per cubic metre

3 DISPERSION MODELLING APPROACH

3.1 Introduction

The following sections are included to provide the reader with an understanding of the model and modelling approach applied for the assessment.

The modelling was undertaken using a combination of the CALPUFF Modelling System and The Air Pollution Model (TAPM). CALPUFF is an advanced air dispersion model which can deal with the effects of complex local terrain on the dispersion meteorology over the modelling domain in a three-dimensional, hourly varying time step. TAPM is a prognostic air model used to simulate the upper air data for CALMET input.

CALPUFF is considered an appropriate air dispersion model for this project considering the local terrain features and proximity to the coast, and in particular the ability of the model to consider low wind speed conditions and also the release of a large volume of fumigant in a short period.

3.2 Modelling methodology

The model was setup in general accordance with the model-specific recommendations set out in *Generic Guidance and Optimum Model Setting for the CALPUFF Modeling System for Inclusion into the 'Approved Methods for the Modeling and Assessments of Air Pollutants in NSW, Australia'* (**TRC**, **2011**). These model-specific guidelines are consistent with more generalised guidance for any model, such as the New Zealand Ministry for the Environment, *Good Practice Guide for Atmospheric Dispersion Modelling* (**MfE, 2004**).

3.2.1 Meteorological modelling

An analysis of modelling predictions was initially conducted over the five contiguous years spanning 2014 to 2018 to select the most representative year for modelling. No significant discernible difference could be distinguished between the assessed meteorological years, indicating low variability in the inter-annual conditions. The 2018 calendar year was found to yield the highest predicted impacts overall and for this reason was selected for use in this assessment.

The TAPM model was applied to generate a three dimensional upper air data file for use in CALMET. The centre of analysis for the TAPM modelling used is at Tauranga Port, 37deg 39min south and 176deg 11min east. The simulation involved an outer grid of 30km, with three nested grids of 10km, 3km and 1km with 35 vertical grid levels.

The CALMET domain was run on an initial domain of 30 x 30km grid with a 0.6km grid resolution and refined for a final domain of 10 x 10km with a 0.1km grid resolution. The available meteorological data from the nearby meteorological monitoring site were included in the simulation. **Table 3-1** outlines the parameters used from the station.

Table 3-1: Surface observation stations

Weather Stations	Parameters						
	WS	WD	CH	CC	T	RH	SLP
Tauranga Aero AWS	✓	✓	✓	✓	✓	✓	✓

WS = wind speed, WD= wind direction, CH = cloud height, CC = cloud cover, T = temperature, RH = relative humidity, SLP = station level pressure

The seven critical parameters used in the CALMET modelling are presented in **Table 3-2**.

Table 3-2: Seven critical parameters used in CALMET

Option	Parameter	Value
Terrain radius of influence (km)	TERRAD	10
Vertical extrapolation of surface wind observations	IEXTRP	-4
Layer dependent weighting factor of surface vs. upper air wind observations in defining the Initial Guess Field (IGF) winds. Observations are always weighted by inverse distance squared ($1/R^2$) from the station to the grid point. The BIAS parameter changes that weight.	BIAS (NZ)	-1, -0.5, -0.25, 0, 0, 0, 0, 0
Weighting parameter for Step 1 wind field vs. observations in Layer 1 (R1) and Layer 2 and above (R2)	R1 and R2	3, 3
Maximum radius of influence for meteorological stations in layer 1 (Step2) and layers aloft (Step2)	RMAX1 and RMAX2	6, 6

An evaluation of the TAPM meteorological modelling and the outputs from the CALMET modelling is presented in **Appendix A**.

3.2.2 Dispersion modelling

The CALPUFF air dispersion model has been used to predict the potential emissions of EDN from its use in the fumigation of timber exports at the Port of Tauranga.

Modelling of the emission sources was conducted using the emissions rates and parameters outlined in the following section and utilising the meteorological data described in the previous section.

It is noted that modelled sources in this assessment may not represent the full spatial extent of the operations, but provide a representation of potential likely worst-case scenarios from individual sources of EDN.

3.3 Modelling sources and scenarios

3.3.1 Log stacks under a tarpaulin cover

EDN emissions associated with the fumigation of log stacks under a tarpaulin cover have been identified to arise during the ventilation period (following the fumigation) when the tarpaulin sheet enclosures are lifted.

It is understood that during fumigation the EDN is expected to be absorbed into the timber logs and that there is no significant desorption following fumigation and therefore desorption has not been considered in this assessment. Fugitive emissions of EDN, escaping during the fumigation are also assumed to be negligible and have been excluded in this assessment. Thus, the only emission of EDN assumed in the modelling occurs during the ventilation period.

The ventilation of the log stacks under a tarpaulin cover is modelled as a volume source. The modelling has assumed the log stacks have dimensions of 60 metres (m) long, 5m wide and 4m high with a free

air space volume of 450 cubic metres (m^3) under the tarpaulin cover. An endpoint concentration of 500ppm, 700ppm and 1,000ppm of EDN following fumigation is applied to estimate the emission during ventilation.

It is assumed that the ventilation of EDN would occur for a ten minute period for each log stack, occurring at the start of each modelled hour to represent potential ventilation activities occurring at any possible hour of the day.

A summary of the modelled source parameters is presented in **Table 3-3**.

Table 3-3: Modelled log stack source parameters

Source	Log stack under tarpaulin cover
Type	Volume
Effective height (m)	4
Initial lateral dimension, Sig y (m)	14
Initial vertical dimension, Sig z (m)	1

To examine the impacts associated with the ventilation of EDN, a range of potential scenarios were analysed. Ventilation of EDN from log stacks under a tarpaulin cover can occur at various locations within the permissible fumigation area at the Port of Tauranga with a number of different log stack ventilations occurring over a day period and multiple ventilations occurring in close proximity.

Eight modelling scenarios were used to assess the potential range of impacts during ventilation of EDN from log stacks under a tarpaulin cover. The scenarios were as follows:

- One Log stack scenario - ventilation of one log stack in a 24-hour period. Ventilation occurs for a ten minute period at the start of the release hour.
- Three log stacks scenario (localised) - ventilation of three log stacks separated by 1-5m in a 24-hour period. Ventilation of two stacks occur simultaneously for a ten minute period at the start of the release hour, followed by the third log stack ten minutes later.
- Three log stacks scenario (60m distance) - ventilation of three log stacks each separated by a distance of 60m in a 24-hour period. Ventilation of each of the three stacks occurs simultaneously for a ten minute period at the start of the release hour.
- Three log stacks scenario (20 minutes apart) - ventilation of three log stacks in one hour in a 24-hour period. Ventilation occurs for a ten minute period at the start of the release hour, with the following log stacks ventilated 20 minutes apart.
- Nine log stacks scenario - ventilation of nine log stacks in a 24-hour period with three log stacks per event and each event occurring four hours apart. For each event, ventilation of one log stack occurs for a ten minute period, followed by the second log stack ten minutes later and the third ten minutes later.
- Ten log stacks scenario - ventilation of ten log stacks within two hours (five log stacks per hour) in a 24-hour period. Ventilation of each log stack occurs for a ten minute period with the next log stack ventilated ten minutes later.

- Thirty log stacks (over a 8.5-hour period) scenario – This scenario intends to reflect ventilation of 32 log stacks which took place at the Port of Tauranga in 2019 over an approximate 8.5-hour period. The thirty log stacks are ventilated over a 9-hour period from three log stack events consisting of 8 log stacks (with ventilation of each log stack for a ten minute period with the following log stack ventilated ten minutes apart), a 0.5 hour gap, 7 log stacks (with ventilation of each log stack for a ten minute period with the following log stack ventilated ten minutes apart), a 3-hour gap and then 15 log stacks (with ventilation of each log stack for a ten minute period with the following log stack ventilated ten minutes apart). An emissions profile of the thirty log stacks (over an 8.5-hour period) scenario is presented below in **Figure 3-1**.

- Thirty log stacks (over a 6-hour period) scenario - ventilation of thirty log stacks within 6-hours in a 24-hour period. Five log stacks are ventilated each hour with ventilation of each log stack for a ten minute period with the following log stack ventilated ten minutes apart.

For each of the modelling scenarios, each hour of the day has been assumed to be a potential release hour (i.e. 8760 hours modelled). Each release hour is independent and there are no residual impacts from the proceeding or following hour to ensure there is no overlap and the potential impact for each release hour can be assessed individually.

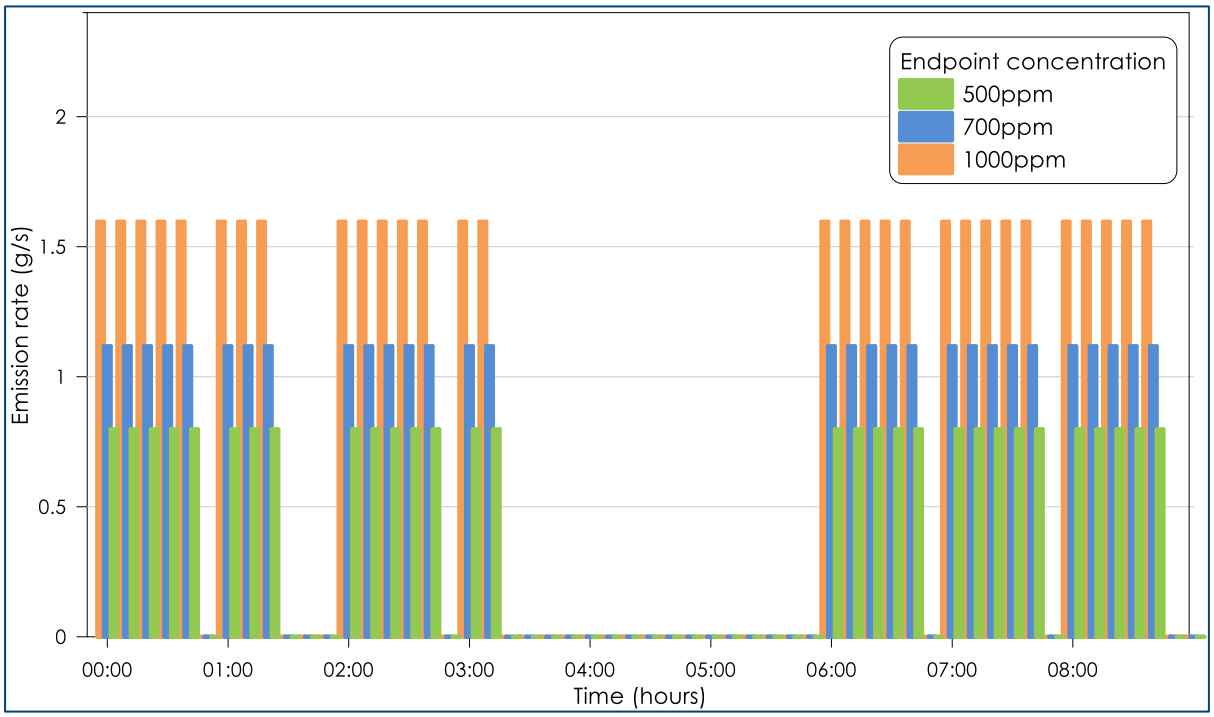

Figure 3-1: Example of emission profile for ventilation of thirty log stacks (over 8.5-hour period)

3.3.2 Ship holds

Similar to the fumigation of log stacks under tarpaulin covers, EDN emissions associated with the fumigation of logs in ship holds have been identified to arise during the ventilation period (following the fumigation) when the ship hold enclosures are opened.

EDN emissions from desorption and fugitive emissions during the fumigation are assumed to be negligible and have also been excluded in this assessment. Thus, the only emission of EDN assumed in the modelling occurs during the ventilation period.

The ventilation of the logs in ship holds are modelled as volume sources. A single ship was modelled with five ship holds assuming each ship hold has dimensions of 24.5m by 24.5m with a depth of 15m and a free air space volume of 3800 cubic metres (m^3). An endpoint concentration of 500ppm, 700ppm and 1,000ppm of EDN following fumigation is applied to estimate the emission during ventilation.

Ventilation of ship hold emissions were assumed to occur over a 6-hour period from the time the holds begin to be opened. Emission rates are assumed to increase for the first two hours as more hold area is progressively opened, and to thereafter decrease for the next four hours as the fumigant progressively exits the holds. Ventilation was modelled to occur at the start of each modelled hour to represent potential ventilation activities occurring at any possible hour of the day. The ventilation profile for the ship holds is presented in **Figure 3-2**.

Each hour of the day has been assumed to be a potential release hour and has been assessed separately to ensure there is no overlap between each hour and the potential impact for each release hour can be assessed individually.

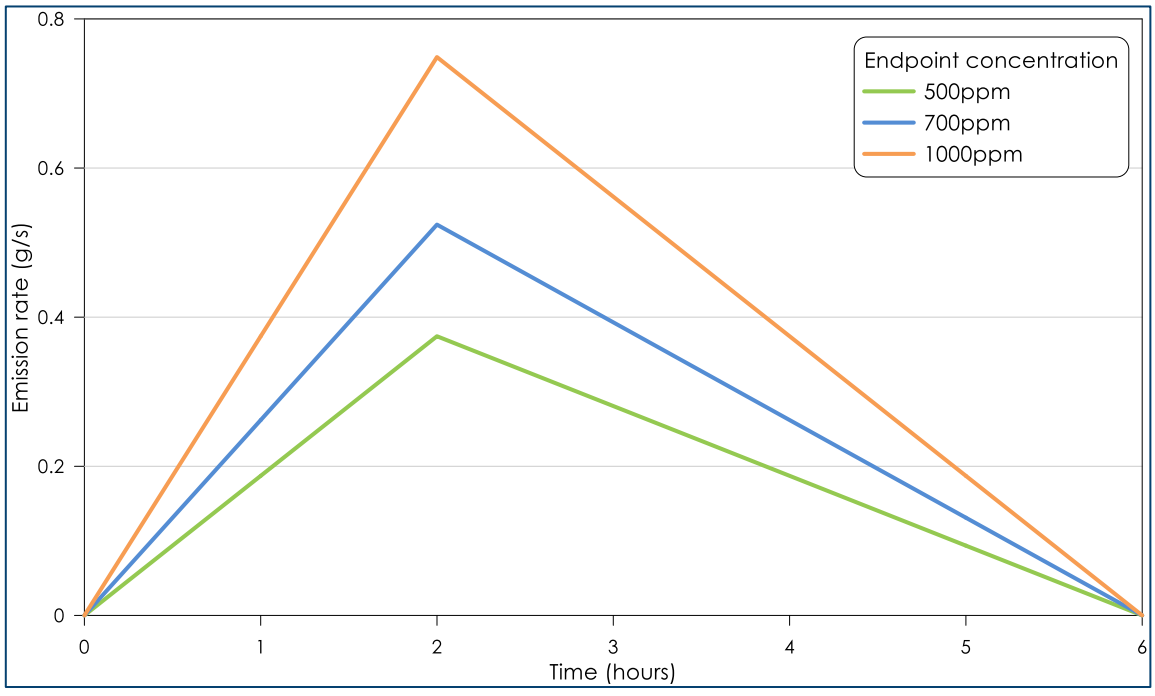

Figure 3-2: Example of emission profile for ventilation of ship holds

A summary of the modelled source parameters is presented in **Table 3-4.**

Table 3-4: Modelled ship hold source parameters

Source	Ship hold
Type	Volume
Effective height (m)	7
Initial lateral dimension, Sig y (m)	5.7
Initial vertical dimension, Sig z (m)	1

3.3.3 Location of modelled sources

An indicative layout of modelled sources is presented in **Figure 3-3**.

The log stack sources are located in groups of ten log stacks approximately 60m apart. Each group of ten log stacks consists of five rows of log stacks, 1m apart with a 5m spacing between the rows. It is noted that modelled sources in this assessment may not represent the full spatial extent of the operations, but provide a representation of potential likely worst-case scenarios from individual sources of EDN.

A single ship with five ship holds docked at the port is show in **Figure 3-3** to the west of the modelled log stack locations.

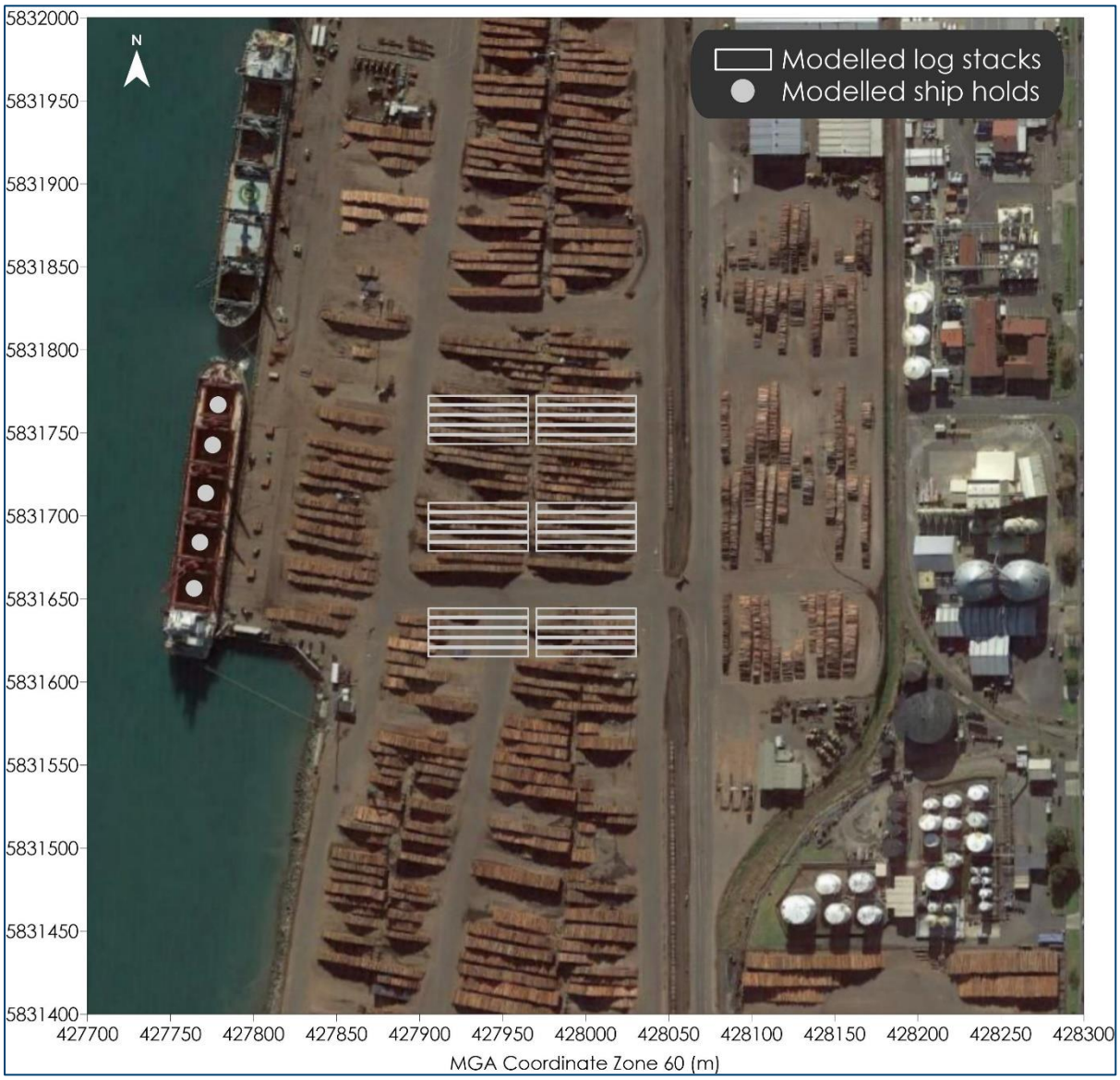

Figure 3-3: Placement of modelled sources

4 DISPERSION MODELLING RESULTS

The dispersion modelling predictions for each of the assessed scenarios are presented in this section. The results presented include those for the ventilation of log stacks under a tarpaulin cover and from ship holds.

Selected modelling scenarios showing the maximum predicted levels of the 10-minute average and 24-hour average levels for the limiting endpoint concentration of either 500ppm, 700ppm or 1,000ppm are analysed in detail in the following sections.

Associated isopleth diagrams of all averaging periods and endpoint concentrations are presented in **Appendix B**.

4.1 Log stacks under a tarpaulin cover

This section presents the predicted EDN ground level concentrations associated with the ventilation of log stacks under a tarpaulin cover.

4.1.1 Predicted maximum EDN concentrations

Selected isopleth diagrams of the dispersion modelling results are presented below to show the maximum predicted levels of selected averaging periods at selected endpoint concentrations of for each scenario.

The isopleth diagrams present the relevant criteria (red contour line) for the averaging period presented. Note that where no criteria line is shown the maximum predicted levels are below the criteria.

4.1.1.1 One log stack scenario

Ventilation of one log stack in a 24-hour period. Ventilation occurs for a ten minute period at the start of the release hour. Modelling predictions for the other averaging periods and endpoint concentrations are presented in **Appendix B**.

Figure 4-1 indicates that the predicted 10-minute average levels with an endpoint concentration of 500ppm occurring in all hours would be below the relevant criteria at a 50m distance.

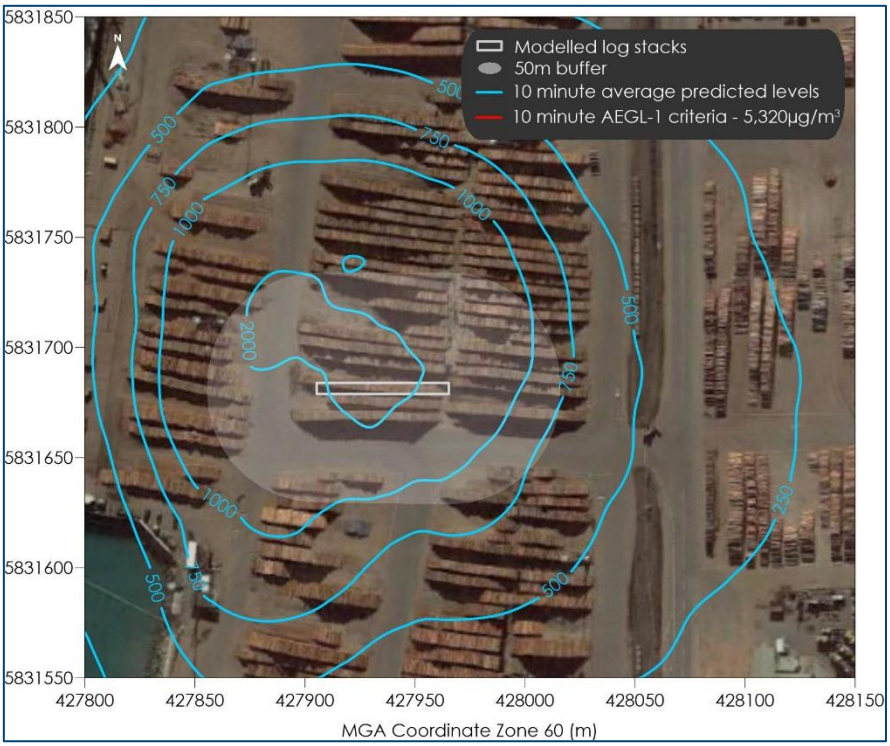

Figure 4-1: Maximum predicted EDN concentrations (µg/m³) - One log stack scenario, 10-minute averages, 500ppm

Figure 4-2 indicates that the predicted 10-minute average levels with an endpoint concentration of 1,000ppm occurring in all hours would be below the relevant criteria at a 50m distance.

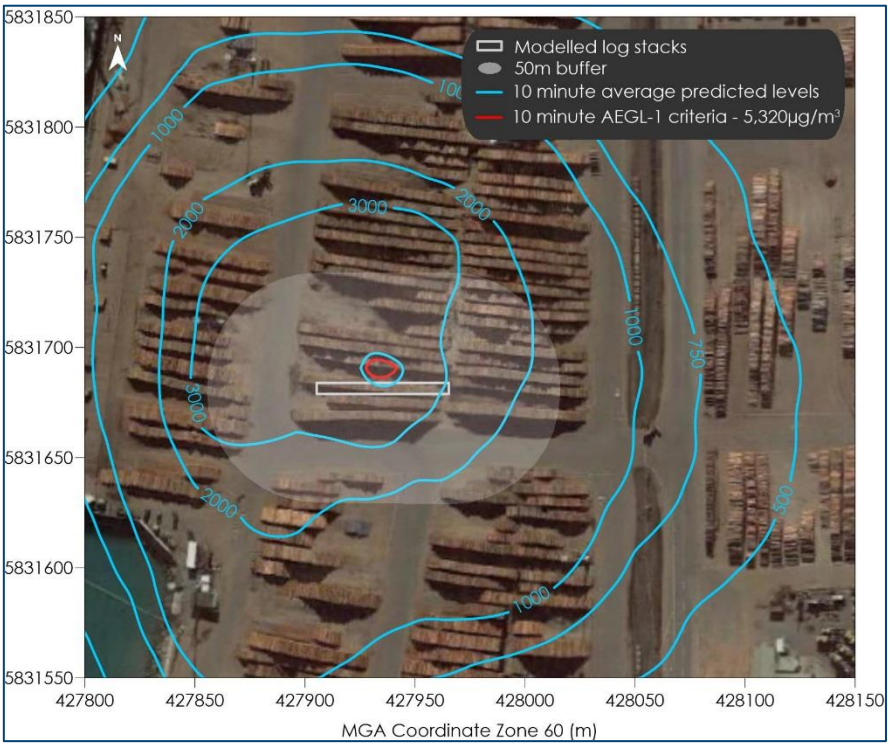

Figure 4-2: Maximum predicted EDN concentrations (µg/m³) - One log stack scenario, 10-minute averages, 1,000ppm

Figure 4-3 indicates that the predicted 24-hour average levels with an endpoint concentration of 500ppm occurring in all hours would be below the relevant criteria at a 50m distance.

Figure 4-3: Maximum predicted EDN concentrations (µg/m³) – One log stack scenario, 24-hour averages, 500ppm

Figure 4-4 indicates that the predicted 24-hour average levels with an endpoint concentration of 1,000ppm occurring in all hours would be below the relevant criteria at a 50m distance.

Figure 4-4: Maximum predicted EDN concentrations (µg/m³) – One log stack scenario, 24-hour averages, 1,000ppm

The modelling predictions indicate that:

- For ventilation per the one log stack scenario, predicted impacts would be below the relevant criteria at a 50m distance for all averaging periods and endpoint concentrations of 500ppm, 700ppm and 1,000ppm of EDN.

4.1.1.2 Three log stacks scenario (localised)

Three log stacks scenario (localised) - ventilation of three log stacks separated by 1-5m apart in a 24-hour period. Ventilation of two stacks occur simultaneously for a ten minute period at the start of the release hour, followed by the third log stack ten minutes later.

Figure 4-5 indicates that the predicted 10-minute average levels with an endpoint concentration of 500ppm occurring in all hours would be below the relevant criteria at a 50m distance.

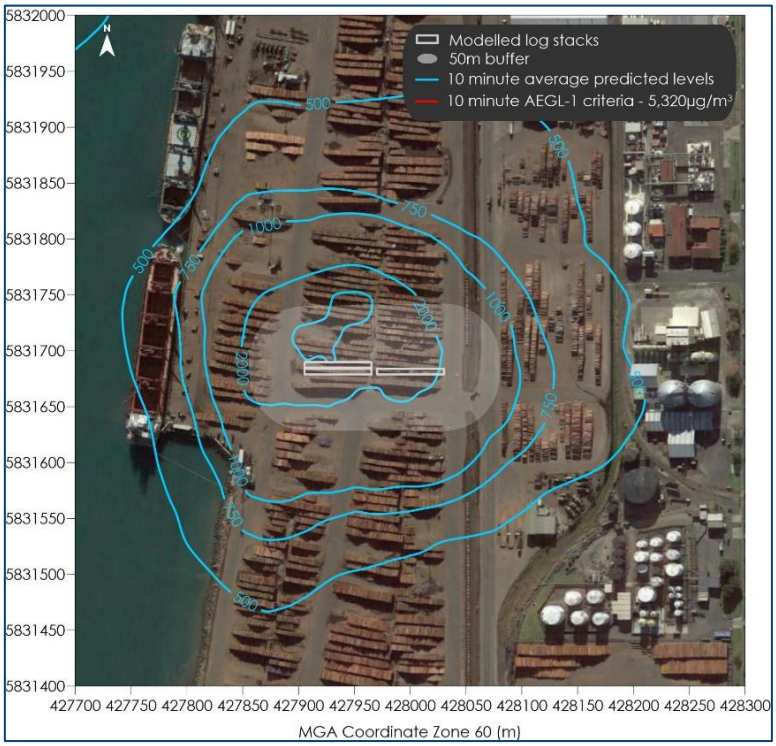

Figure 4-5: Maximum predicted EDN concentrations (µg/m³) - Three log stack scenario (localised), 10-minute averages, 500ppm

Figure 4-6 indicates that the predicted 10-minute average levels with an endpoint concentration of 1,000ppm occurring in all hours would exceed the relevant criteria at a 50m distance.

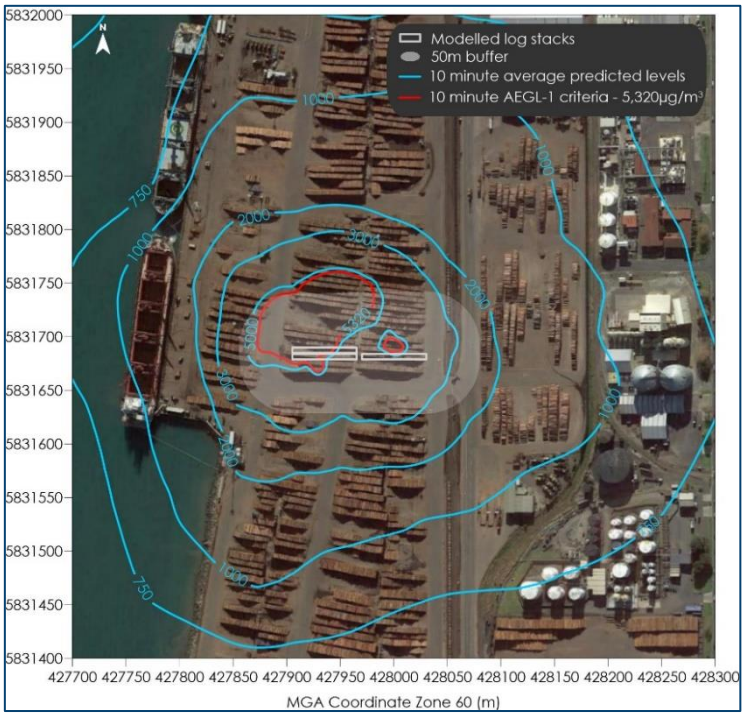

Figure 4-6: Maximum predicted EDN concentrations (µg/m³) - Three log stack scenario (localised), 10-minute averages, 1,000ppm

Figure 4-7 indicates that the predicted 24-hour average levels with an endpoint concentration of 500ppm occurring in all hours would be below the relevant criteria at a 50m distance.

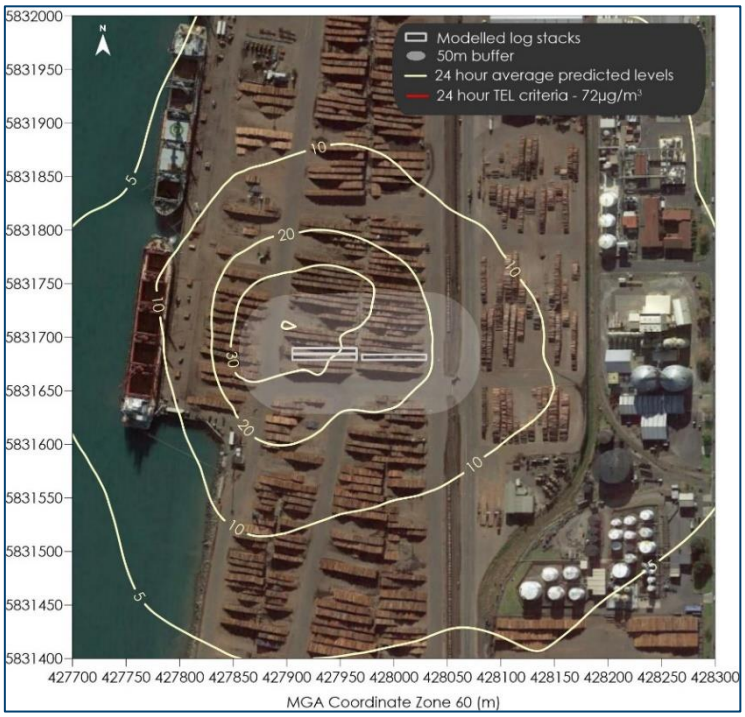

Figure 4-7: Maximum predicted EDN concentrations (µg/m³) - Three log stack scenario (localised), 24-hour averages, 500ppm

Figure 4-8 indicates that the predicted 24-hour average levels with an endpoint concentration of 1,000ppm occurring in all hours would exceed the relevant criteria at a 50m distance.

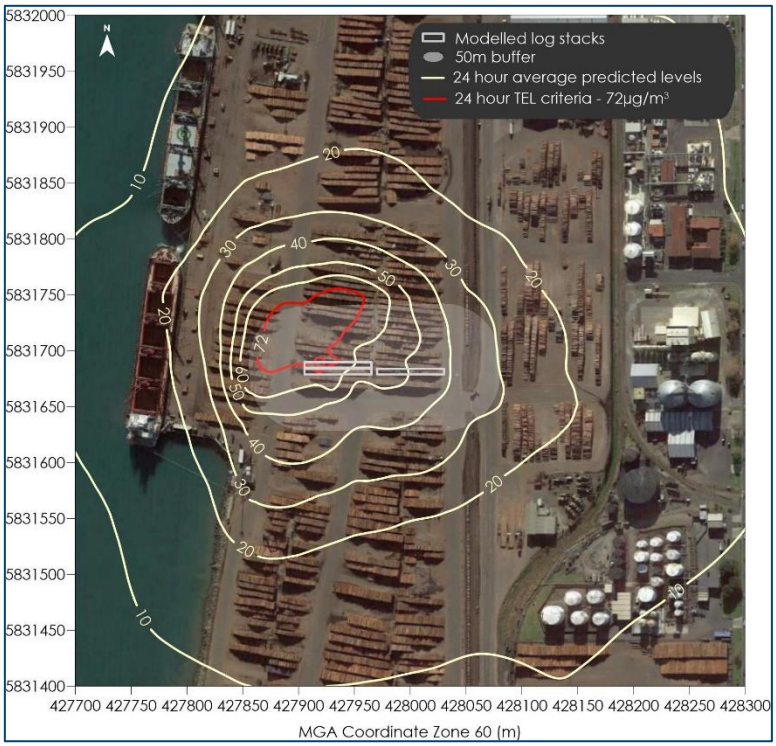

Figure 4-8: Maximum predicted EDN concentrations (µg/m³) - Three log stack scenario (localised), 24-hour averages, 1,000ppm

The modelling predictions indicate that:

- For ventilation per the three log stacks scenario (localised), predicted impacts would be above the relevant criteria at a 50m distance for the 10-minute average and 24-hour average periods and an endpoint concentrations of 1,000ppm of EDN.
- For the other averaging periods and endpoint concentrations, predicted impacts would be below the relevant criteria at a 50m distance.
- A buffer of at least 70m should be used for ventilation of three log stacks in a localised area.

4.1.1.3 Three log stacks scenario (60m distance)

Three log stacks scenario (60m distance) - ventilation of three log stacks each separated by a distance of 60m in a 24-hour period. Ventilation of each of the three stacks occur simultaneously for a ten minute period at the start of the release hour.

Figure 4-9 indicates that the predicted 10-minute average levels with an endpoint concentration of 500ppm occurring in all hours would be below the relevant criteria at a 50m distance.

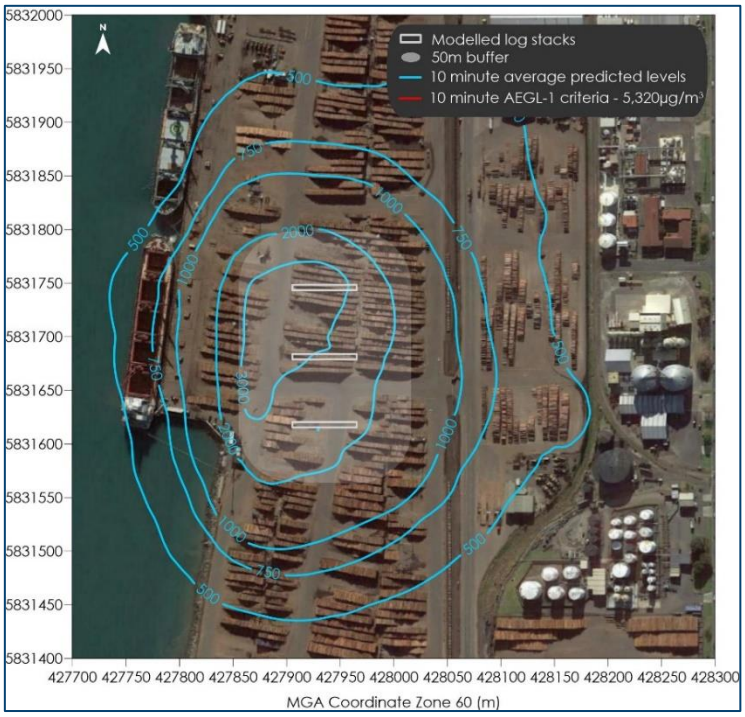

Figure 4-9: Maximum predicted EDN concentrations (µg/m³) - Three log stack scenario (60m distance), 10-minute averages, 500ppm

Figure 4-10 indicates that the predicted 10-minute average levels with an endpoint concentration of 500ppm occurring in all hours would be below the relevant criteria beyond a 50m distance.

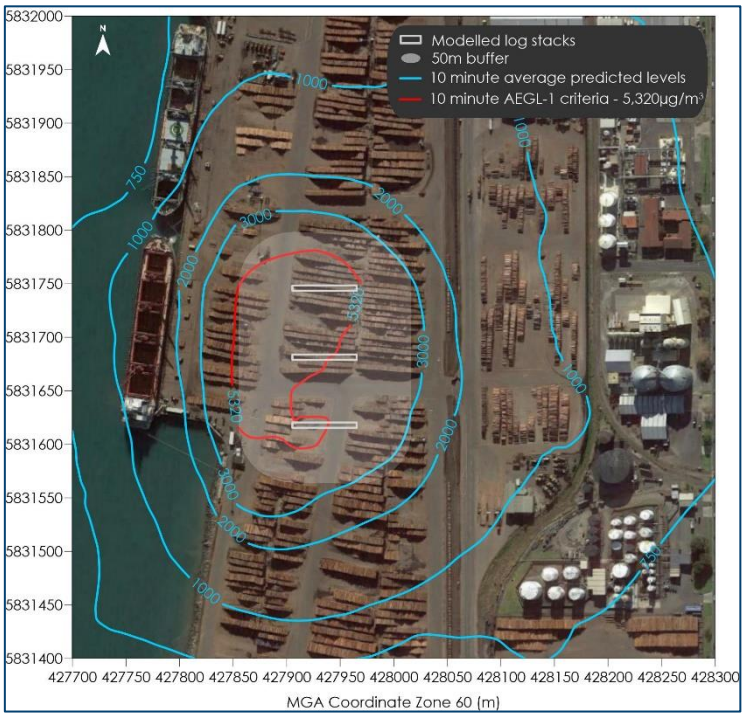

Figure 4-10: Maximum predicted EDN concentrations (µg/m³) - Three log stack scenario (60m distance), 10-minute averages, 1,000ppm

Figure 4-11 indicates that the predicted 24-hour average levels with an endpoint concentration of 500ppm occurring in all hours would be below the relevant criteria at a 50m distance.

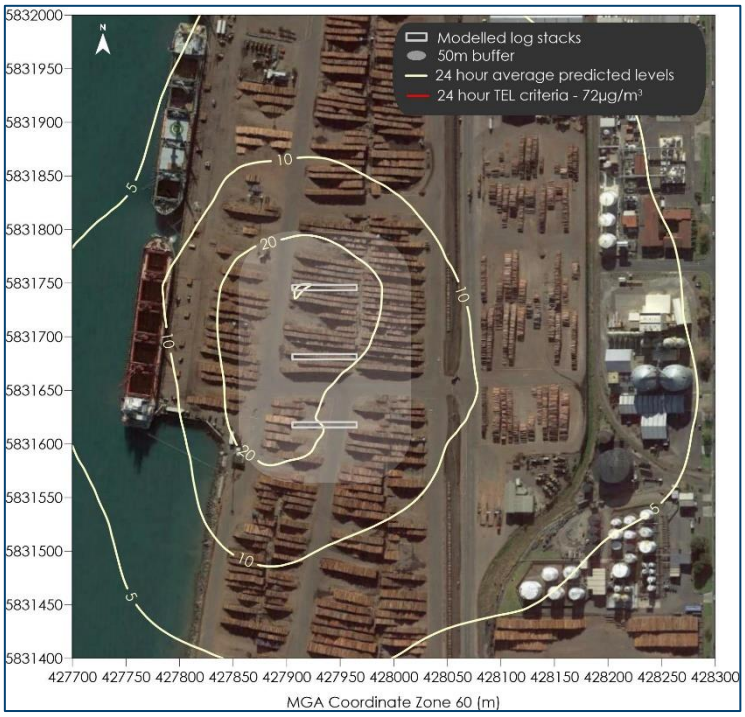

Figure 4-11: Maximum predicted EDN concentrations (µg/m³) - Three log stack scenario (60m distance), 24-hour averages, 500ppm

Figure 4-12 indicates that the predicted 24-hour average levels with an endpoint concentration of 1,000ppm occurring in all hours would be below the relevant criteria at a 50m distance.

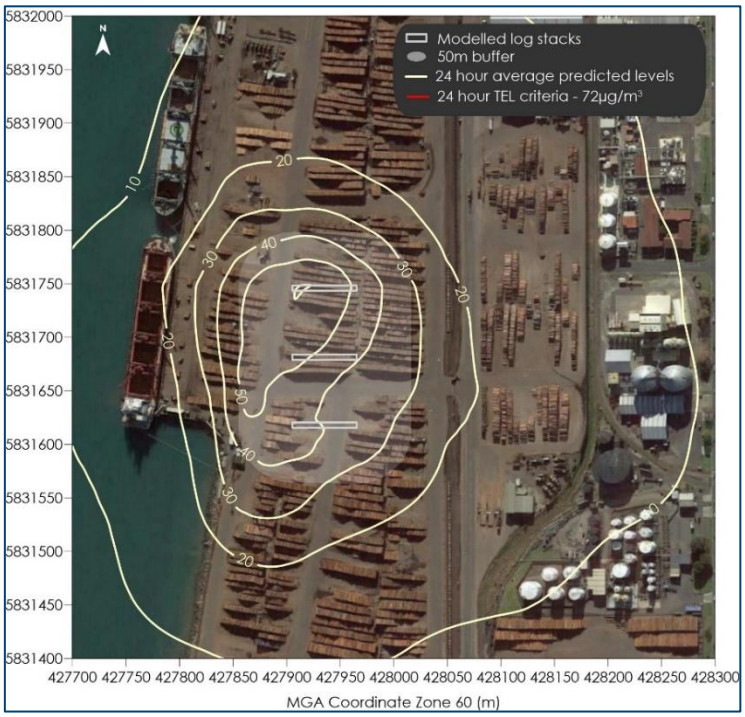

Figure 4-12: Maximum predicted EDN concentrations (µg/m³) - Three log stack scenario (60m distance), 24-hour averages, 1,000ppm

The modelling predictions indicate that:

- For ventilation per the three log stacks scenario (60m distance), predicted impacts would be at the relevant criteria at a 50m distance for the 10-minute average period and an endpoint concentration of 1,000ppm of EDN.
- For the other averaging periods and endpoint concentrations, predicted impacts would be below the relevant criteria at a 50m distance.
- A separation distance of at least 60m between log stacks should be used for simultaneous ventilation of up to three logs stacks.

4.1.1.4 Three log stack scenario (20 minutes apart)

Three log stacks scenario (20 minutes apart) - ventilation of three log stacks in a 24-hour period. Ventilation occurs for a ten minute period, 20 minutes apart at the start of the release hour.

Figure 4-13 indicates that the predicted 10-minute average levels with an endpoint concentration of 500ppm occurring in all hours would be below the relevant criteria at a 50m distance.

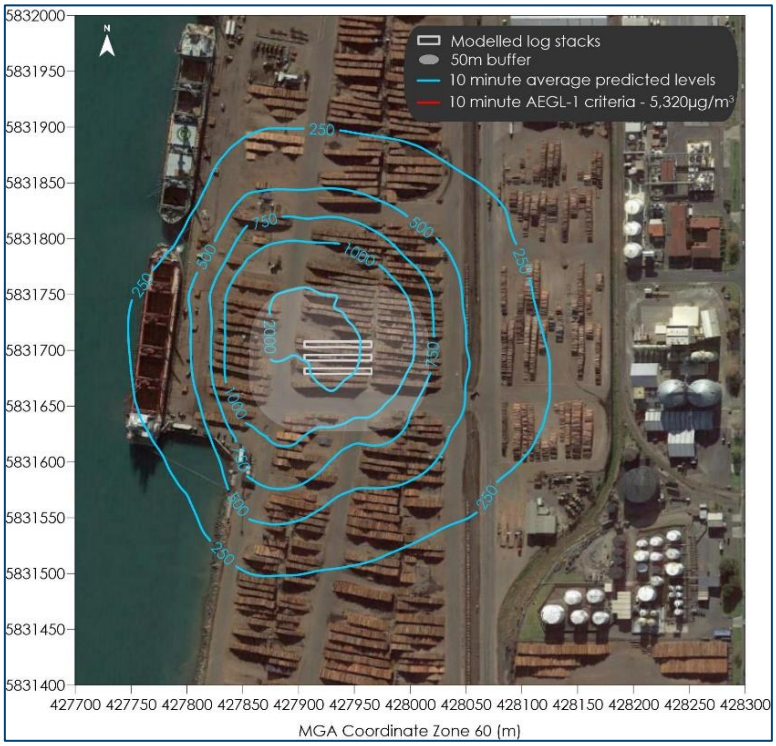

Figure 4-13: Maximum predicted EDN concentrations (µg/m³) - Three log stack scenario (20 minutes apart), 10-minute averages, 500ppm

Figure 4-14 indicates that the predicted 10-minute average levels with an endpoint concentration of 1,000ppm occurring in all hours would be below the relevant criteria at a 50m distance.

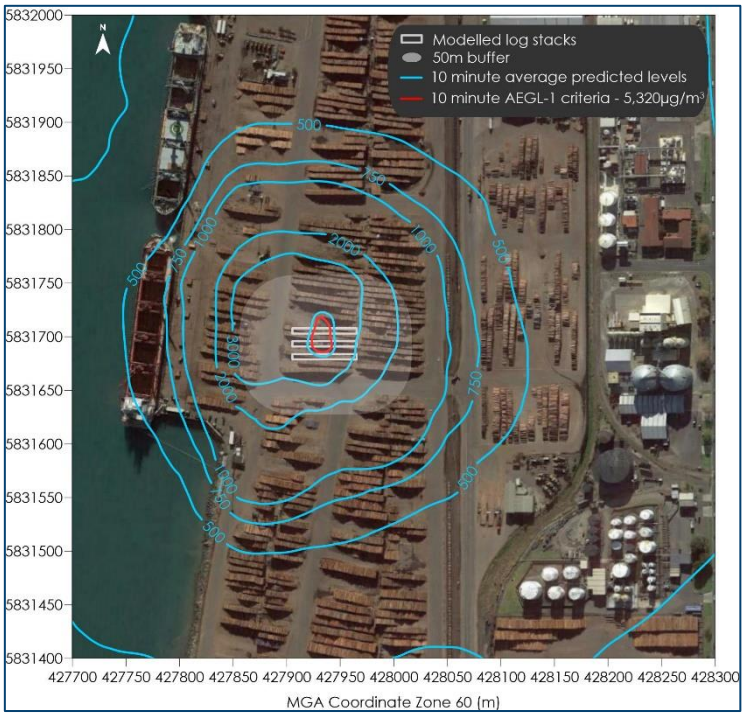

Figure 4-14: Maximum predicted EDN concentrations (µg/m³) - Three log stack scenario (20 minutes apart), 10-minute averages, 1,000ppm

Figure 4-15 indicates that the predicted 24-hour average levels with an endpoint concentration of 500ppm occurring in all hours would be below the relevant criteria at a 50m distance.

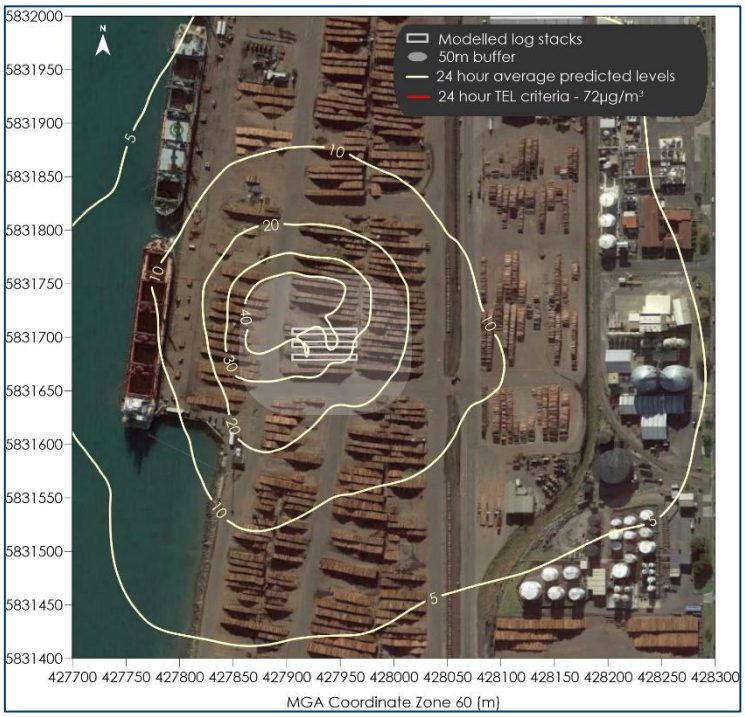

Figure 4-15: Maximum predicted EDN concentrations (µg/m³) - Three log stack scenario (20 minutes apart), 24-hour averages, 500ppm

Figure 4-16 indicates that the predicted 24-hour average levels with an endpoint concentration of 1,000ppm occurring in all hours would be above the relevant criteria at a 50m distance.

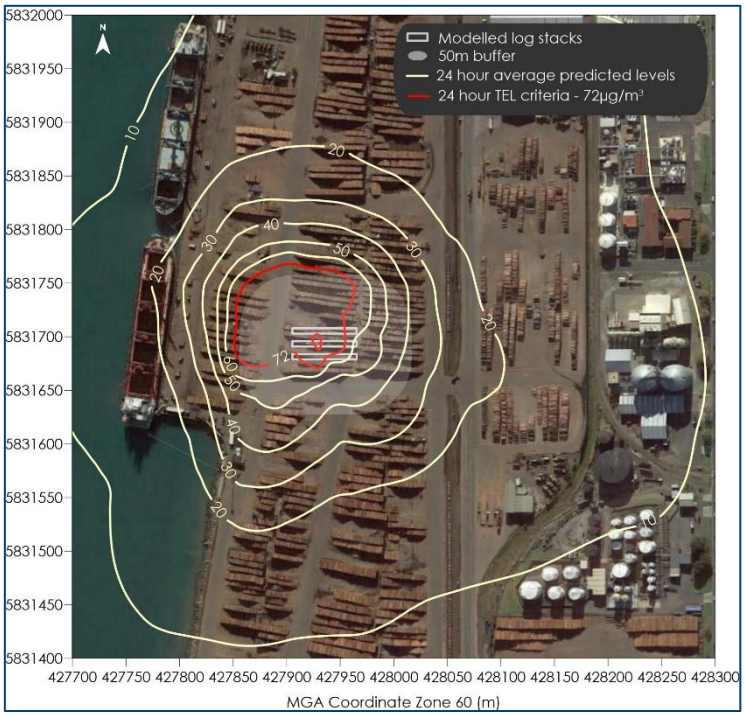

Figure 4-16: Maximum predicted EDN concentrations (µg/m³) - Three log stack scenario (20 minutes apart), 24-hour averages, 1,000ppm

The modelling predictions indicate that:

- For ventilation per the three log stacks scenario (20 minutes apart), predicted impacts would be above the relevant criteria at a 50m distance for the 24-hour average period and an endpoint concentration of 1,000ppm of EDN.
- For the other averaging periods and endpoint concentrations, predicted impacts would be below the relevant criteria at a 50m distance.
- A buffer of at least 60m should be used for ventilation of three log stacks vented 20 minutes apart in a localised area.

4.1.1.5 Nine log stacks scenario

Nine log stacks scenario - ventilation of nine log stacks in a 24-hour period with three log stacks per event and each event occurring four hours apart. For each event, ventilation of one log stack occurs for a ten minute period, followed by the second log stack ten minutes later and the third ten minutes later.

Modelling predictions for the other averaging periods and endpoint concentrations are presented in **Appendix B**.

Figure 4-17 indicates that the predicted 10-minute average levels with an endpoint concentration of 500ppm occurring in all hours would be below the relevant criteria at a 50m distance.

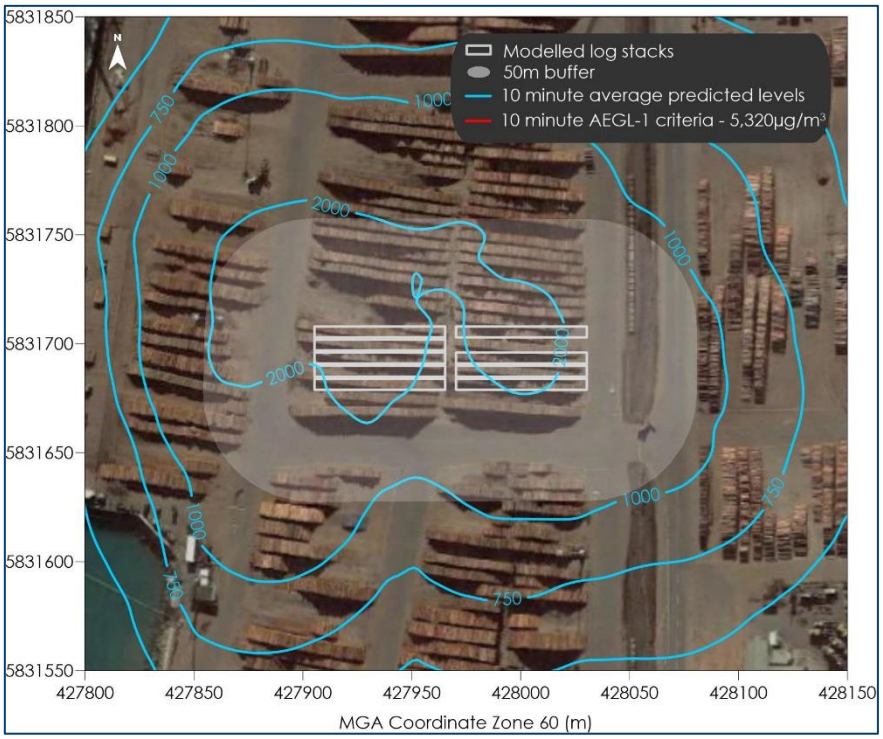

Figure 4-17: Maximum predicted EDN concentrations (µg/m³) - Nine log stack scenario, 10-minute averages, 500ppm

Figure 4-18 indicates that the predicted 10-minute average levels with an endpoint concentration of 1,000ppm occurring in all hours would be below the relevant criteria at a 50m distance.

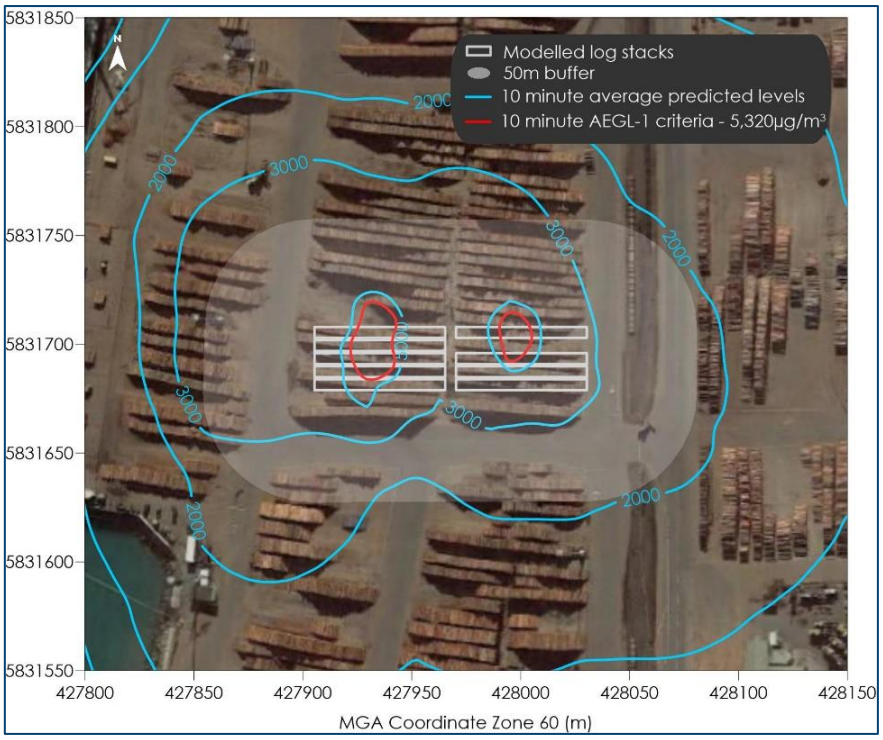

Figure 4-18: Maximum predicted EDN concentrations (µg/m³) - Nine log stack scenario, 10-minute averages, 1,000ppm

Figure 4-19 indicates that the predicted 24-hour average levels with an endpoint concentration of 500ppm would exceed the relevant criteria at a 50m distance.

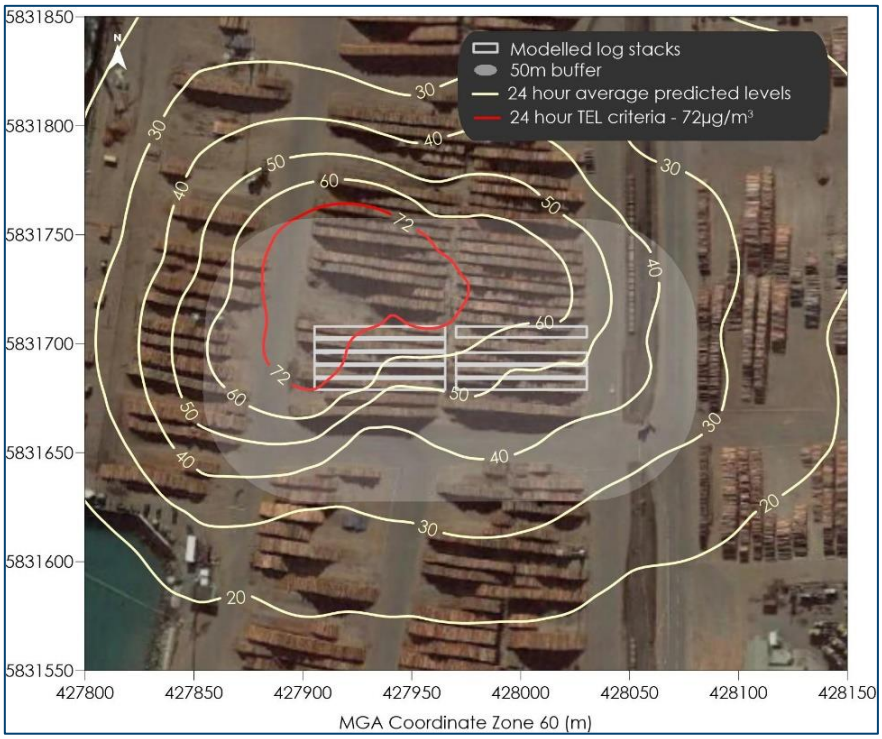

Figure 4-19: Maximum predicted EDN concentrations (µg/m³) - Nine log stack scenario, 24-hour averages, 500ppm

The modelling predictions indicate that:

- For ventilation per the nine log stacks scenario, predicted impacts would be below the relevant criteria at a 50m distance for the 10-minute average periods and endpoint concentrations of 500ppm, 700ppm and 1,000ppm of EDN.
- Predicted impacts would be above the relevant criteria at a 50m distance for the 24-hour average periods and an endpoint concentrations of 500ppm, 700ppm and 1,000ppm of EDN.
- For the other averaging periods and endpoint concentrations, predicted impacts would be below the relevant criteria at a 50m distance.

4.1.1.6 Ten log stacks scenario

Ten log stacks scenario - ventilation of ten log stacks within two hours (five log stacks per hour) in a 24-hour period. Ventilation of each log stack occurs for a ten minute period with the next log stack ventilated ten minutes later.

Modelling predictions for the other averaging periods and endpoint concentrations are presented in **Appendix B**.

Figure 4-20 indicates that the predicted 10-minute average levels with an endpoint concentration of 500ppm occurring in all hours would be below the relevant criteria at a 50m distance.

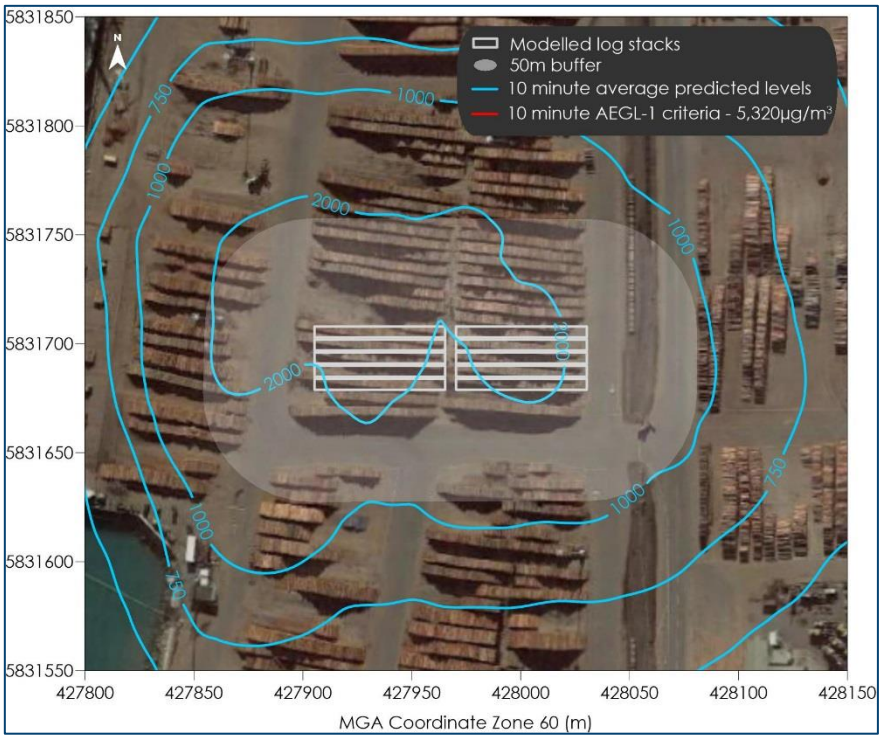

Figure 4-20: Maximum predicted EDN concentrations (µg/m³) – Ten log stack scenario, 10-minute averages, 500ppm

Figure 4-21 indicates that the predicted 10-minute average levels with an endpoint concentration of 500ppm and 1,000ppm occurring in all hours would be below the relevant criteria at a 50m distance.

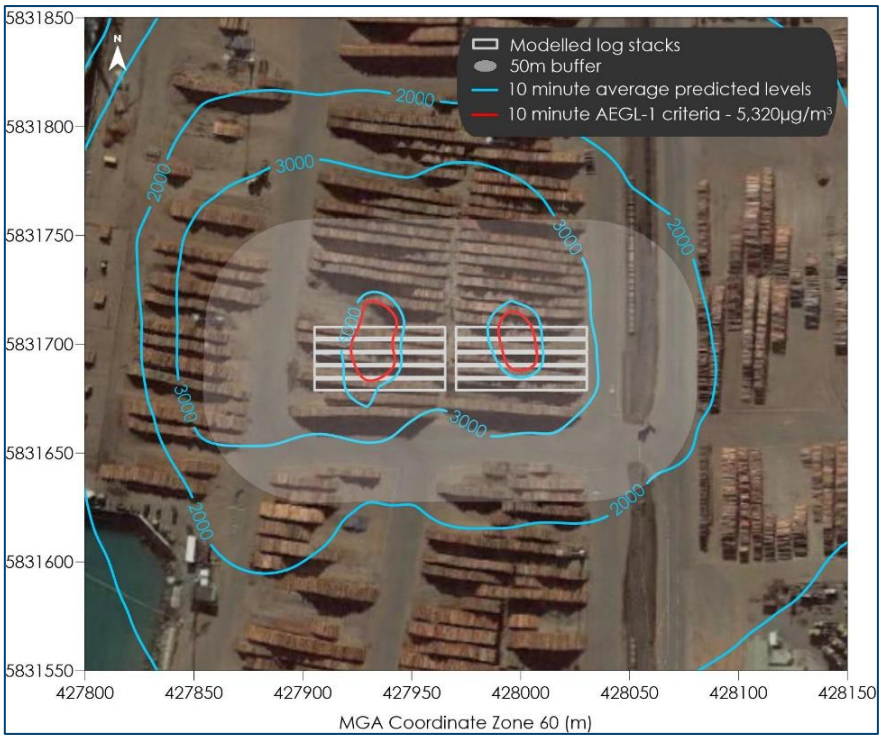

Figure 4-21: Maximum predicted EDN concentrations (µg/m³) – Ten log stack scenario, 10-minute averages, 1,000ppm

Figure 4-22 indicates that the predicted 24-hour average levels with an endpoint concentration of 500ppm would exceed the relevant criteria at a 50m distance.

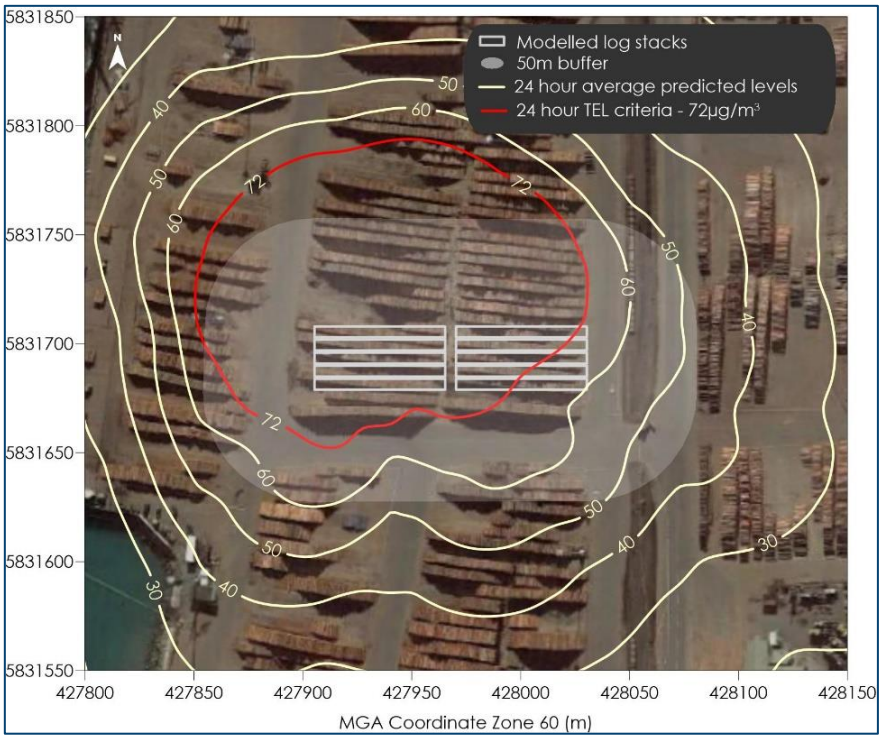

Figure 4-22: Maximum predicted EDN concentrations (µg/m³) – Ten log stack scenario, 24-hour averages, 500ppm

The modelling predictions indicate that:

- For ventilation of ten log stacks scenario, predicted impacts would be below the relevant criteria at a 50m distance for the 10-minute average periods and endpoint concentrations of 500ppm, 700ppm and 1,000ppm of EDN.
- Predicted impacts would be above the relevant criteria at a 50m distance for the 24-hour average periods and an endpoint concentrations of 500ppm, 700ppm and 1,000ppm of EDN.
- For the other averaging periods and endpoint concentrations, predicted impacts would be below the relevant criteria at a 50m distance.

4.1.1.7 Thirty log stacks scenario (over an 8.5-hour period)

Thirty log stacks (over a 8.5-hour period) scenario – This scenario intends to reflect ventilation of 32 log stacks which took place at the Port of Tauranga in 2019 over an approximate 8.5-hour period. The thirty log stacks are ventilated over a 9-hour period from three log stack events consisting of 8 log stacks (with ventilation of each log stack for a ten minute period with the following log stack ventilated ten minutes apart), a 0.5 hour gap, 7 log stacks (with ventilation of each log stack for a ten minute period with the following log stack ventilated ten minutes apart), a 3-hour gap and then 15 log stacks (with ventilation of each log stack for a ten minute period with the following log stack ventilated ten minutes apart). Modelling predictions for the other averaging periods and endpoint concentrations are presented in **Appendix B**.

Figure 4-23 indicates that the predicted 10-minute average levels with an endpoint concentration of 500ppm occurring in all hours would be below the relevant criteria at a 50m distance.

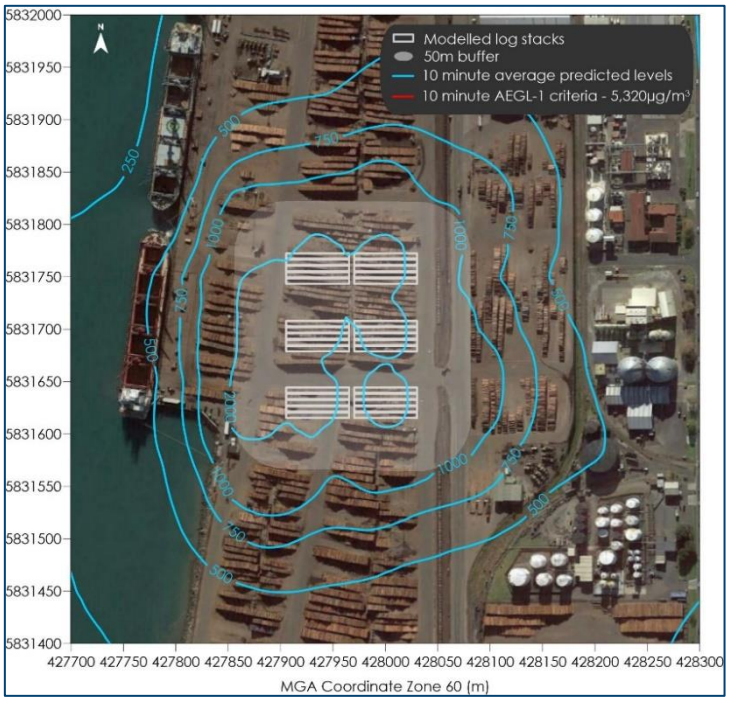

Figure 4-23: Maximum predicted EDN concentrations (µg/m³) - Thirty log stack scenario (over an 8.5-hour period), 10-minute averages, 500ppm

Figure 4-24 indicates that the predicted 10-minute average levels with an endpoint concentration of 1,000ppm occurring in all hours would be below the relevant criteria at a 50m distance.

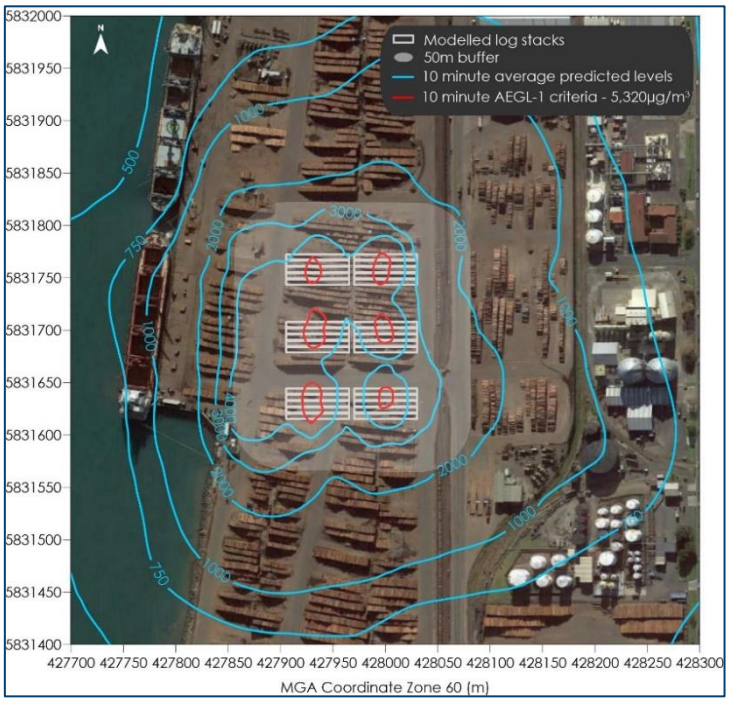

Figure 4-24: Maximum predicted EDN concentrations (µg/m³) - Thirty log stack scenario (over an 8.5-hour period), 10-minute averages, 1,000ppm

Figure 4-25 indicates that the predicted 24-hour average levels with an endpoint concentration of 500ppm would exceed the relevant criteria at a 50m distance.

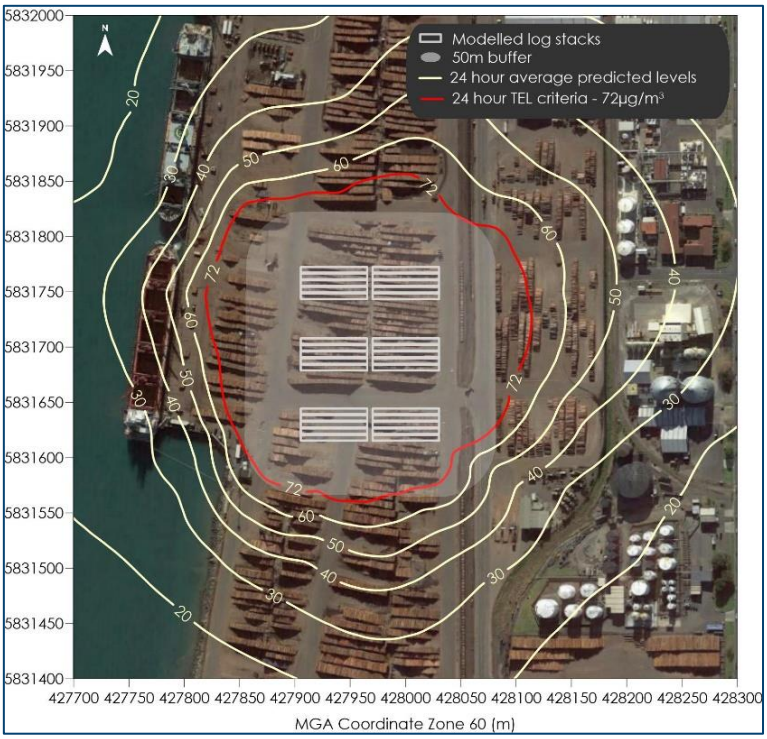

Figure 4-25: Maximum predicted EDN concentrations (µg/m³) - Thirty log stack scenario (over an 8.5-hour period), 24-hour averages, 500ppm

The modelling predictions indicate that:

- For ventilation of the thirty log stacks scenario (over an 8.5-hour period), predicted impacts would be below the relevant criteria at a 50m distance for the 10-minute average periods and endpoint concentrations of 500ppm, 700ppm and 1,000ppm of EDN.
- Predicted impacts would be above the relevant criteria at a 50m distance for the 24-hour average periods and an endpoint concentrations of 500ppm, 700ppm and 1,000ppm of EDN.
- For the other averaging periods and endpoint concentrations, predicted impacts would be below the relevant criteria at a 50m distance.

4.1.1.8 Thirty log stacks scenario (over a 6-hour period)

Thirty log stacks (over a 6-hour period) scenario - ventilation of thirty log stacks within 6-hours in a 24-hour period. Five log stacks are ventilated each hour with ventilation of each log stack for a ten minute period with the following log stack ventilated ten minutes apart.

Figure 4-26 indicates that the predicted 10-minute average levels with an endpoint concentration of 500ppm occurring in all hours would be below the relevant criteria at a 50m distance.

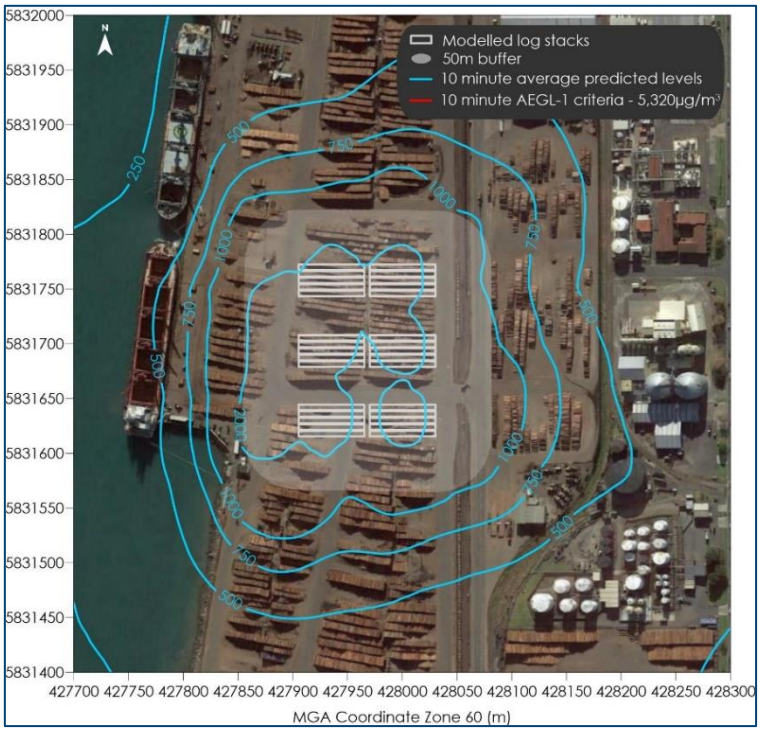

Figure 4-26: Maximum predicted EDN concentrations (µg/m³) - Thirty log stack scenario (over a 6-hour period), 10-minute averages, 500ppm

Figure 4-27 indicates that the predicted 10-minute average levels with an endpoint concentration of 1,000ppm occurring in all hours would be below the relevant criteria at a 50m distance.

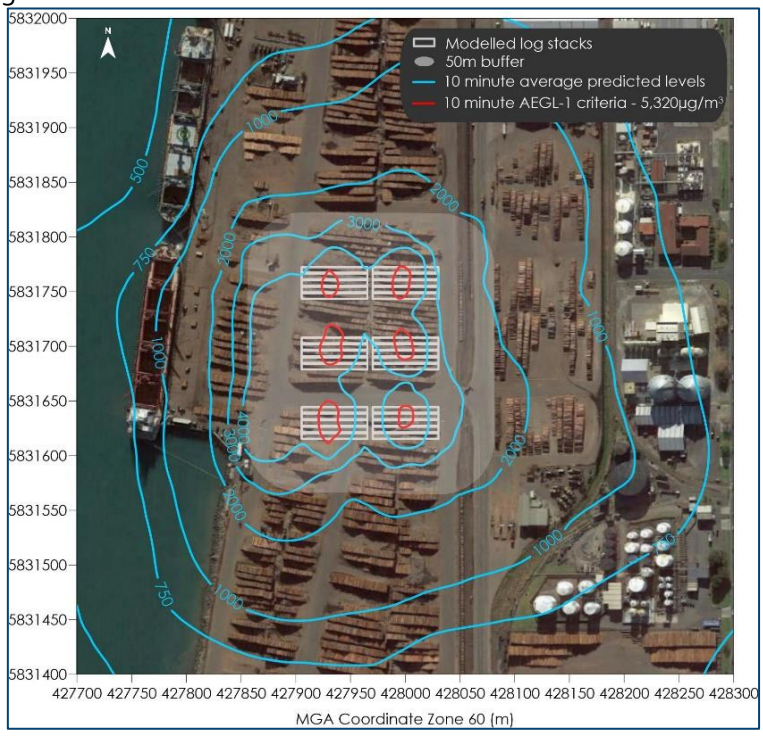

Figure 4-27: Maximum predicted EDN concentrations (µg/m³) - Thirty log stack scenario (over a 6-hour period), 10-minute averages, 1,000ppm

Figure 4-28 indicates that the predicted 24-hour average levels with an endpoint concentration of 500ppm would exceed the relevant criteria at a 50m distance.

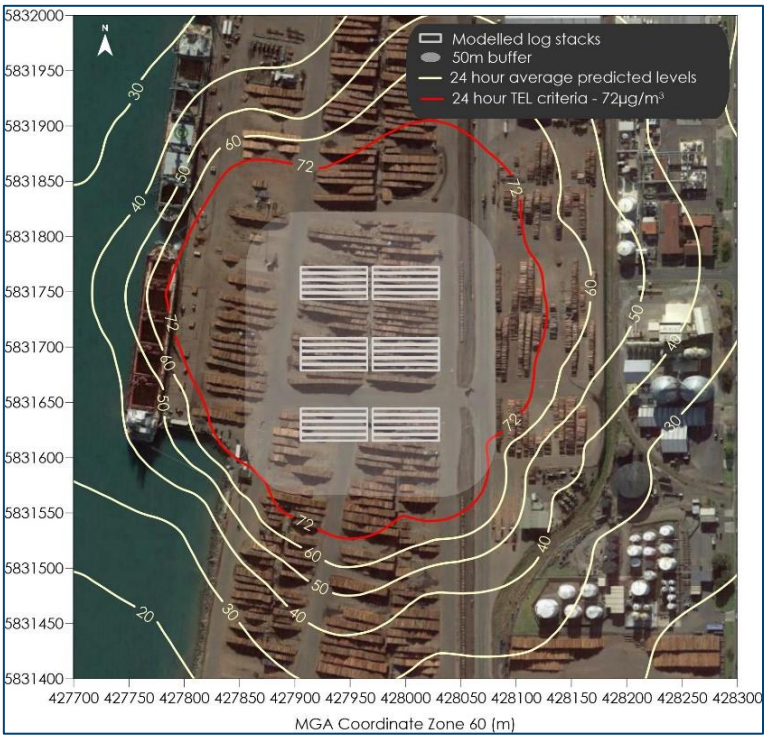

Figure 4-28: Maximum predicted EDN concentrations (µg/m³) - Thirty log stack scenario (over a 6-hour period), 24-hour averages, 500ppm

The modelling predictions indicate that:

- For ventilation of thirty log stacks scenario (over an 6-hour period), predicted impacts would be below the relevant criteria at a 50m distance for the 10-minute average periods and endpoint concentrations of 500ppm, 700ppm and 1,000ppm of EDN.
- Predicted impacts would be above the relevant criteria at a 50m distance for the 24-hour average periods and an endpoint concentrations of 500ppm, 700ppm and 1,000ppm of EDN.
- For the other averaging periods and endpoint concentrations, predicted impacts would be below the relevant criteria at a 50m distance.

4.1.2 Analysis of endpoint concentrations

The maximum predicted levels for the 10-minute, 1-hour, 8-hour and 24-hour averaging periods with endpoint concentrations of 500ppm, 700ppm and 1,000ppm for each scenario show a consistent trend that the extent of impact is governed by the endpoint concentration.

For the different scenarios, the higher endpoint concentrations will require a larger buffer area during ventilation. For example with an endpoint concentration of 1,000ppm, required buffer may need to be approximately 2 times larger than the required buffer for an endpoint concentration of 500ppm buffer to meet the relevant 24-hour criteria.

4.1.3 Duration of impact

Figure 4-29 to **Figure 4-33** presents the potential duration of predicted 1-hour average impacts for the one log stack, nine log stacks, ten log stacks, thirty log stacks (over an 8.5-hour period) and thirty log stacks (over a 6-hour period) scenarios, respectively, for an endpoint concentration of 500ppm.

The profiles show the average, maximum and minimum 1-hour average concentrations averaged across each starting hour over a 24-hour period at the most impacted receptor within a 50m distance for each scenario.

Figure 4-29 shows that EDN concentrations for the one log stack scenario rise quickly following release with predicted concentrations diminishing to negligible levels over a 1-hour period. The maximum predicted 1-hour average level for the one log scenario is well below the 1-hour AEGL-1 criteria of 4,256µg/m^3.

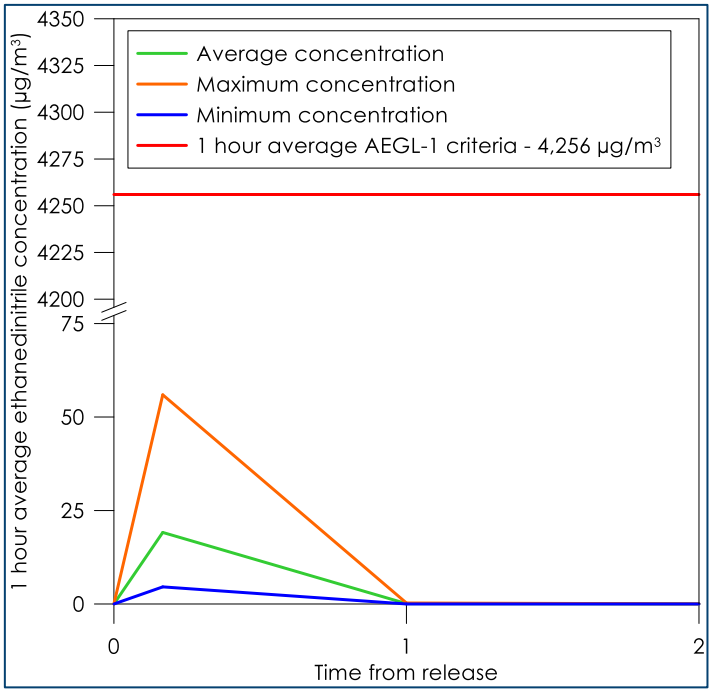

Figure 4-29: Duration of impact 1-hour average EDN concentrations - One log stack scenario

Figure 4-30 shows that EDN concentrations for ventilation of the nine log stacks scenario. The duration of impacts are similar to the one log scenario with EDN levels diminishing over a 1-hour period for each venting event with the staggered ventilation of the log stacks apparent in the graph.

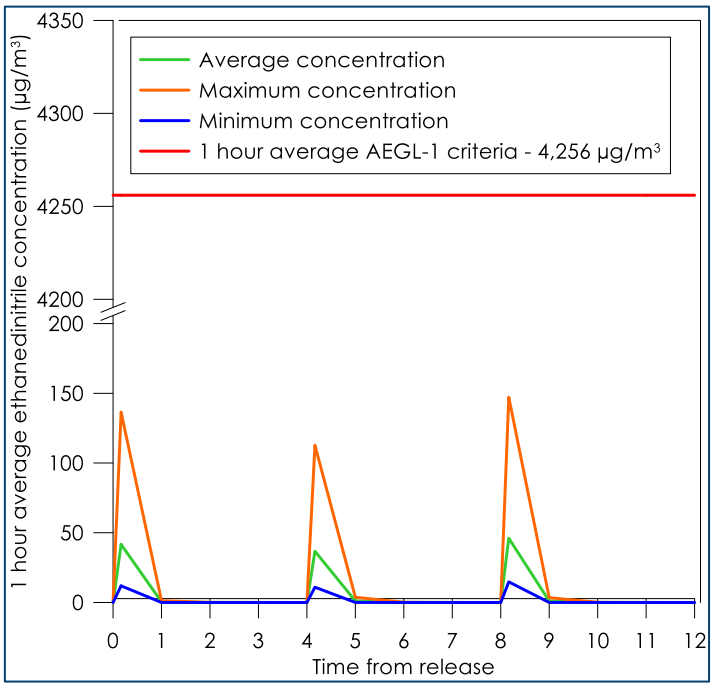

Figure 4-30: Duration of impact 1-hour average EDN concentrations - Nine log stacks scenario

Figure 4-31 shows that EDN concentrations for ventilation of the ten log stacks scenario. The EDN levels are predicted to diminish following the 2-hour period which is consistent with the other modelled scenarios.

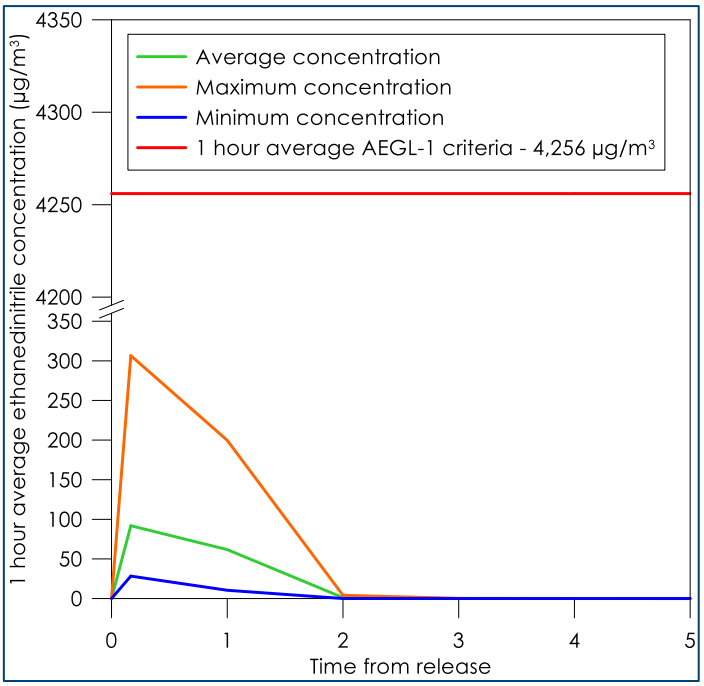

Figure 4-31: Duration of impact 1-hour average EDN concentrations - Ten log stacks scenario

Figure 4-32 shows that EDN concentrations for ventilation of the thirty log stacks scenario (over an 8.5-hour period). The EDN levels spike and gradually decline to negligible levels between each venting event. Similarly to the ten log stacks scenario, the EDN levels are predicted to diminish following completion of all thirty logs over the over an 8.5-hour period which is consistent with the other modelled scenarios.

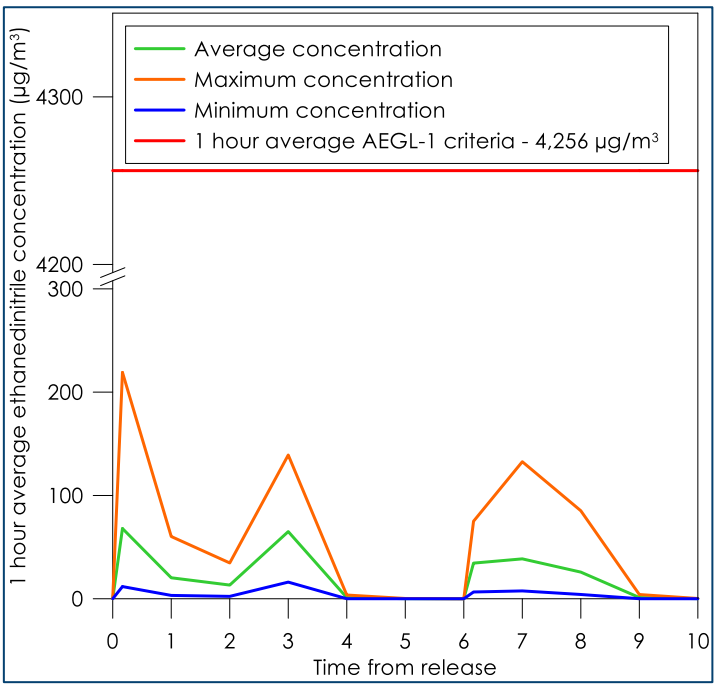

Figure 4-32: Duration of impact 1-hour average EDN concentrations - Thirty log stacks (over an 8.5-hour period) scenario

Figure 4-33 shows that EDN concentrations for ventilation of the thirty log stacks scenario (over a 6-hour period). Similarly to the ten log stacks scenario, the EDN levels are predicted to diminish following completion of all thirty logs over the 6-hour period which is consistent with the other modelled scenarios.

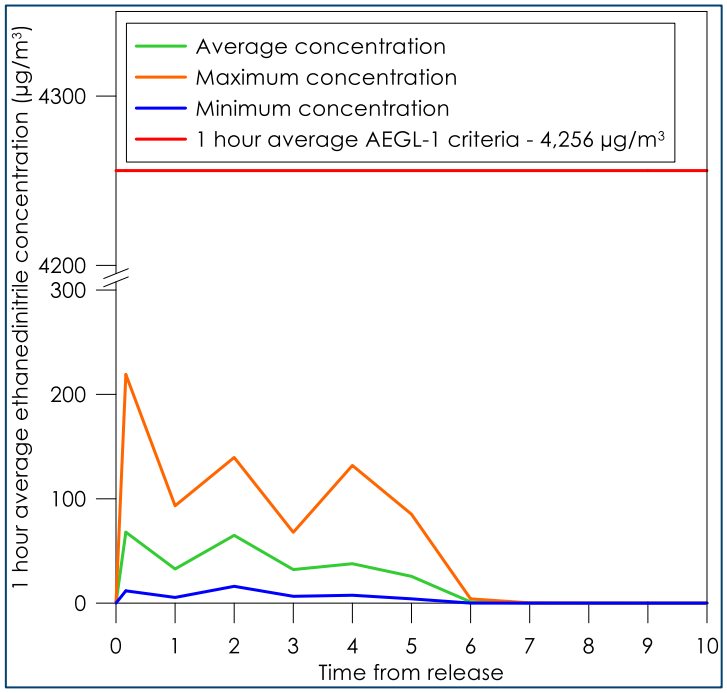

Figure 4-33: Duration of impact 1-hour average EDN concentrations - Thirty log stacks (over a 6-hour period) scenario

Overall, EDN concentrations are shown to diminish within a 1-hour period following each venting event of log stacks under a tarpaulin cover. The results indicate that maintaining the buffer zone in place up to three hours following a ventilation event would be adequate to ensure EDN concentrations have diminished.

4.1.4 Diurnal impacts

To investigate the effects of ventilation of log stacks under a tarpaulin cover occurring at different times during the day, the predicted maximum 1-hour average EDN concentration for each starting hour at the most impacted receptor within a 50m distance for the one log stack, nine log stacks, ten log stacks, the thirty log stacks (over an 8.5-hour period) and thirty log stacks (over a 6-hour period) scenario, respectively, are analysed graphically and presented in **Figure 4-34** to **Figure 4-38**.

The results in **Figure 4-34** to **Figure 4-38** show that EDN concentrations are greatest during the hours of 4pm to 8am in each scenario with low levels occurring in the middle of the day due to better dispersion conditions.

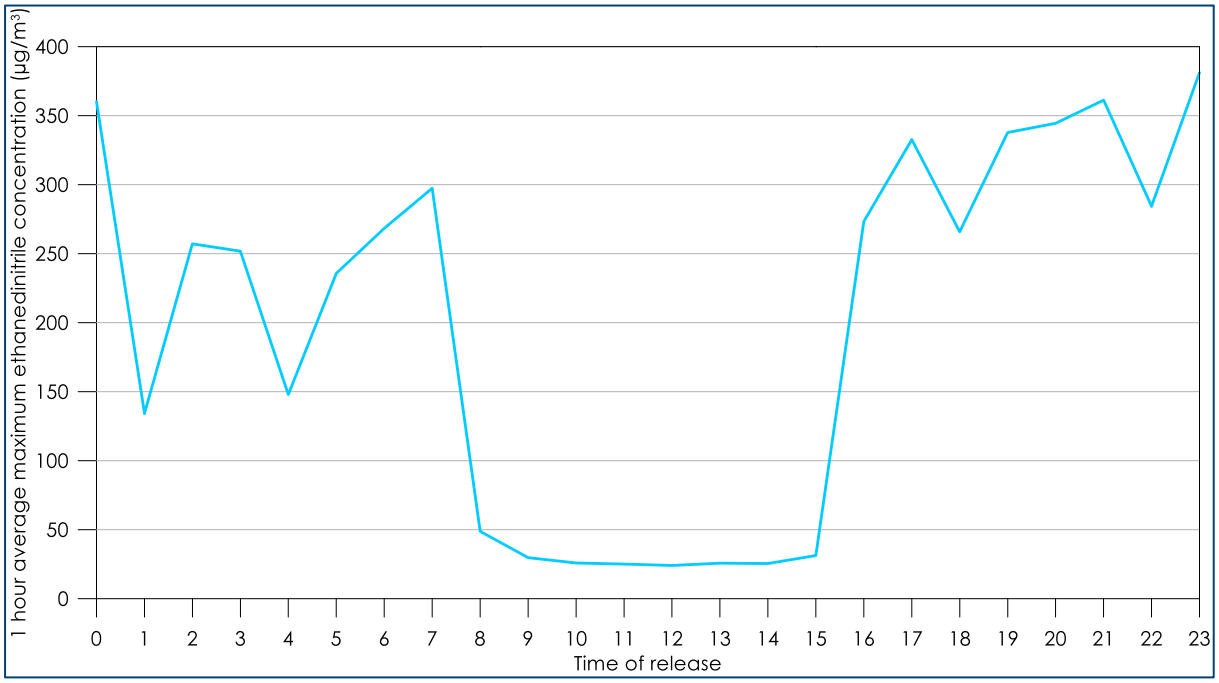

Figure 4-34: Maximum 1-hour average EDN concentrations by time of release – One log stack scenario

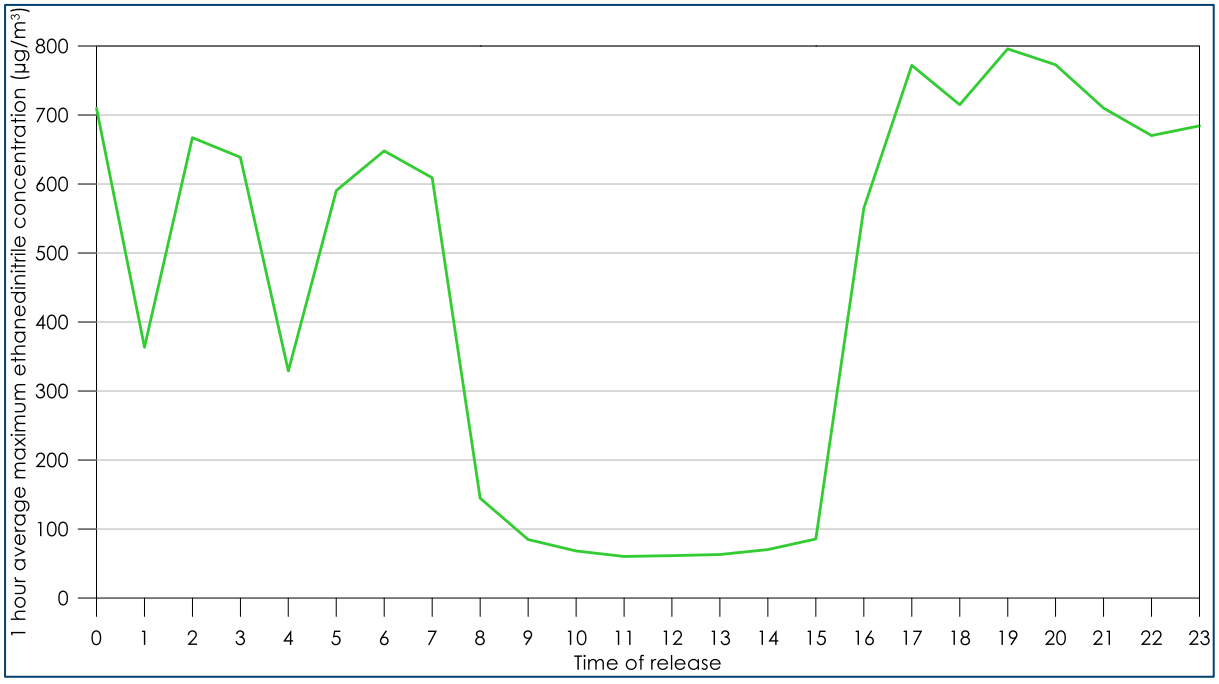

Figure 4-35: Maximum 1-hour average EDN concentrations by time of release – Nine log stacks scenario

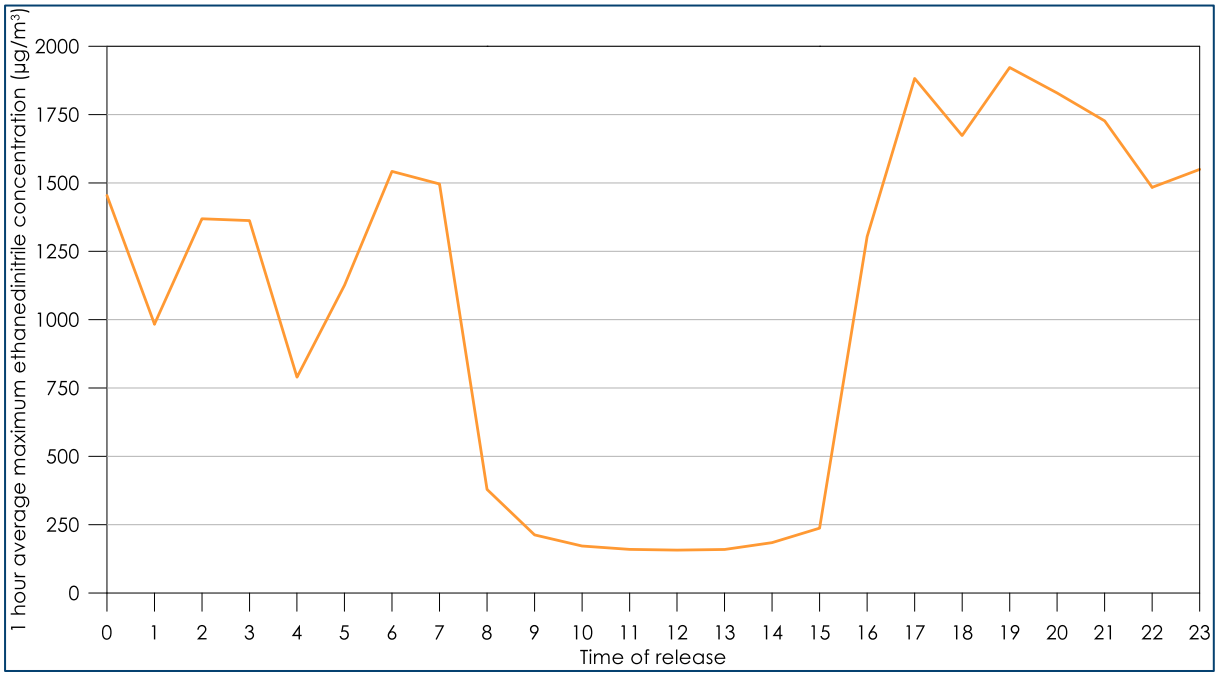

Figure 4-36: Maximum 1-hour average EDN concentrations by time of release – Ten log stacks scenario

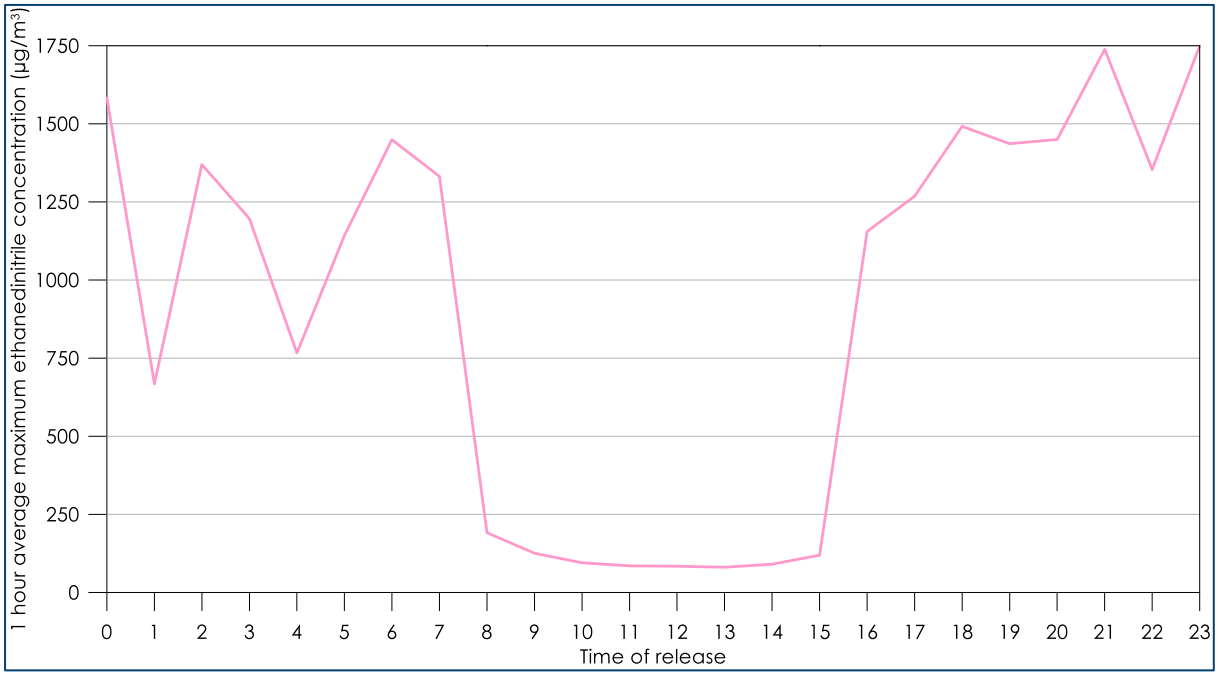

Figure 4-37: Maximum 1-hour average EDN concentrations by time of release – Thirty log stacks (over an 8.5-hour period) scenario

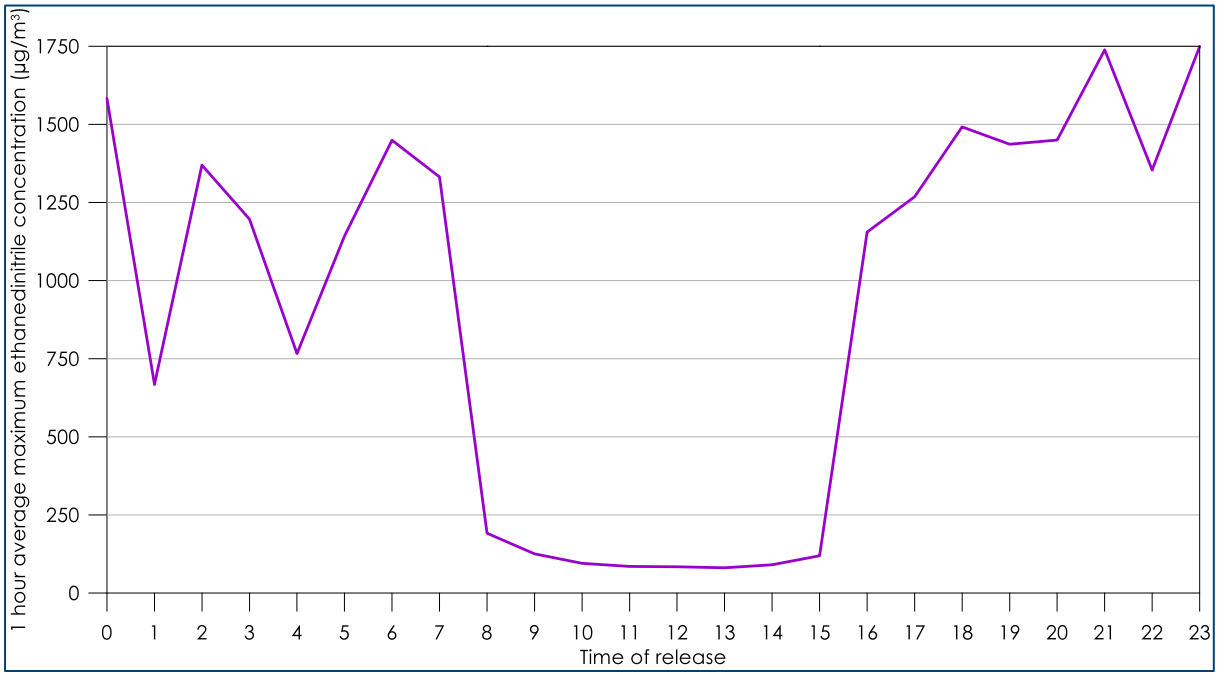

Figure 4-38: Maximum 1-hour average EDN concentrations by time of release – Thirty log stacks (over a 6-hour period) scenario

4.1.5 Impacts from ventilation between 8am and 3pm

Figure 4-39 to **Figure 4-50** present the isopleth diagrams of the dispersion modelling results showing 24-hour average criteria level at various endpoint concentrations ventilated over all hours and also between 8am and 3pm for the nine log stacks, ten log stacks, the thirty log stacks (over an 8.5-hour period) and thirty log stacks (over a 6-hour period) scenario.

The figures compare the predicted contours for the 24-hour TEL criteria for ventilation across all hours (blue contour line) and for ventilation between 8am and 3pm (pink contour line). Note that where no contour line is shown the maximum predicted levels are below the 24-hour TEL criteria.

Note that the one log stack scenario maximum predicted 24-hour average levels over all hours were below the relevant criteria. As a result, the ventilation of the one log stack scenario restricted between 8am and 3pm is also below the 24-hour average criteria.

A comparison of the results show that the maximum predicted 24-hour average levels have decreased by approximately 35% in some cases. For example, the nine log stacks scenario and ten log stacks scenario are reduced such that the predicted 24-hour average levels would be below the relevant criteria at a 50m distance.

Figure 4-39 to **Figure 4-41** indicates that venting between 8am and 3pm ensures that EDN concentrations are below the 24-hour TEL_{air} criteria at an endpoint concentration of 500ppm, 700ppm and 1,000ppm.

Figure 4-39: Maximum predicted EDN concentrations (µg/m³) - Nine log stacks scenario, 24-hour averages, 500ppm with ventilation across all hours and between 8am and 3pm

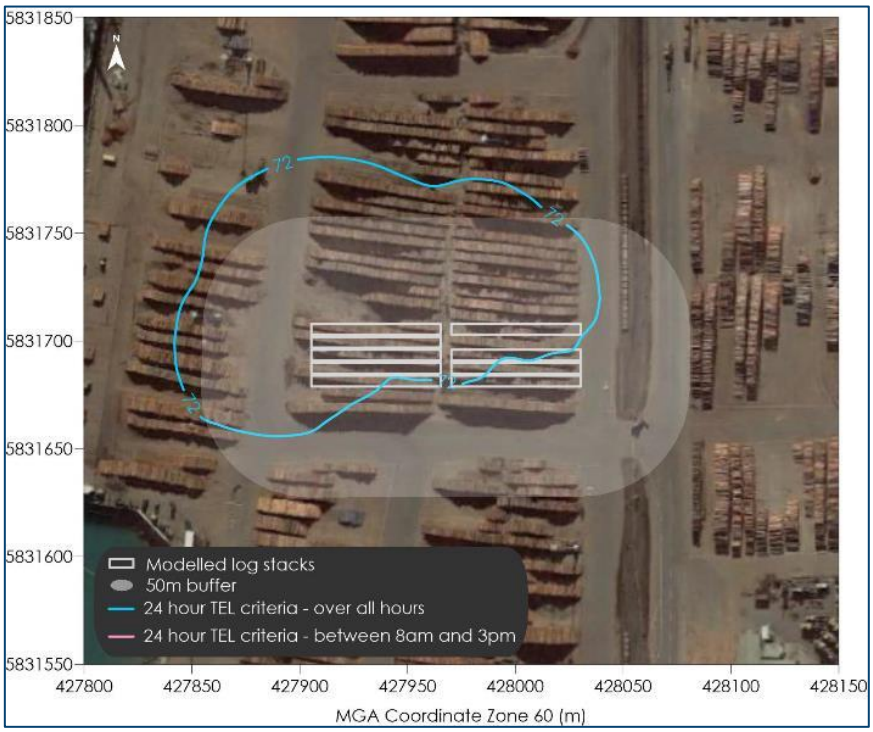

Figure 4-40: Maximum predicted EDN concentrations (µg/m³) - Nine log stacks scenario, 24-hour averages, 700ppm with ventilation across all hours and between 8am and 3pm

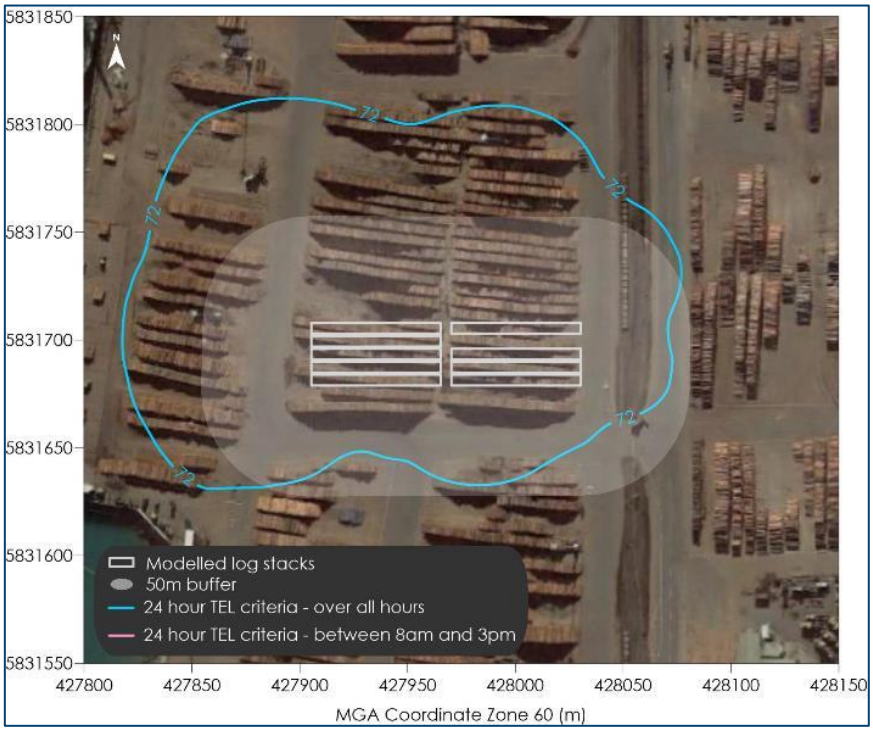

Figure 4-41: Maximum predicted EDN concentrations (µg/m³) - Nine log stacks scenario, 24-hour averages, 1,000ppm with ventilation between 8am and 3pm

Figure 4-42 and **Figure 4-43** indicates that venting between 8am and 3pm ensures that EDN concentrations are below the 24-hour TEL_{air} criteria at an endpoint concentration of 500ppm and 700ppm.

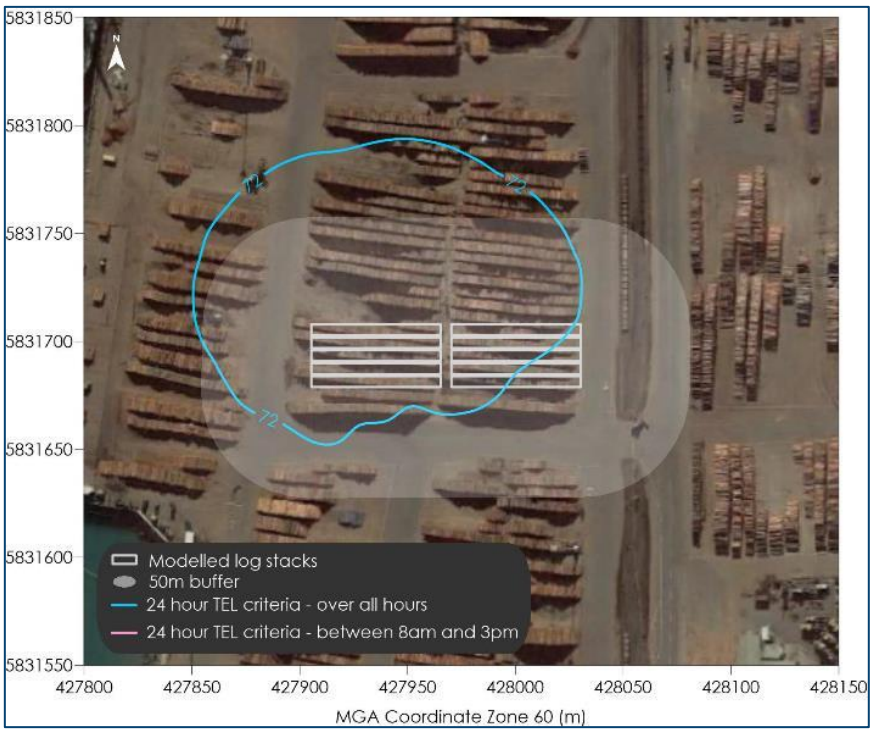

Figure 4-42: Maximum predicted EDN concentrations (µg/m3) - Ten log stacks scenario, 24-hour averages, 500ppm with ventilation across all hours and between 8am and 3pm

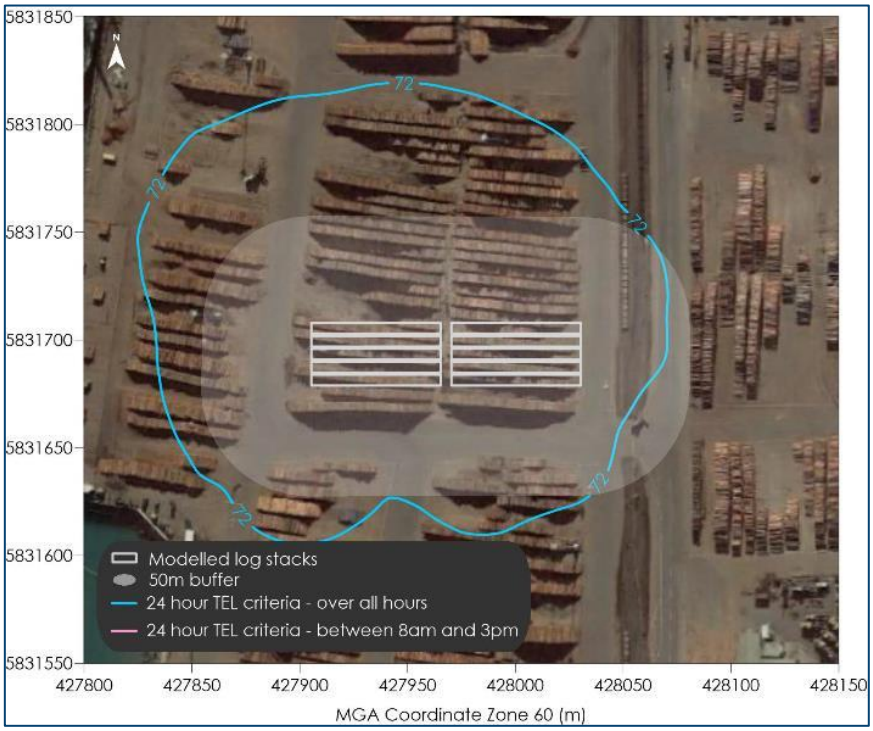

Figure 4-43: Maximum predicted EDN concentrations (µg/m³) - Ten log stacks scenario, 24-hour averages, 700ppm with ventilation across all hours and between 8am and 3pm

Figure 4-44 indicates that venting between 8am and 3pm ensures that EDN concentrations are below the 24-hour TEL_{air} criteria at a 50m distance with an endpoint concentration of 1,000ppm.

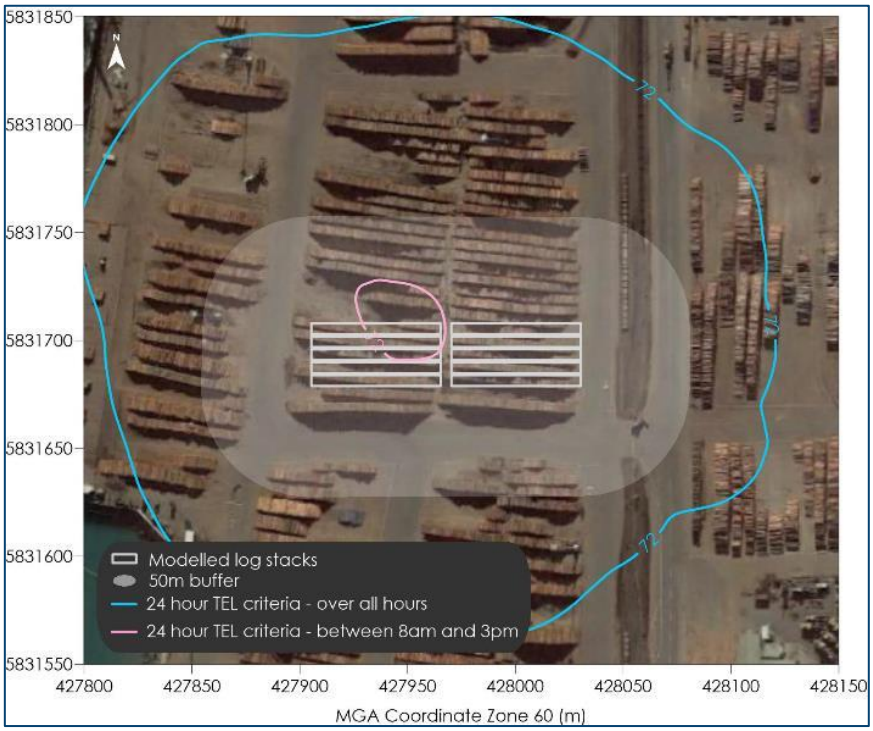

Figure 4-44: Maximum predicted EDN concentrations (µg/m³) - Ten log stacks scenario, 24-hour averages, 1,000ppm with ventilation across all hours and between 8am and 3pm

Figure 4-45 and **Figure 4-46** indicates that venting between 8am and 3pm ensures that EDN concentrations are below the 24-hour TEL_{air} criteria at a 50m distance with an endpoint concentration of 500ppm and 700ppm.

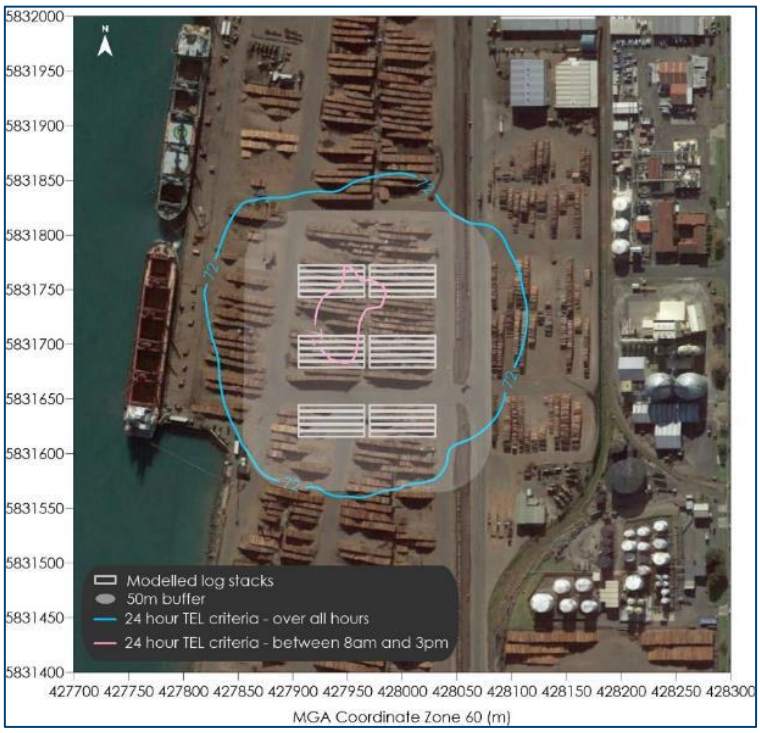

Figure 4-45: Maximum predicted EDN concentrations (µg/m³) - Thirty log stacks scenario (over a 8.5-hour period), 24-hour averages, 500ppm with ventilation across all hours and between 8am and 3pm

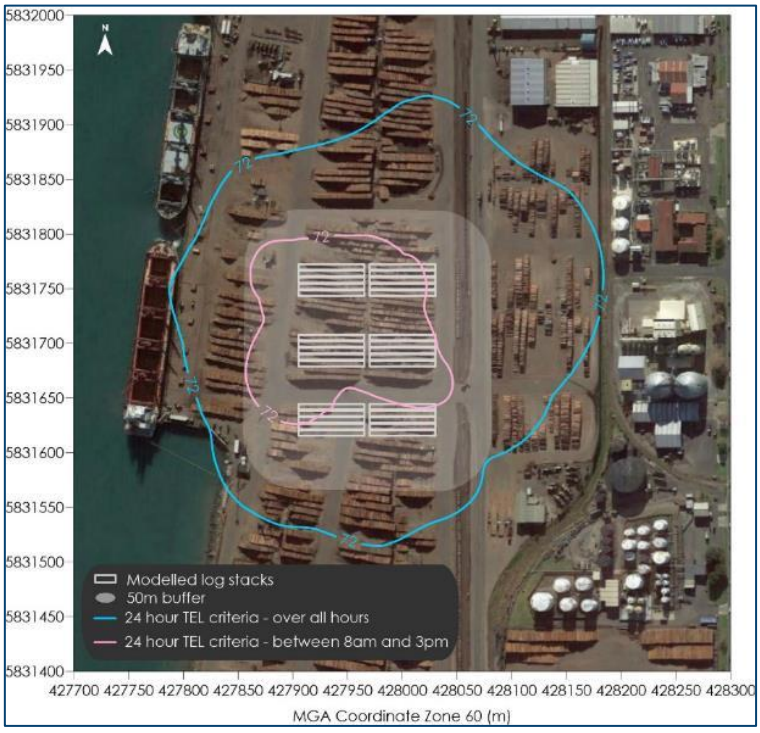

Figure 4-46: Maximum predicted EDN concentrations (µg/m³) - Thirty log stacks scenario (over a 8.5-hour period), 24-hour averages, 700ppm with ventilation across all hours and between 8am and 3pm

Figure 4-47 indicates that venting between 8am and 3pm with an endpoint concentration of 1,000ppm would be above the relevant criteria at a 50m distance.

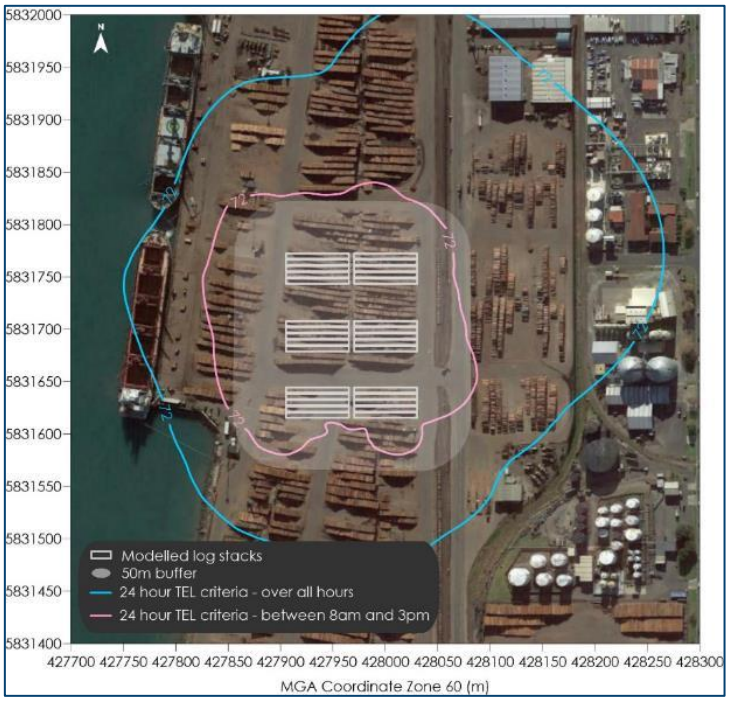

Figure 4-47: Maximum predicted EDN concentrations (µg/m³) - Thirty log stacks scenario (over a 8.5-hour period), 24-hour averages, 1,000ppm with ventilation between 8am and 3pm

Figure 4-48 to **Figure 4-50** indicates that venting between 8am and 3pm with endpoint concentrations of 500ppm, 700ppm and 1,000ppm would be above the relevant criteria at a 50m distance.

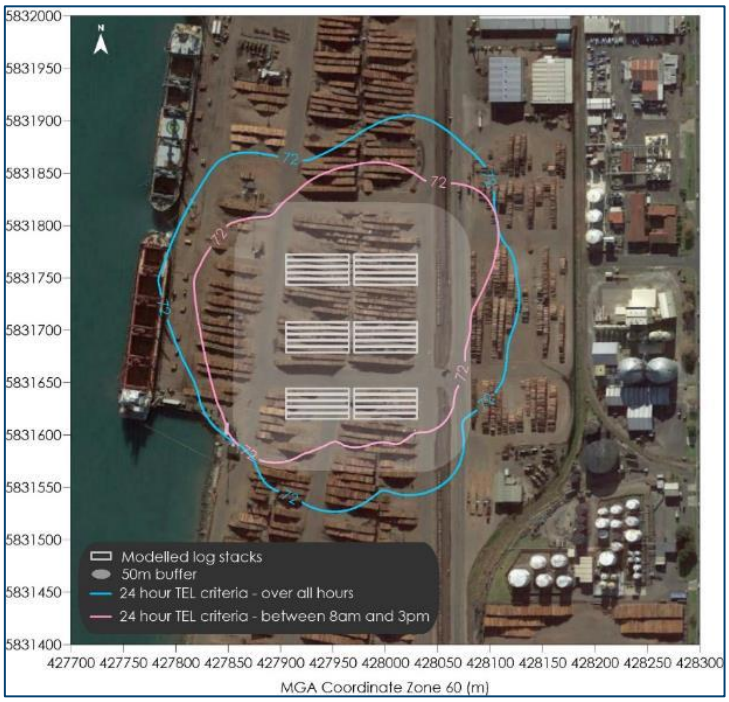

Figure 4-48: Maximum predicted EDN concentrations (µg/m3) - Thirty log stacks scenario (over a 6-hour period), 24-hour averages, 500ppm with ventilation across all hours and between 8am and 3pm

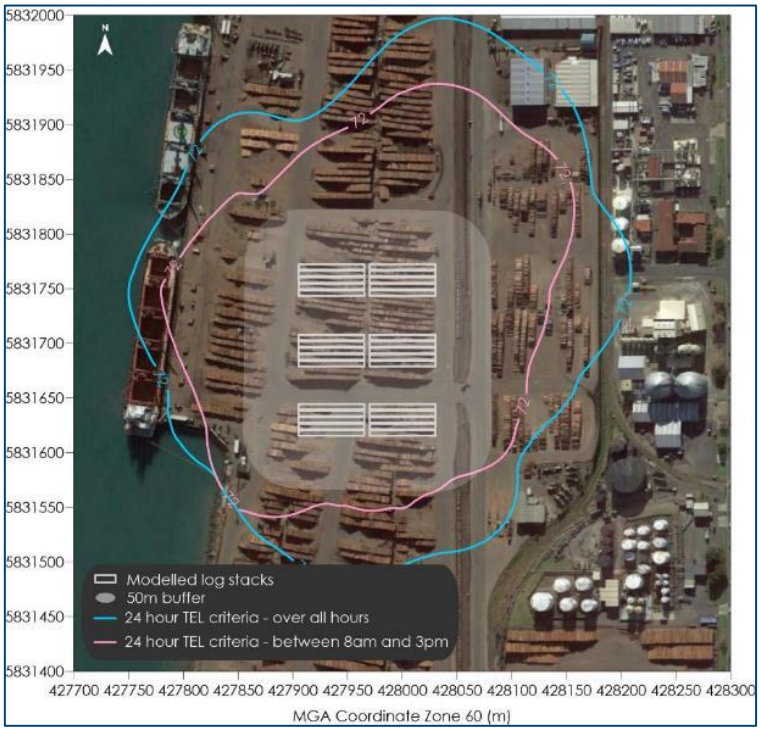

Figure 4-49: Maximum predicted EDN concentrations (µg/m³) - Thirty log stacks scenario (over a 6-hour period), 24-hour averages, 700ppm with ventilation across all hours and between 8am and 3pm

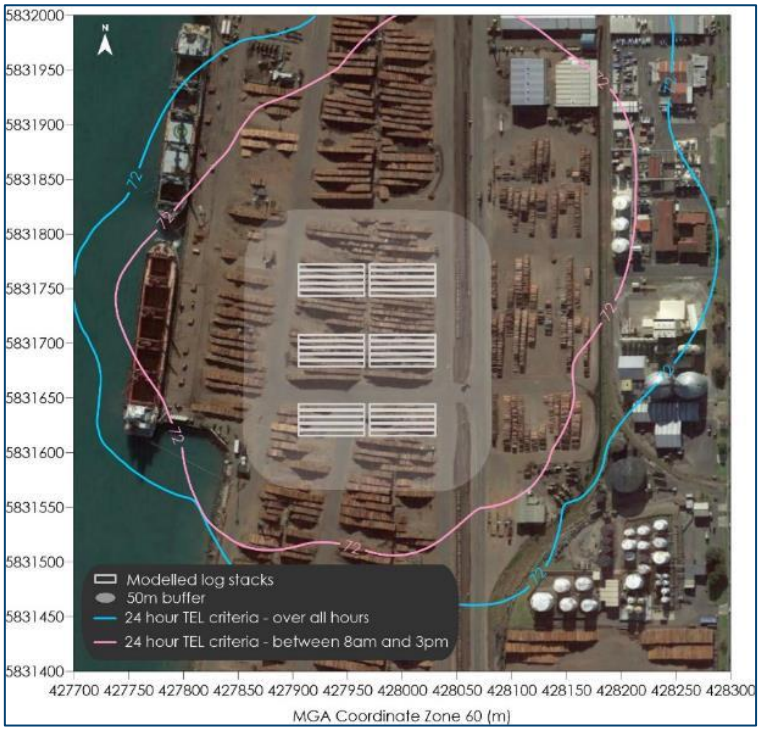

Figure 4-50: Maximum predicted EDN concentrations (µg/m³) - Thirty log stacks scenario (over a 6-hour period), 24-hour averages, 1,000ppm with ventilation between 8am and 3pm

4.1.6 Hypothetical scenario - Separation distance for three log stacks per hour

A hypothetical scenario was developed to investigate the potential interaction of ventilation of three logs stacks per hour, with a maximum of ten log stacks in this location, plus another set of ten log stacks located at different separation distances.

The modelling predictions for "Three log stacks scenario (localised)" (refer to **Section 4.1.1.2**) and "Three log stacks scenario (20 minutes apart)" (refer to **Section 4.1.1.4**) indicate that a buffer of 50m is sufficient when ventilation with an endpoint concentration of 500ppm and at least 70m and 60m is recommended, respectively when ventilating with an endpoint concentration of 1,000ppm.

The extent of impact for three logs stacks per hour, with a maximum of ten log stacks would likely see the impacts similar these three log stacks scenarios and has been applied for this hypothetical scenario.

By analysing the predicted levels at a 50m distance (when ventilation with an endpoint concentration of 500ppm) and adding the corresponding level at various distances (200m, 250m and 300m) from the log stacks for the three log stacks scenarios we can approximately estimate the potential for cumulative impacts to arise including another set of ventilating logs these separation distances. For an endpoint concentration of 1,000ppm we have analysed the predicted levels at the 80m buffer.

The results indicate that a 200m separation distance between log stacks would be sufficient with an endpoint concentration of 500ppm at a 50m distance. For an endpoint concentration of 1,000ppm a separation distance of at least 300m would be recommended with a buffer distance of 80m.

The hypothetical scenario approximately indicates that:

- For ventilation of three log stacks per hour, in a maximum of ten log stacks per location, with an endpoint concentration of 500ppm, a 200m separation distance between log stacks would be sufficient with a buffer distance of 50m.
- For ventilation of three log stacks per hour, in a maximum of ten log stacks per location, with an endpoint concentration of 1,000ppm a 300m separation distance between log stacks would be sufficient at a buffer distance of 80m.

4.1.7 Summary of dispersion modelling results for venting log stacks under a tarpaulin cover

- For the ventilation of the one log stack scenario a 50m buffer zone is sufficient.
- For the ventilation of the three log stacks scenarios (60m apart) a 50m buffer zone is sufficient.
- For the ventilation of the three log stacks scenarios (localised) with endpoint concentrations up to 700ppm, a 50m buffer is sufficient.
- For the ventilation of the three log stacks scenario (localised), with endpoint concentrations at 1,000ppm, a buffer of at least 70m is recommended with ventilation 20 minutes apart.
- For simultaneous ventilation of log stacks, it is recommended to have a separation distance between logs of greater than 60m apart.
- For the ventilation of the nine log stacks scenario:

- with endpoint concentrations of 500ppm, a buffer at least 60m is recommended.
- with endpoint concentrations of 700ppm, a buffer at least 80m is recommended.
- with endpoint concentrations of 1,000ppm, a buffer at least 100m is recommended.

- For the ventilation ten log stacks scenario:
  - with endpoint concentrations of 500ppm, a buffer at least 85m is recommended.
  - with endpoint concentrations of 700ppm, a buffer at least 110m is recommended.
  - with endpoint concentrations of 1,000ppm, a buffer at least 140m is recommended.
- For the ventilation thirty log stacks scenario (over an 8.5-hour period):
  - with endpoint concentrations of 500ppm, a buffer at least 140m is recommended.
  - with endpoint concentrations of 700ppm, a buffer at least 220m is recommended.
  - with endpoint concentrations of 1,000ppm, a buffer at least 300m is recommended.
- For the ventilation thirty log stacks scenario (over an 6-hour period):
  - with endpoint concentrations of 500ppm, a buffer at least 200m is recommended.
  - with endpoint concentrations of 700ppm, a buffer at least 290m is recommended.
  - with endpoint concentrations of 1,000ppm, a buffer at least 330m is recommended.
- All predicted maximum levels are below their applicable criteria for the 1-hour and 8-hour average periods.
- Venting thirty log stacks over a 6-hour period results in predicted long-term (8-hour and 24-hour) impacts greater than venting thirty log stacks over an 8.5-hour period.
- The maximum predicted levels for each averaging period with an endpoint concentration of 1,000ppm are approximately 2 times larger than the predicted levels with an endpoint concentration of 500ppm.
- EDN concentrations are shown to diminish within a 1-hour period following each ventilation event.
- Restricting ventilation times between 8am and 3pm reduce the extent of impact due to better dispersion conditions.

4.1.8 Summary of dispersion modelling results for venting log stacks under a tarpaulin cover between 8am and 3pm

- For the ventilation of the one log stack scenario a 50m buffer zone is sufficient at endpoint concentration of 500ppm, 700ppm and 1,000ppm to meet the 24-hour TEL_{air} criteria.

- For the ventilation of the nine log stacks scenario a 50m buffer zone is sufficient at endpoint concentration of 500ppm, 700ppm and 1,000ppm to meet the 24-hour TEL_{air} criteria.
- For the ventilation a ten log stack scenario a 50m buffer zone is sufficient at endpoint concentration of 500ppm, 700ppm and 1,000ppm to meet the 24-hour TEL_{air} criteria.
- For the ventilation of the thirty log stack scenario (over a 8.5-hour period):
  - with endpoint concentrations of 500ppm, a buffer of 50m is sufficient.
  - with endpoint concentrations of 700ppm, a buffer of 50m is sufficient.
  - with endpoint concentrations of 1000ppm, a buffer of 80m is recommended.
- For the ventilation a thirty log stack scenario (over a 6-hour period):
  - with endpoint concentrations of 500ppm, a buffer of 85m is sufficient.
  - with endpoint concentrations of 700ppm, a buffer of 170m is sufficient.
  - with endpoint concentrations of 1000ppm, a buffer of 240m is recommended.

4.2 Ship holds

This section presents the predicted EDN ground level concentrations associated with the ventilation of ship holds.

Selected modelling scenarios showing the maximum predicted levels of the 1-hour average and 24-hour average levels for the limiting endpoint concentration of either 500ppm, 700ppm or 1,000ppm are analysed in detail in the following sections.

The isopleth diagrams present the relevant criteria (red contour line) for the averaging period presented. Note that where no criteria line is shown the maximum predicted levels are below the criteria.

Associated isopleth diagrams of all averaging periods and endpoint concentrations are presented in **Appendix B**.

4.2.1 Predicted maximum EDN concentrations

Figure 4-51 indicates the predicted 1-hour average levels with an endpoint concentration of 500ppm occurring in all hours would be below the relevant criteria at a 50m distance.

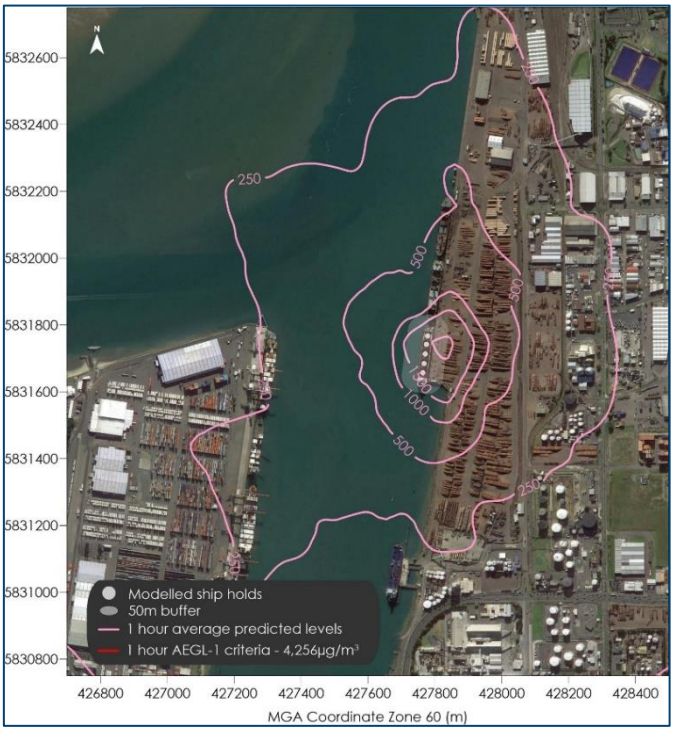

Figure 4-51: Maximum predicted EDN concentrations (µg/m³) - Ship holds, 1-hour averages, 500ppm

Figure 4-52 indicates the predicted 1-hour average levels with an endpoint concentration of 700ppm occurring in all hours would be above the relevant criteria at a 50m distance.

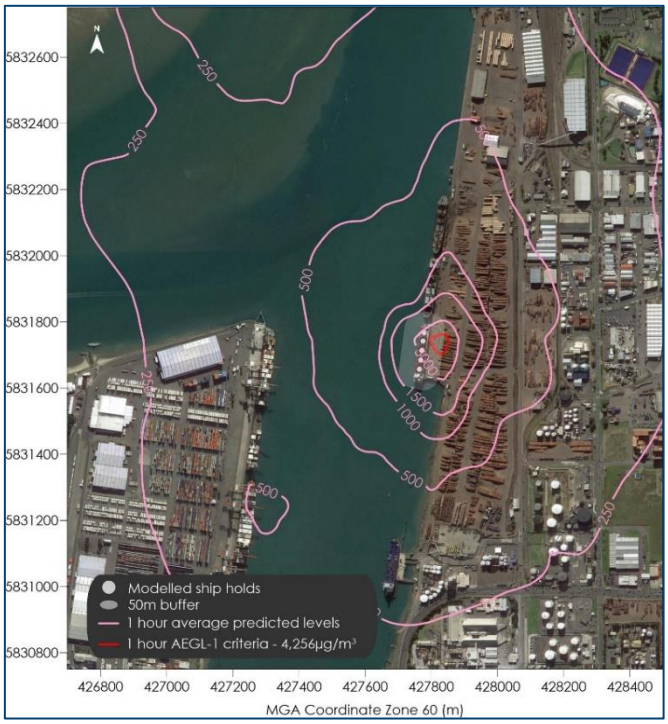

Figure 4-52: Maximum predicted EDN concentrations (µg/m³) - Ship holds, 1-hour averages, 700ppm

Figure 4-53 and **Figure 4-54** indicates the predicted 24-hour average levels with an endpoint concentration of 500ppm and 1,000ppm occurring in all hours would be above the relevant criteria at a 50m distance.

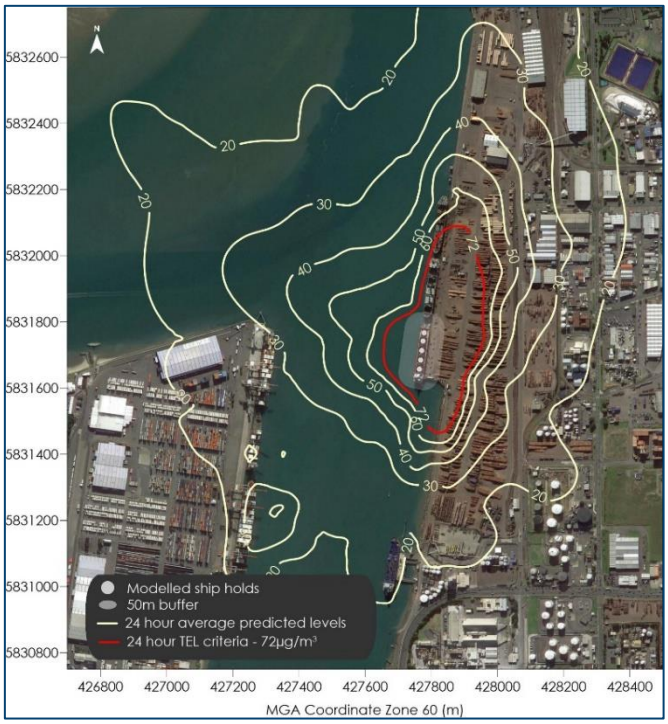

Figure 4-53: Maximum predicted EDN concentrations (µg/m³) - Ship holds, 24-hour averages, 500ppm

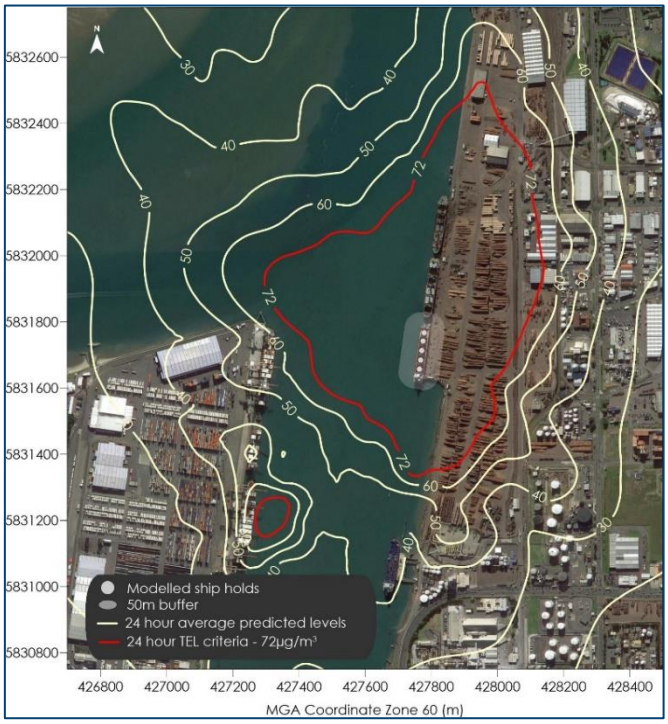

Figure 4-54: Maximum predicted EDN concentrations (µg/m³) - Ship holds, 24-hour averages, 1,000ppm

The modelling predictions indicate that:

- For ventilation of ship holds, predicted impacts would be above the relevant criteria at a 50m distance for the 1-hour average period at an endpoint concentration of 700ppm and above of EDN.
- Predicted impacts would be above the relevant criteria at a 50m distance for the 24-hour average period for all endpoint concentrations of EDN.

4.2.2 Analysis of endpoint concentrations

Similar to the venting of log stacks under a tarpaulin cover, the maximum predicted level of 10-minute, 1-hour, 8-hour and 24-hour averaging periods between endpoint concentrations of 500ppm, 700ppm and 1,000ppm show the same trend.

For an endpoint concentration of 1,000ppm, predicted impacts are approximately 2 times larger than for a corresponding endpoint concentration of 500ppm.

4.2.3 Duration of impact

Figure 4-55 presents the duration of predicted 1-hour average impacts for the ventilation of ship holds. The profiles show the average, maximum and minimum 1-hour average concentrations averaged across each starting hour over a 24-hour period at the most impacted receptor within a 200m buffer, for an endpoint concentration of 500ppm.

The predicted EDN levels gradually increase and peak after 2 hours from initial release and then gradually decline to negligible levels after the 6-hour venting period.

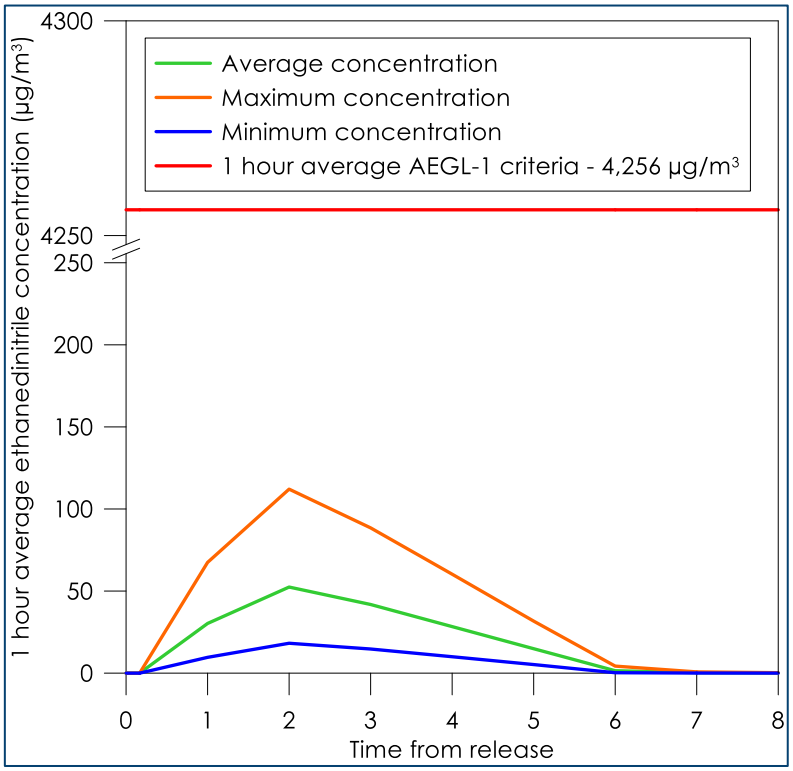

Figure 4-55: Duration of impact 1-hour average EDN concentrations – Ship holds

Overall, EDN concentrations are shown to diminish within a 6-hour period of ventilation of ship holds. The results indicate that maintaining the buffer zone in place up to three hours following the completion of the ventilation event would be adequate to ensure EDN concentrations have diminished.

4.2.4 Diurnal impacts

To investigate the effects of ventilation occurring at different times during the day, the predicted maximum 1-hour average EDN concentration for each starting hour at the most impacted receptor at an approximate 200m buffer is presented in **Figure 4-56**.

The results in **Figure 4-56** show that EDN concentrations are greatest during the hours of 4pm to 9am in each scenario with low levels occurring in the middle of the day due to better dispersion conditions. It is noted that between 9am and 4pm concentrations are lowest between 9am and 12pm.

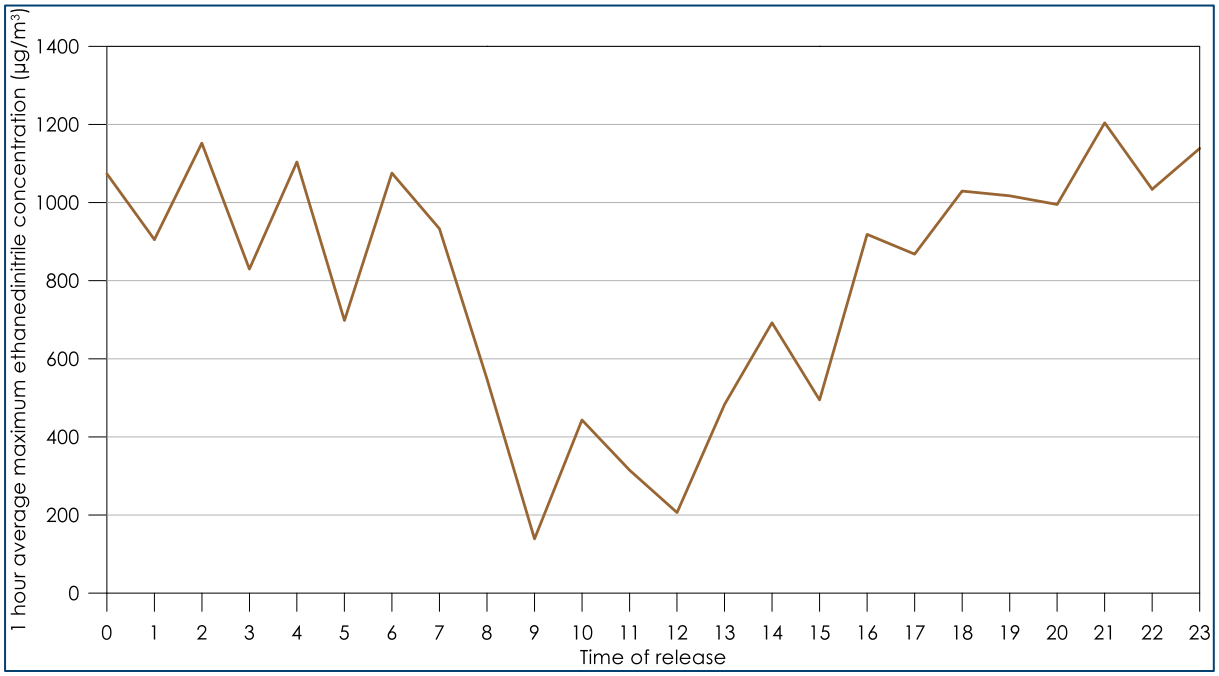

Figure 4-56: Maximum 1-hour average EDN concentrations by time of release – Ship holds

Figure 4-57 to **Figure 4-59** present the isopleth diagrams of the dispersion modelling results showing 24-hour average criteria level at various endpoint concentration ventilated over all hours, between 9am and 3pm, and between 9am and 12pm for ventilation of ship holds.

The figures compare the predicted contours for the 24-hour TEL criteria for ventilation across all hours (blue contour line), ventilation between 9am and 3pm (pink contour line) and for ventilation between 9am and 12pm (green contour line).

The figures indicate that venting between 9am and 3pm or 9am and 12pm would be above the relevant criteria at a distance of approximately 50m for the 24-hour average period for all endpoint concentrations of EDN.

A comparison of the results show that the maximum predicted 24-hour average levels with ventilation occurring between 9am and 3pm decreases approximately by 14% and would decrease the required buffer zone by approximately 100m. Restricting ventilation between 9am and 12pm decreases the maximum predicted 24-hour average levels approximately by 24% and would decrease the required buffer zone by approximately 200m.

Figure 4-57: Maximum predicted EDN concentrations (µg/m³) - Ship holds, 24-hour averages, 500ppm, with ventilation across all hours, between 9am and 3pm and between 9am and 12pm

Figure 4-58: Maximum predicted EDN concentrations (µg/m³) - Ship holds, 24-hour averages, 700ppm, with ventilation across all hours, between 9am and 3pm and between 9am and 12pm

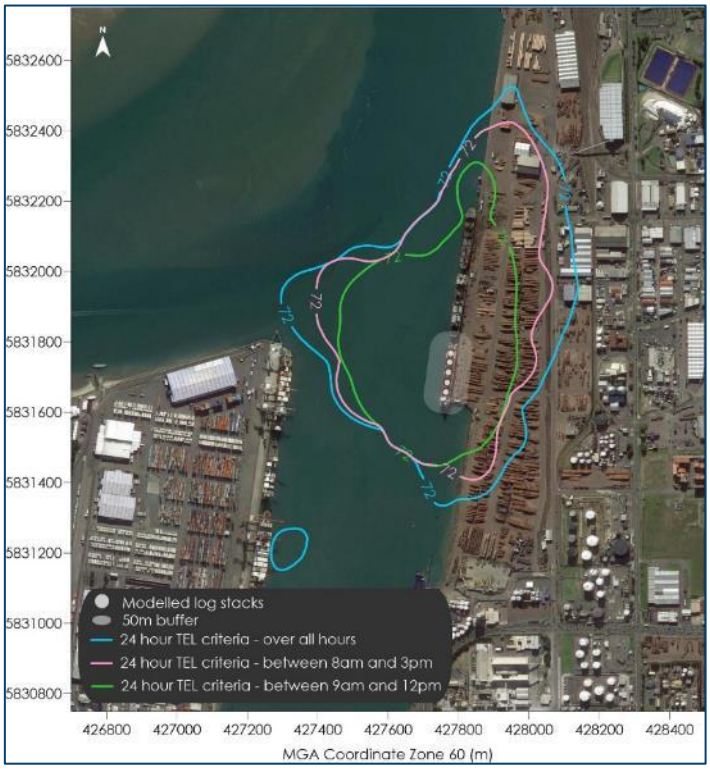

Figure 4-59: Maximum predicted EDN concentrations (µg/m³) - Ship holds, 24-hour averages, 1,000ppm, with ventilation across all hours, between 9am and 3pm and between 9am and 12pm

4.2.5 Summary of dispersion modelling results for ship holds

- For the ventilation of ship holds, a 50m buffer zone is not sufficient.
- For the ventilation of ship holds:
  - with endpoint concentrations greater than 500ppm, a buffer zone of at least 320m is recommended.
  - with endpoint concentrations greater than 700ppm, a buffer zone of at least 530m is recommended.
  - with endpoint concentrations greater than 1,000ppm, a buffer zone of at least 755m is recommended.
- The maximum predicted levels for each averaging period with an endpoint concentration of 1,000ppm are approximately 2 times larger than the predicted levels with an endpoint concentration of 500ppm.
- EDN concentrations are shown to diminish within a 6-hour period following each ventilation event.
- Restricting ventilation times between 9am and 3pm reduce the extent of impact due to better dispersion conditions.

4.2.6 Summary of dispersion modelling results for ship holds 9am and 3pm

- For the ventilation ship holds:
  - with endpoint concentrations greater than 500ppm, a buffer of at least 310m is recommended.
  - with endpoint concentrations greater than 700ppm, a buffer at least of 485m is recommended.
  - with endpoint concentrations greater than 1,000ppm, a buffer of at least 665m is recommended.

4.2.7 Summary of dispersion modelling results for ship holds 9am and 12pm

- For the ventilation ship holds:
  - with endpoint concentrations greater than 500ppm, a buffer zone of at least 185m is recommended.
  - with endpoint concentrations greater than 700ppm, a buffer zone of at least 270m is recommended.
  - with endpoint concentrations greater than 1,000ppm, a buffer zone of at least 540m is recommended.

5 SUMMARY AND CONCLUSIONS

This report has assessed the potential EDN ground level concentrations associated with fumigation of logs at the Port of Tauranga.

Air dispersion modelling with the CALPUFF model was used to predict the potential for air quality impacts. The dispersion modelling considered the ventilation following fumigation of log stacks under a tarpaulin cover and in ship holds for endpoint concentrations of 500ppm, 700ppm and 1,000ppm of EDN.

The dispersion modelling considers the potential for ventilation to occur at any hour of the day, as applicable to the various scenarios assessed.

The dispersion modelling predictions found that for ventilation of log stacks under a tarpaulin cover, the required buffer varies depending on the situation and restricting ventilation times between 8am and 3pm can reduce potential impacts.

For the ventilation of ship holds, the required buffer varies depending on the situation and restricting ventilation times between 9am and 12pm had the most effect on reducing potential impacts.

The endpoint concentration of EDN has a direct relation to predicted impacts with the higher endpoint concentrations resulting in greater impacts.

Overall the results show:

- The required buffer will vary depending on the ventilation situation;
- The EDN concentrations are predicted to reduce to negligible levels a period of one hour following ventilation of covered logs;
- The predictions indicate that maintaining the buffer zone in place up to three hours following a ship ventilation event has stopped would be adequate to ensure EDN concentrations have diminished; and,
- Restricting ventilation to daytime hours reduces the spatial extent of the potential impact.

6 REFERENCES

APVMA (2013)

"Public Release Summary on the Evaluation of the New Active Constituent Ethanedinitrile in the Product Sterigas 1,000 Fumigant", prepared by Australia Pesticides and Veterinary Medicines Authority (APVMA), June 2013

Emery et al. (2005)

Emery, C., E. Tai, and G. Yarwood, 2001, *Enhanced Meteorological Modeling and Performance Evaluation for Two Texas Ozone Episodes*, prepared by ENVIRON, International Corp, for The Texas Natural Resource Conservation Commission Novato, August 2001.

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"Science Memo APP202804 – EDN", prepared by New Zealand Environmental Protection Authority (NZ EPA), July 2018.

TRC (2011)

"Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the Approved Methods for the Modelling and Assessments of Air Pollutants in NSW, Australia", Prepared for the NSW Office of Environment and Heritage by TRC Environmental Corporation.

The National Academy of Sciences (2014)

"National Research Council Committee Review Acute Exposure Guideline Levels for Selected Airborne Chemicals", Volume 17, The National Academy of Sciences, 2014.

Appendix A

Meteorological data evaluation

Meteorological data evaluation

To examine whether the TAPM and CALMET generated data used in the assessment are likely to adequately represent the local terrain and meteorological effects in the modelling domain, an evaluation of quantitative statistical comparisons of two meteorological datasets was performed.

For this evaluation the Tauranga Aero AWS observation station data for each modelling year was compared with the TAPM model output and also the predicted CALMET model outputs.

The statistical measures include;

- Index of Agreement (IOA) which determines the magnitude of deviations of the predicted model meteorological datasets are related to the mean from the observational meteorological dataset with a perfect score being 1;
- Root-mean-square error (RMSE) which is calculated as the square root of the mean squared difference in model-observation pairings with an ideal value of 0;
- Bias error which determines the average difference between model and observational data; and,
- Gross error which determines the average of the absolute value between model and observational data.

The statistical output was evaluated using benchmarks developed by Emery et al. in *Enhanced Meteorological Modeling and Performance Evaluation for Two Texas Ozone Episodes* (**Emery et al. 2005**) and are listed in **Table A-1**.

Table A-1: Benchmarks for meteorological modelling evaluation

Parameter	IOA	RMSE	Mean Bias	Gross Error
Wind speed	≥0.6	≤2 m/s	≤±0.5	
Wind direction			≤±10°	≤30°
Temperature	≥0.8		≤±0.5 K	≤2 K

The result of the statistical evaluation for the 2018 year modelled is presented **Table A-2**. Results highlighted in orange are those which do not meet the relevant benchmarks.

The evaluation of the TAPM vs observational data indicates that for some of the statistical measures the relevant benchmarks are not met. For the majority of these, the values are only marginally exceeded with the exception of the gross error for wind direction.

The statistical evaluation of the CALMET vs observational data indicates the statistical measures meet the relevant benchmarks and indicate the CALMET data compares reasonably well with the observational data.

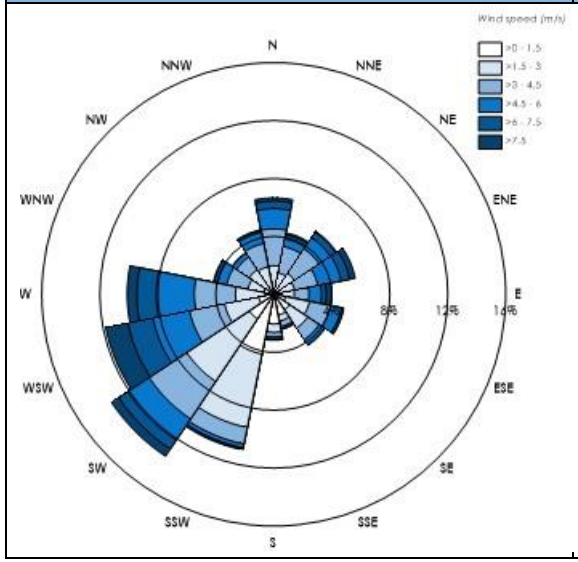
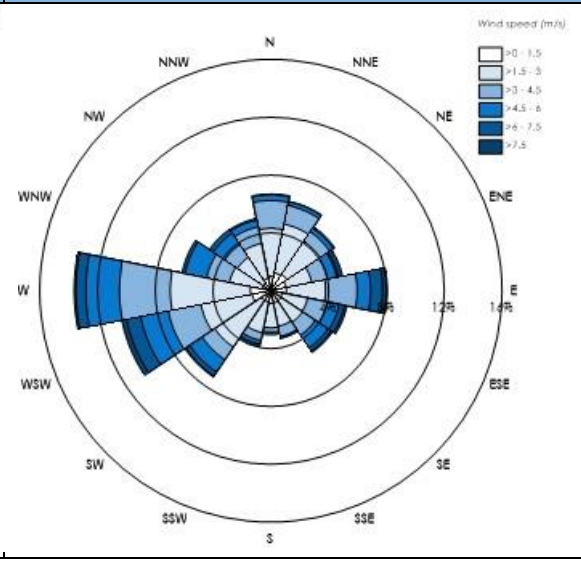
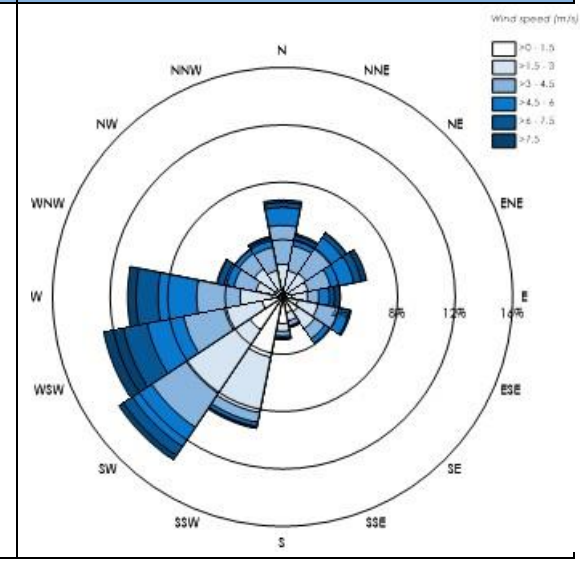
It is noted that whilst the RMSE is a good overall measure of model performance large errors are weighted heavily which can be seen from the statistical output for wind direction for the TAPM and CALMET predicted data.

The annual windroses shown below in **Table A-3** for the 2018 modelling year from Tauranga Aero AWS observation station, TAPM generated data and CALMET generated data appear to adequately represent the observational data.

Table A-2: Statistical evaluation for predicted TAPM and CALMET

Parameter	TAPM			
	IOA	RMSE	BIAS	Gross Error
Wind speed (m/s)	0.6	2.2	-0.4	1.8
Wind direction (deg)	0.6	112.4	-5.7	78.9
Temperature (K)	0.7	4.0	0.2	3.3
	CALMET			
Wind speed (m/s)	1.0	0.3	-0.1	0.2
Wind direction (deg)	1.0	25.4	0.7	6.2
Temperature (K)	1.0	0.0	0.0	0.0

Table A-3: Comparison of annual windroses

Tauranga Aero AWS Observation station	TAPM data extract at site of observation station	CALMET extract extract at port site
		

The outputs from the CALMET modelling are evaluated using visual analysis of the wind fields and extracted data and also through a comparison of the CALMET generated data at locations with measured observational meteorological data within the modelling domain.

Figure A-1 presents a snapshot visualisation of the wind field generated by CALMET for a single hour of the modelling period for the 2018 modelling year. The wind fields are seen to follow the terrain well and indicate the simulation produces realistic fine scale flow fields (such as terrain forced flows) in surrounding areas.

CALMET generated meteorological data were extracted from a point within the CALMET domain. **Figure A-2** presents the annual and seasonal windroses from the CALMET data for the 2018 modelling year. Overall, the windroses generated in the CALMET modelling reflect the expected wind distribution patterns of the area as determined based on the available measured data and the expected terrain effects on the prevailing winds.

Figure A-3 includes graphs of the temperature, wind speed, mixing height and stability classification for the 2018 modelling year and show sensible trends considered to be representative of the area.

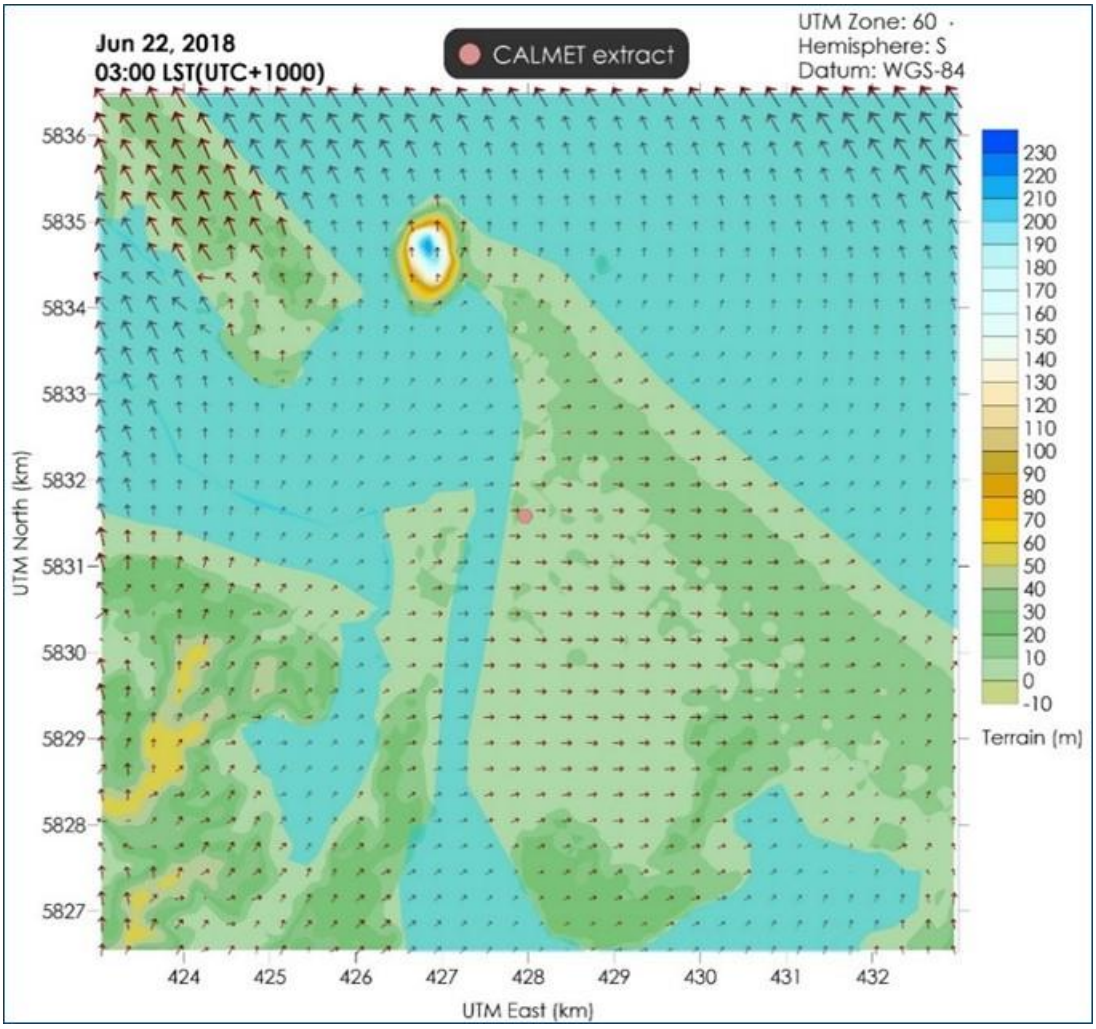


Figure A-1: Representative snapshot of wind field for the Project

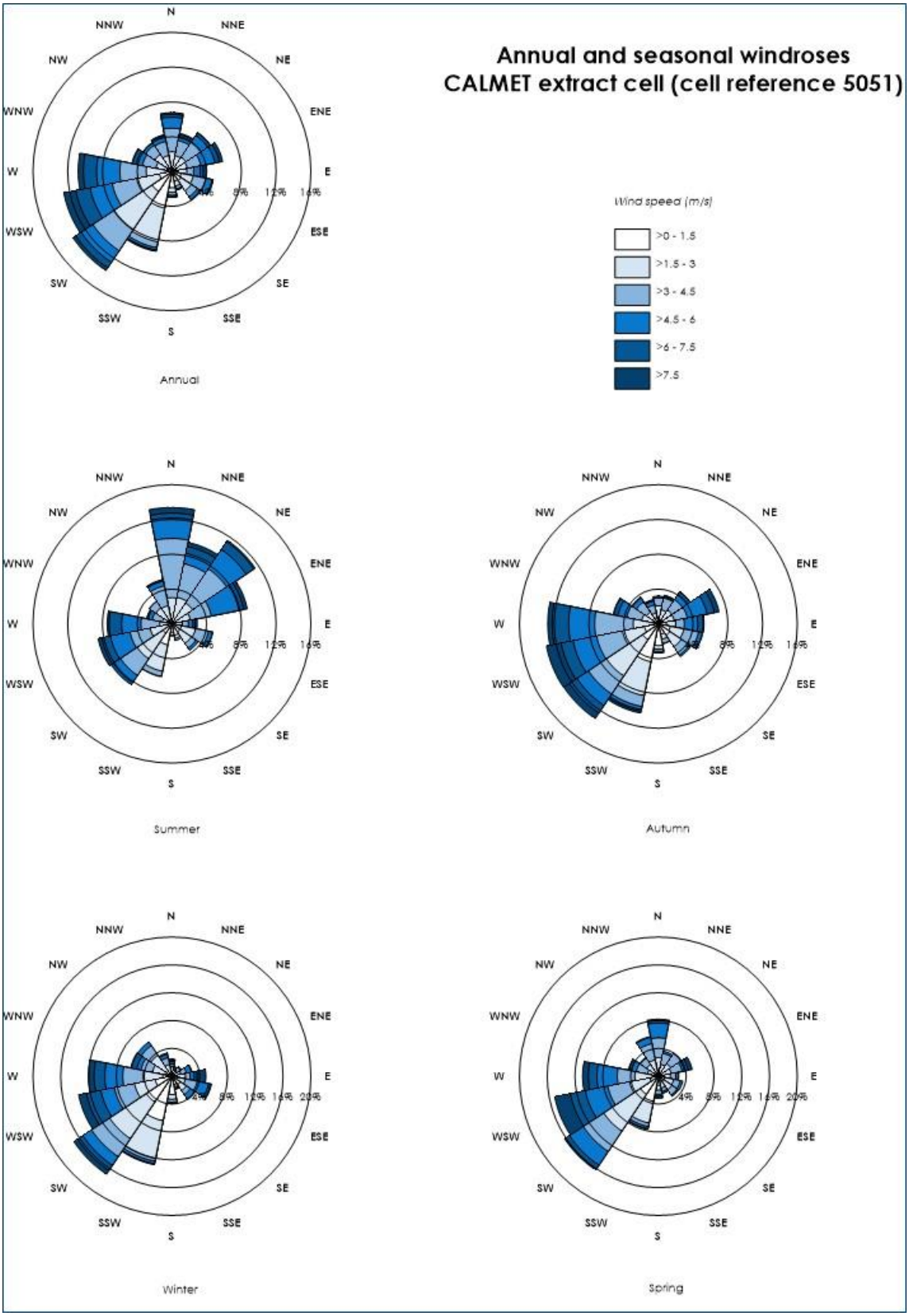


Figure A-2: Annual and seasonal windroses from CALMET (Cell reference 5051)

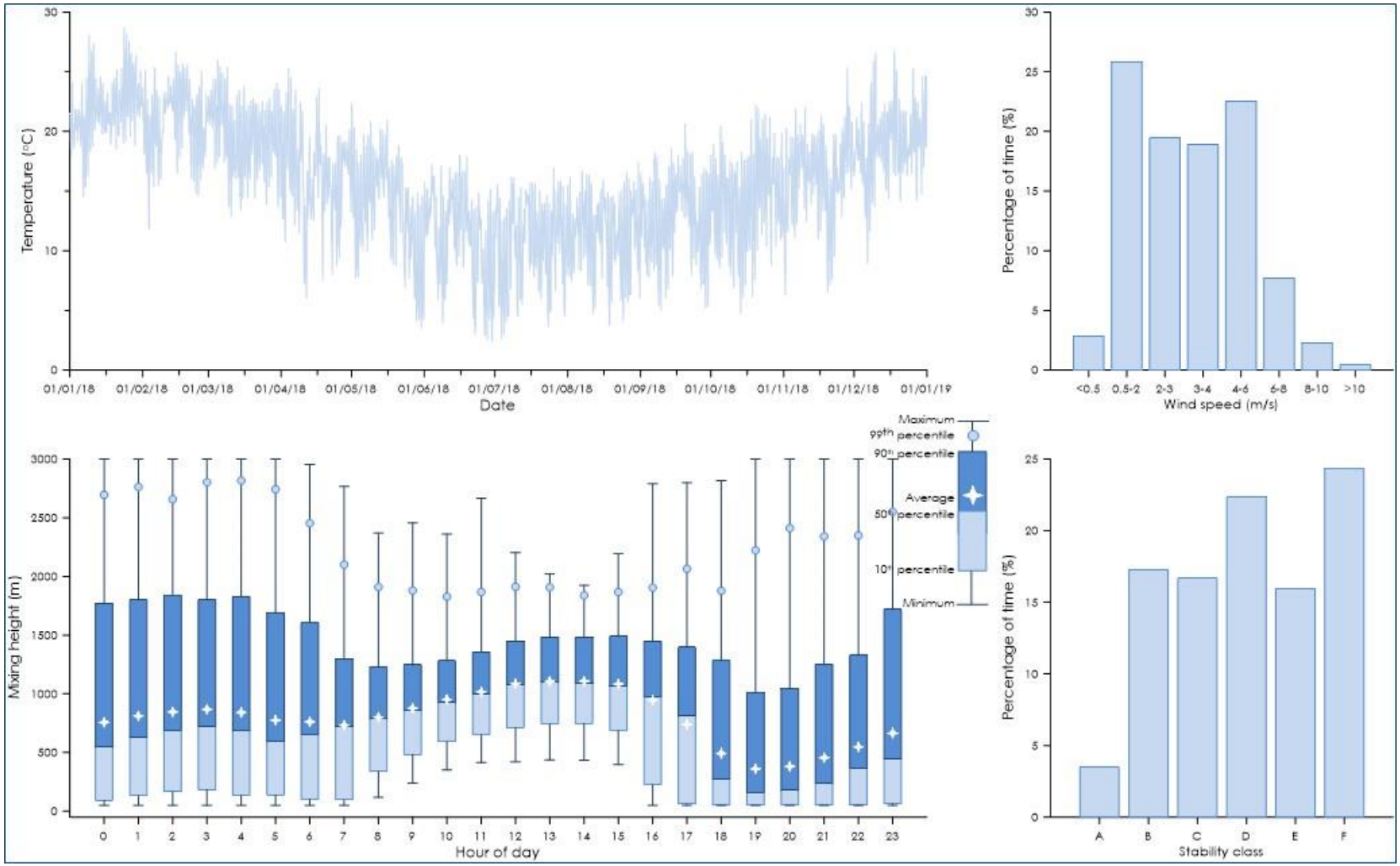


Figure A-3: Meteorological analysis of CALMET (Cell Ref 5051)

Appendix B

Isopleth Diagrams

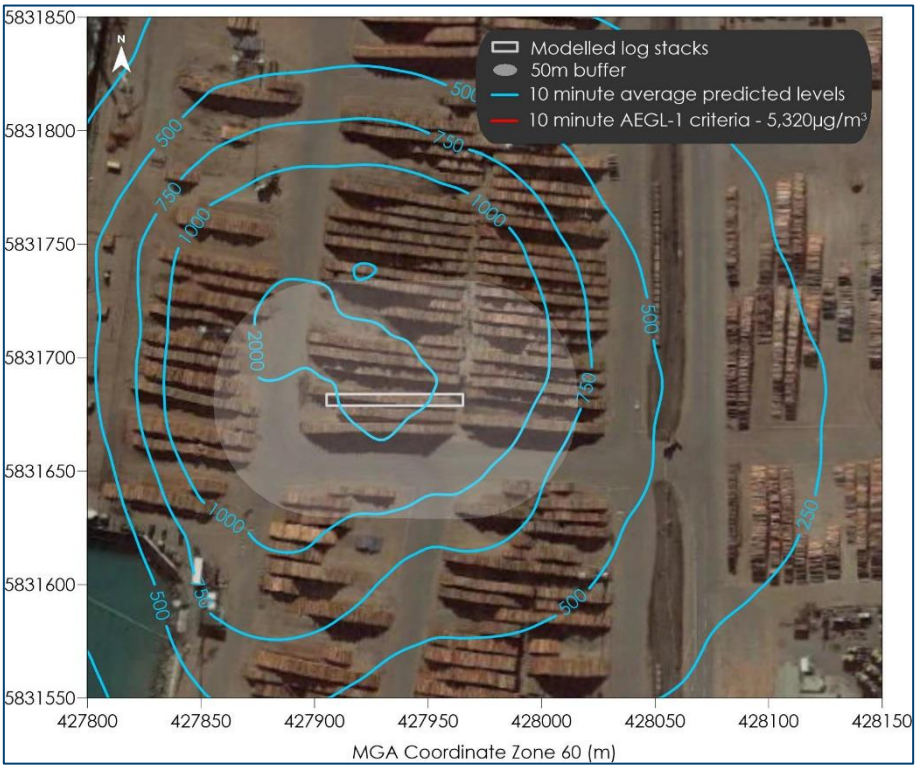


Figure B-1: Maximum predicted EDN concentrations (µg/m³) - One log stack scenario, 10-minute averages, 500ppm

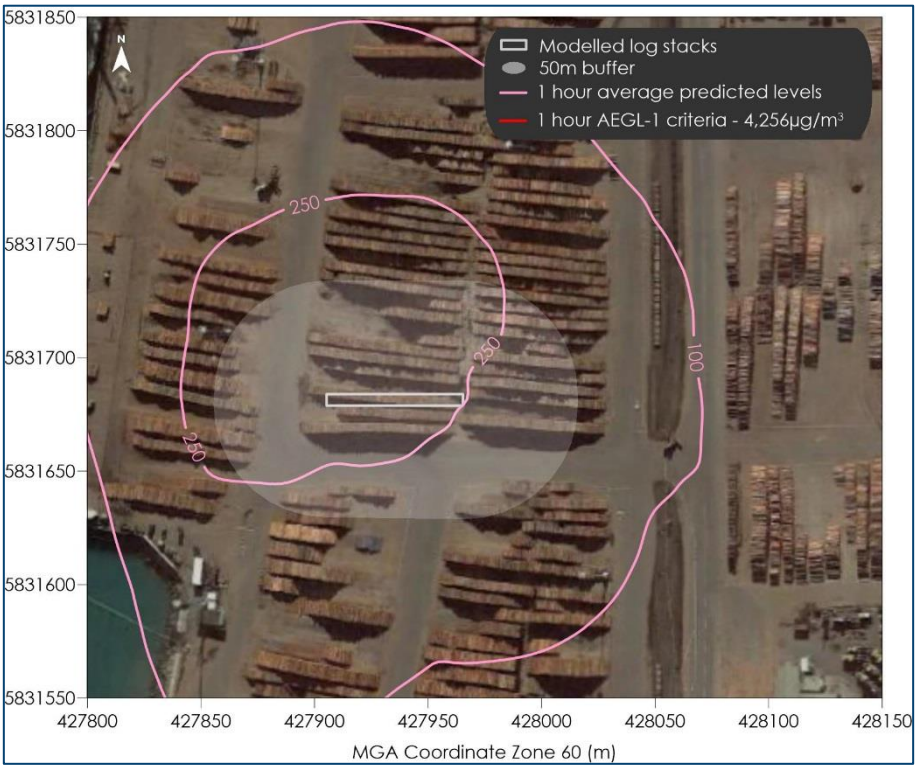


Figure B-2: Maximum predicted EDN concentrations (µg/m³) - One log stack scenario, 1-hour averages, 500ppm

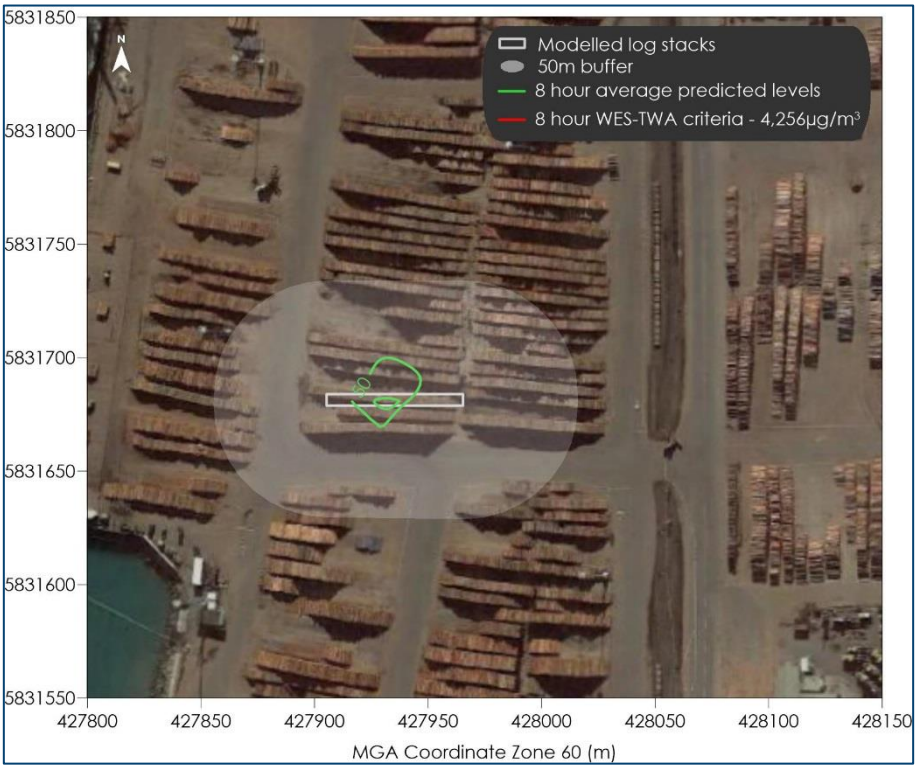


Figure B-3: Maximum predicted EDN concentrations (µg/m³) - One log stack scenario, 8-hour averages, 500ppm

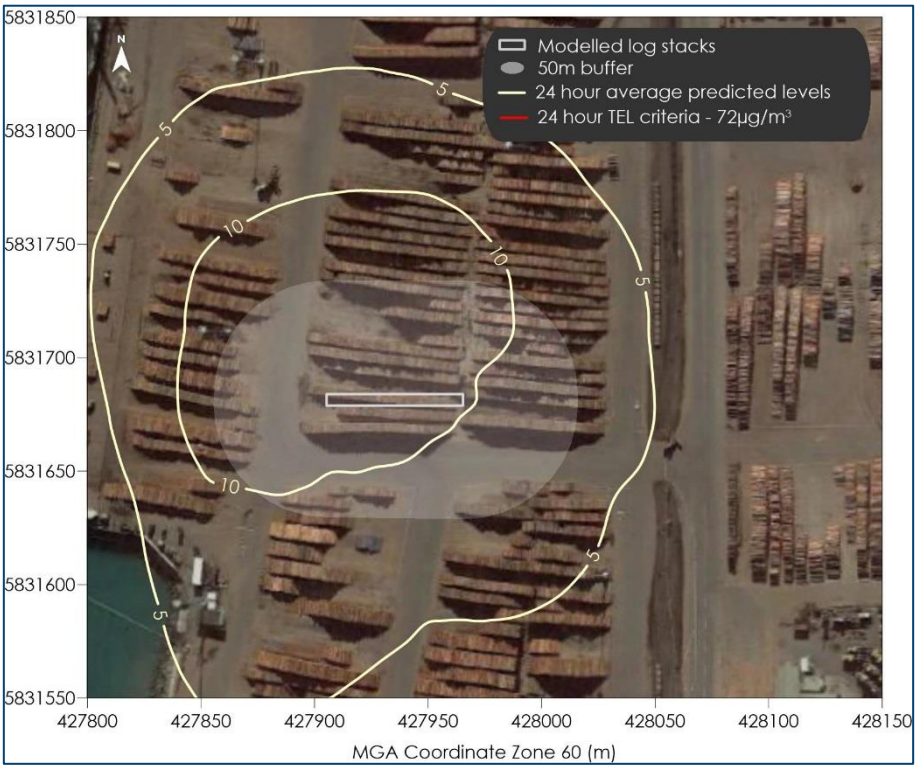


Figure B-4: Maximum predicted EDN concentrations (µg/m³) - One log stack scenario, 24-hour averages, 500ppm

Figure B-5: Maximum predicted EDN concentrations (µg/m³) - One log stack scenario, 10-minute averages, 700ppm

Figure B-6: Maximum predicted EDN concentrations (µg/m³) - One log stack scenario, 1-hour averages, 700ppm

Figure B-7: Maximum predicted EDN concentrations (µg/m³) - One log stack scenario, 8-hour averages, 700ppm

Figure B-8: Maximum predicted EDN concentrations (µg/m³) - One log stack scenario, 24-hour averages, 700ppm

Figure B-9: Maximum predicted EDN concentrations (µg/m³) - One log stack scenario, 10-minute averages, 1,000ppm

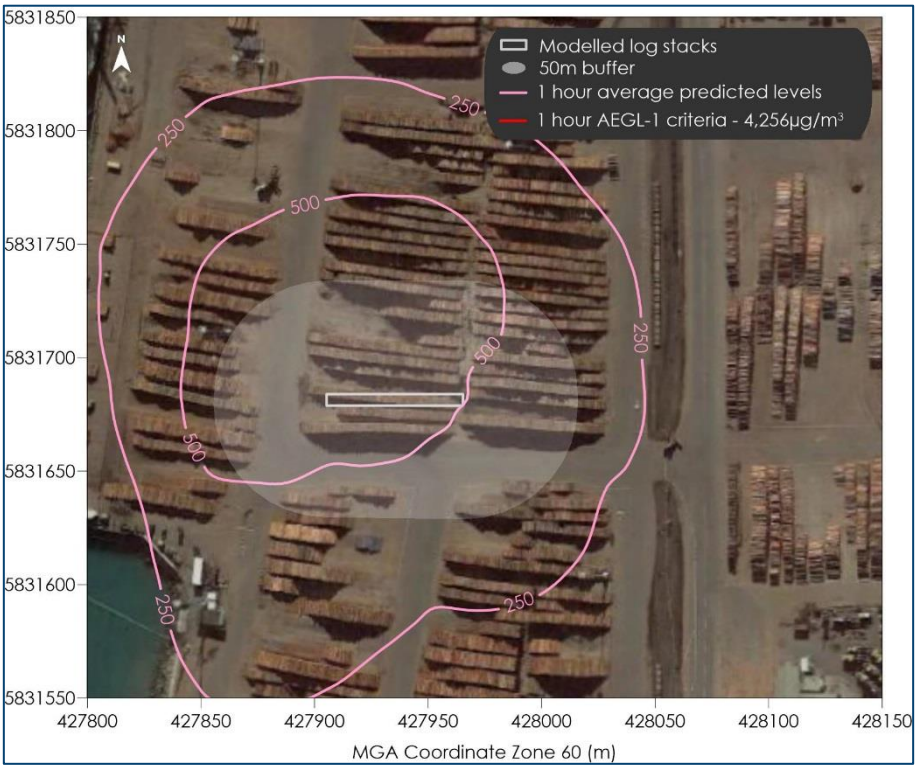


Figure B-10: Maximum predicted EDN concentrations (µg/m³) - One log stack scenario, 1-hour averages, 1,000ppm

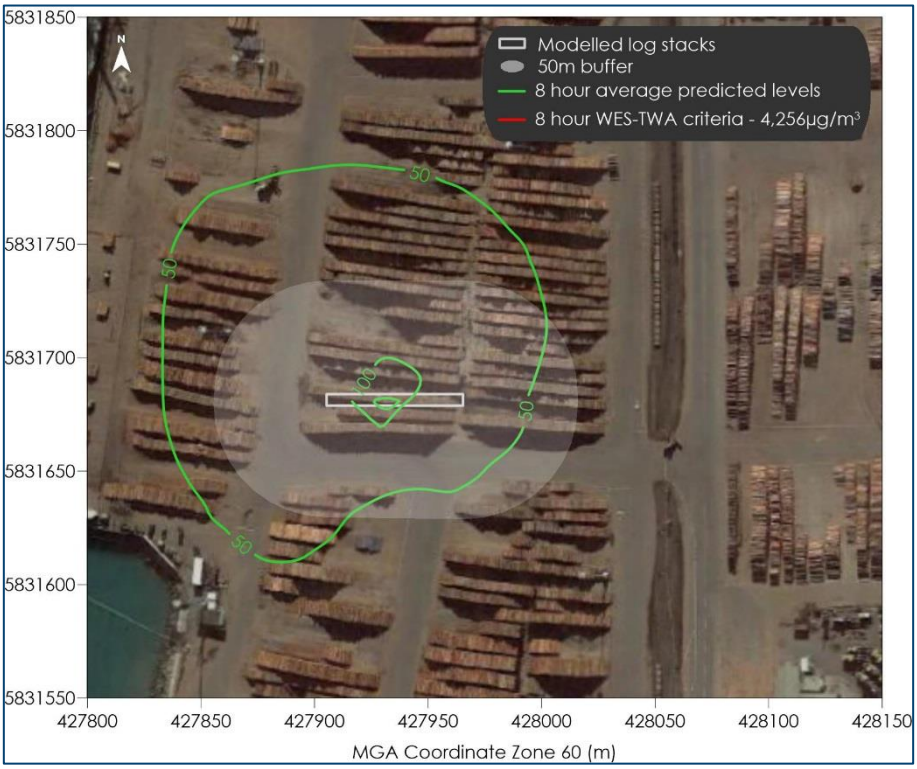


Figure B-11: Maximum predicted EDN concentrations (µg/m³) - One log stack scenario, 8-hour averages, 1,000ppm

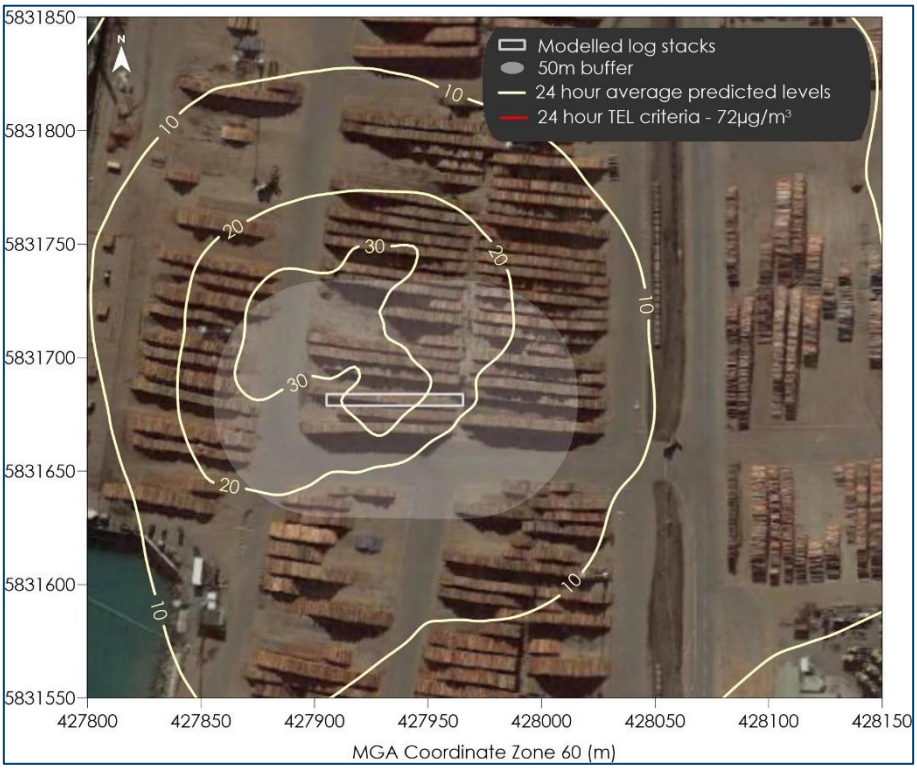


Figure B-12: Maximum predicted EDN concentrations (µg/m³) - One log stack scenario, 24-hour averages, 1,000ppm

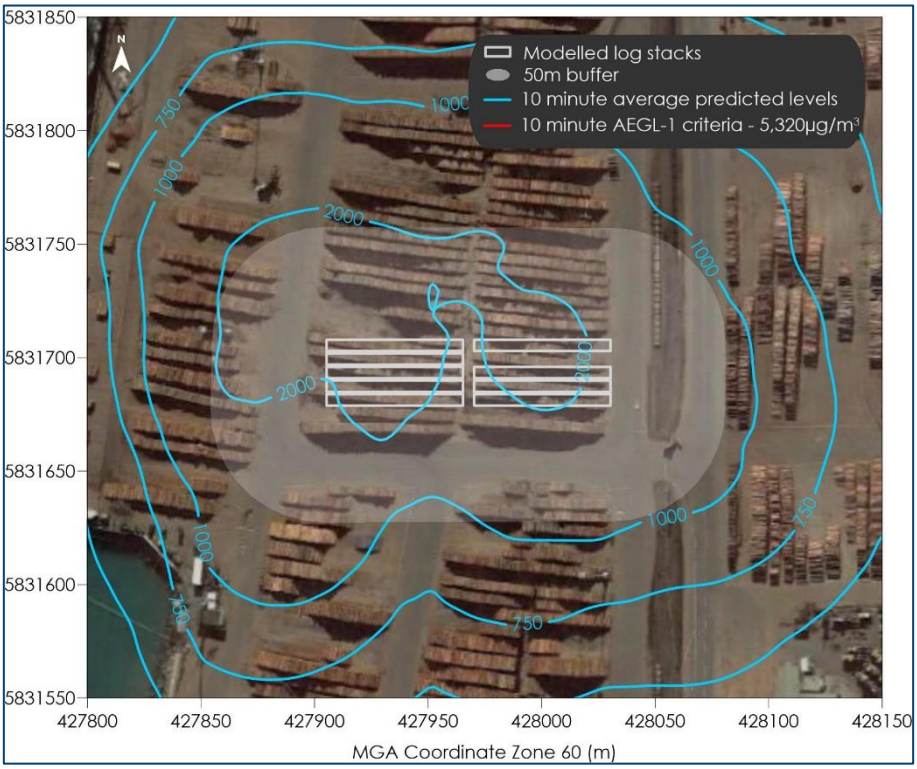


Figure B-13: Maximum predicted EDN concentrations (µg/m³) - Nine log stacks scenario, 10-minute averages, 500ppm

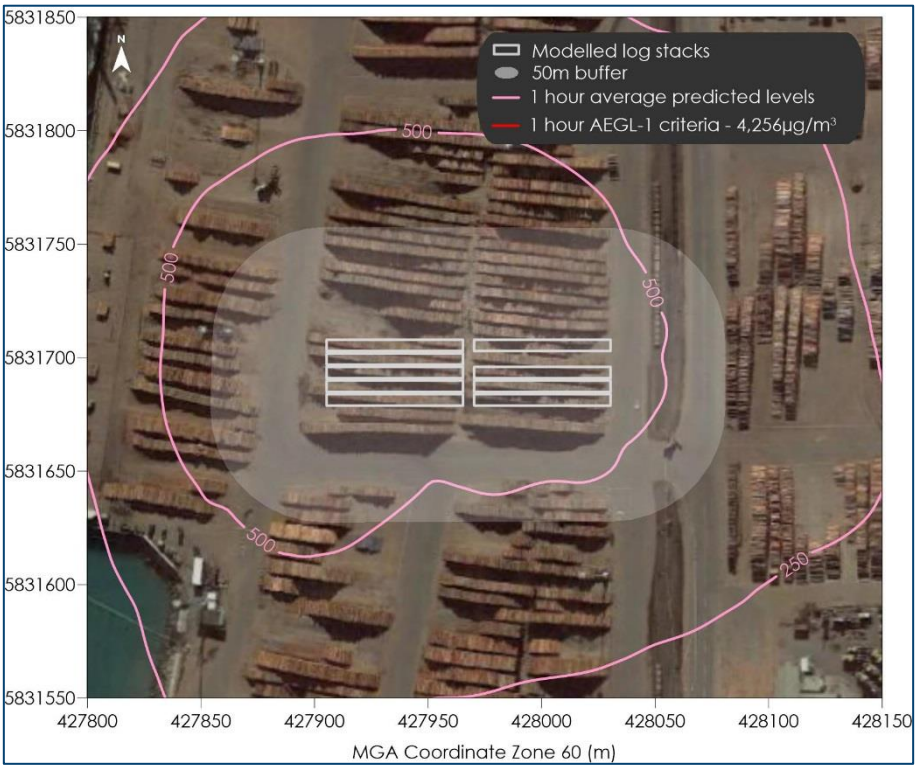


Figure B-14: Maximum predicted EDN concentrations (µg/m³) - Nine log stacks scenario, 1-hour averages, 500ppm

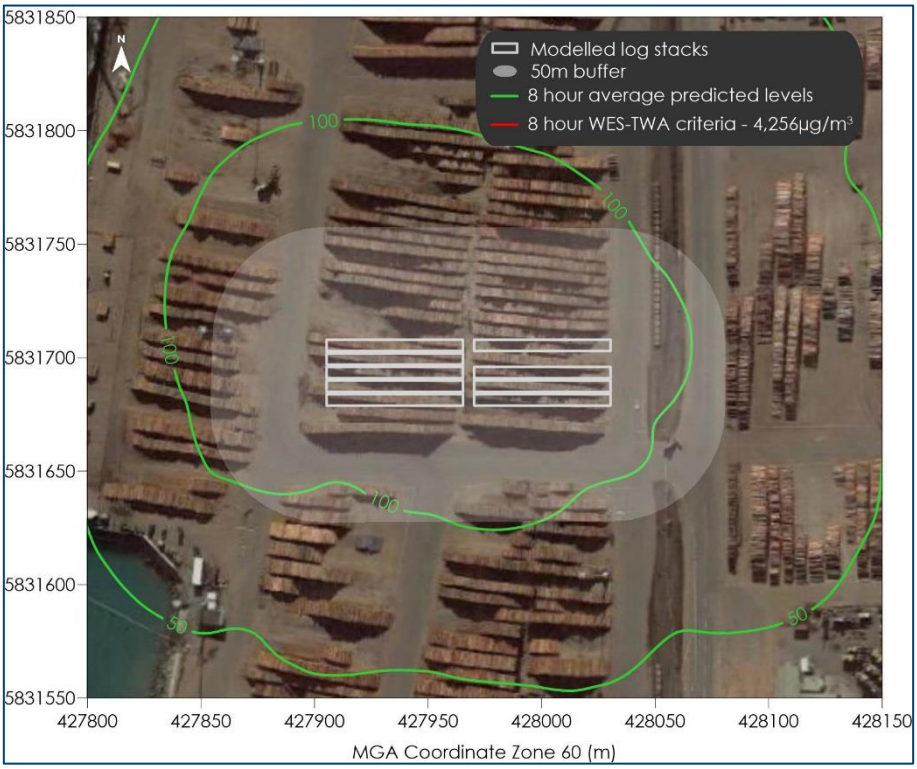


Figure B-15: Maximum predicted EDN concentrations (µg/m³) - Nine log stacks scenario, 8-hour averages, 500ppm

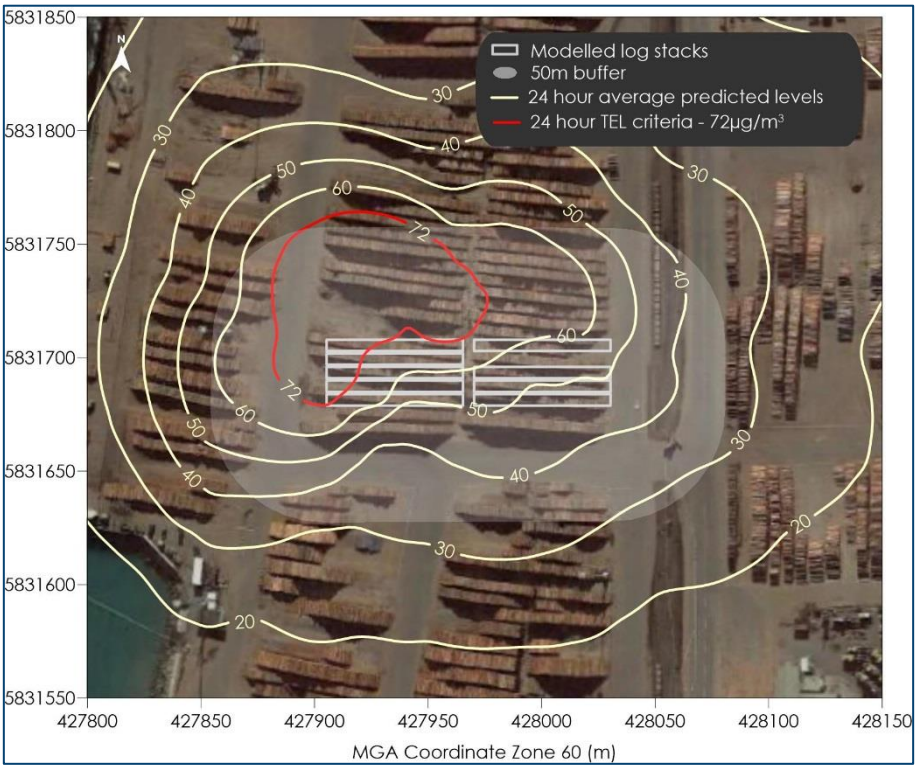


Figure B-16: Maximum predicted EDN concentrations (µg/m³) - Nine log stacks scenario, 24-hour averages, 500ppm

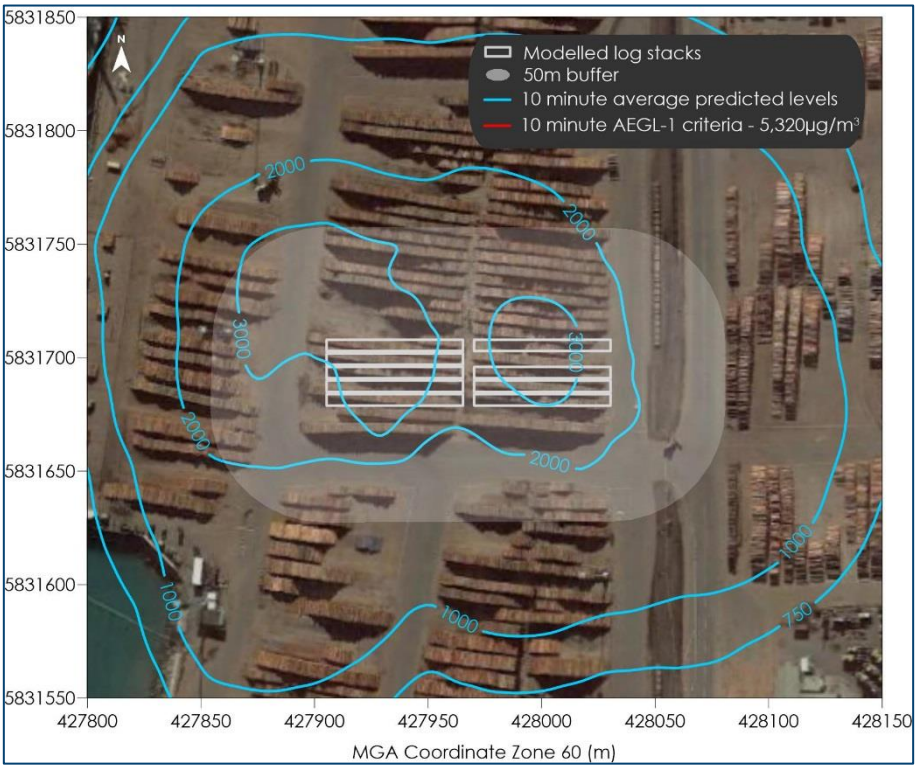


Figure B-17: Maximum predicted EDN concentrations (µg/m³) - Nine log stacks scenario, 10-minute averages, 700ppm

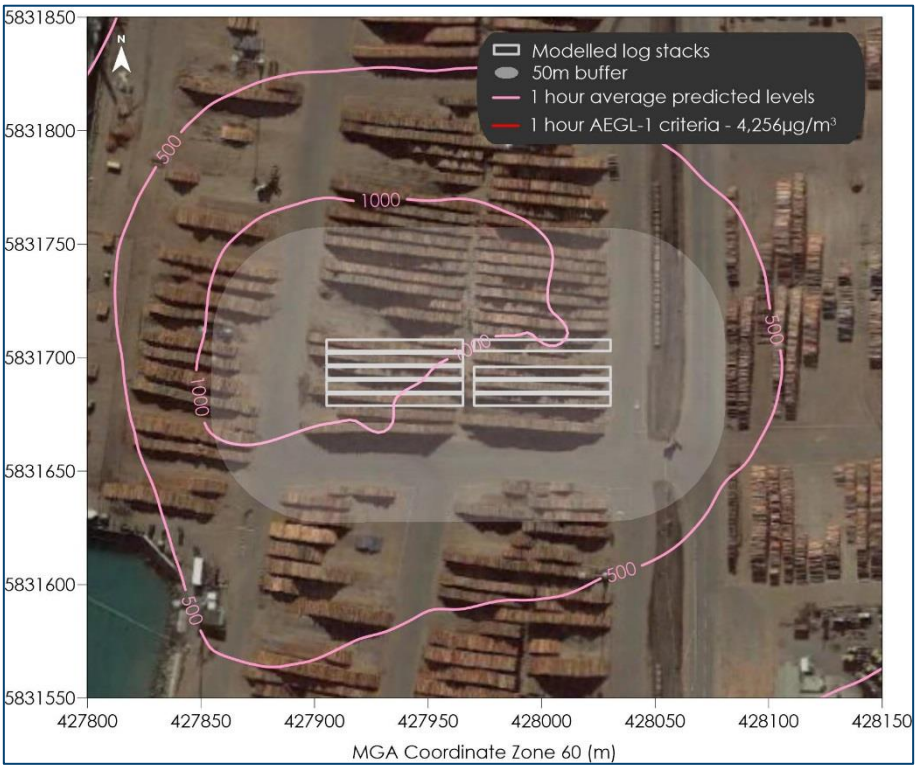


Figure B-18: Maximum predicted EDN concentrations (µg/m³) - Nine log stacks scenario, 1-hour averages, 700ppm

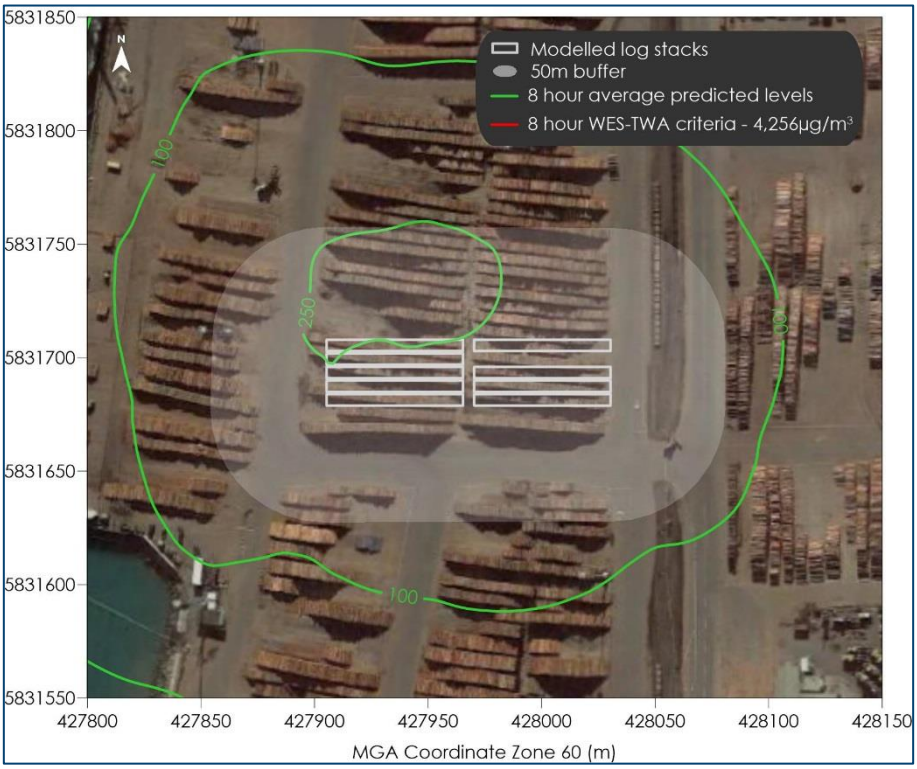


Figure B-19: Maximum predicted EDN concentrations (µg/m³) - Nine log stacks scenario, 8-hour averages, 700ppm

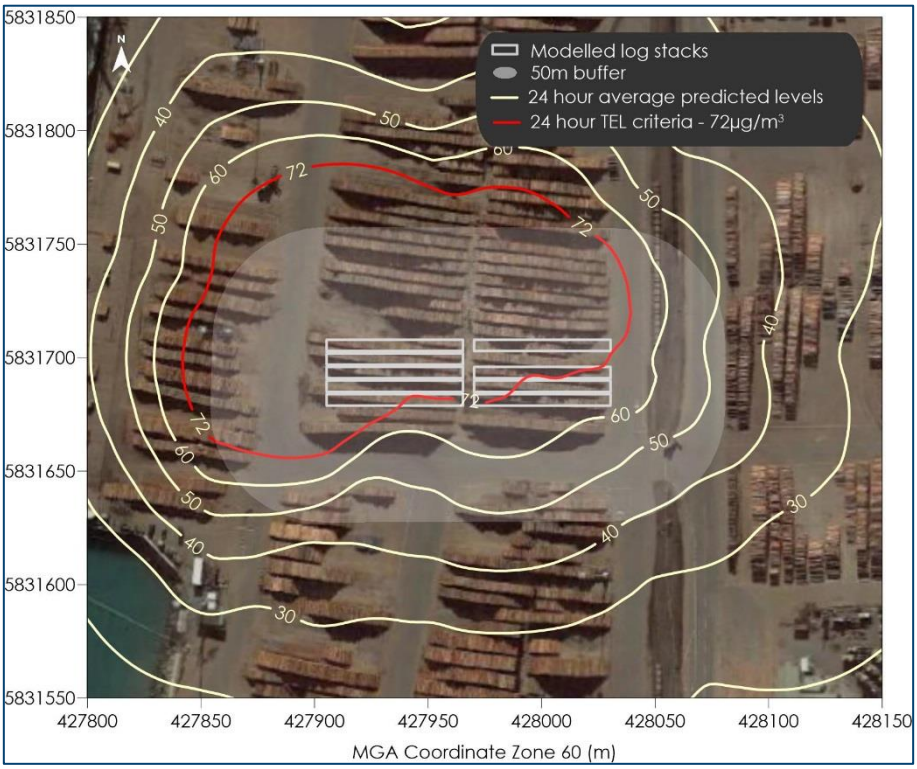


Figure B-20: Maximum predicted EDN concentrations (µg/m³) - Nine log stacks scenario, 24-hour averages, 700ppm

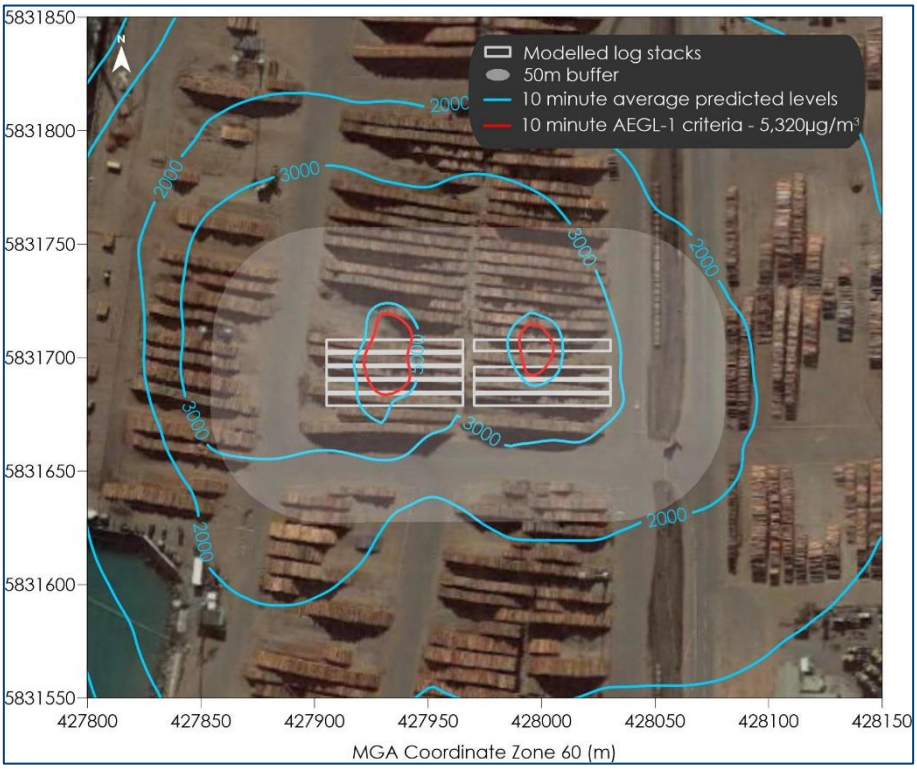


Figure B-21: Maximum predicted EDN concentrations (µg/m3) - Nine log stacks scenario, 10-minute averages, 1,000ppm

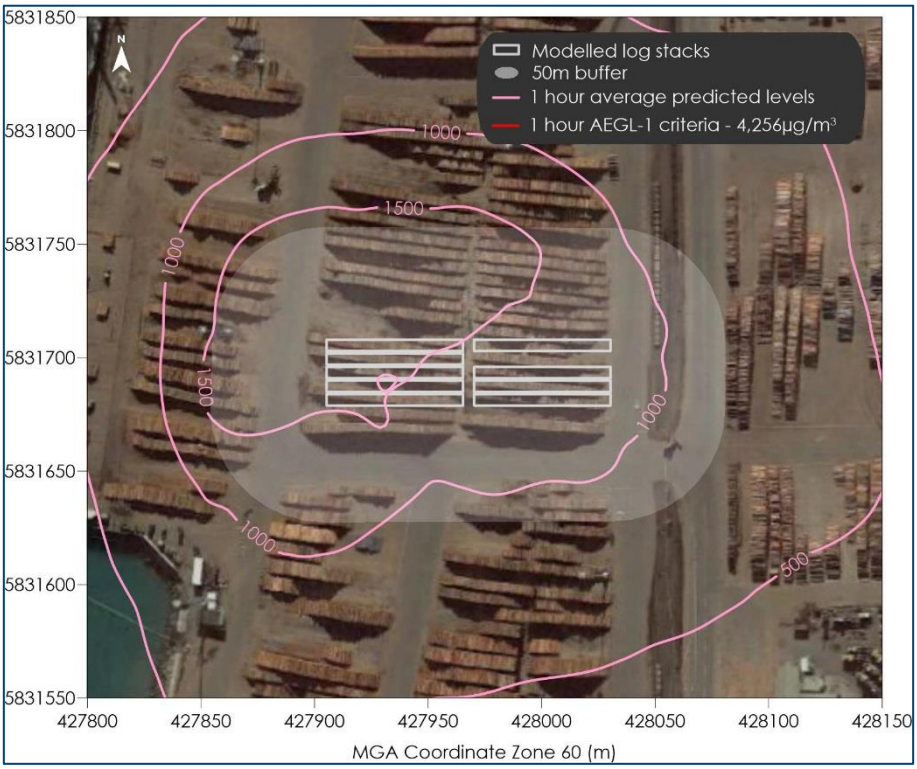


Figure B-22: Maximum predicted EDN concentrations (µg/m3) - Nine log stacks scenario, 1-hour averages, 1,000ppm

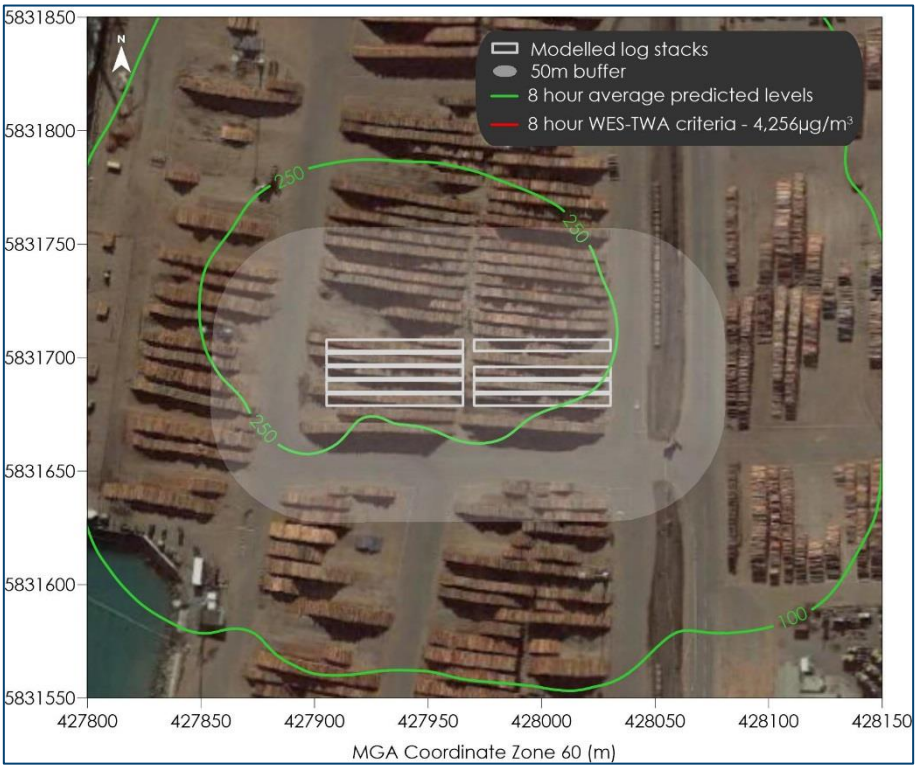


Figure B-23: Maximum predicted EDN concentrations (µg/m³) - Nine log stacks scenario, 8-hour averages, 1,000ppm

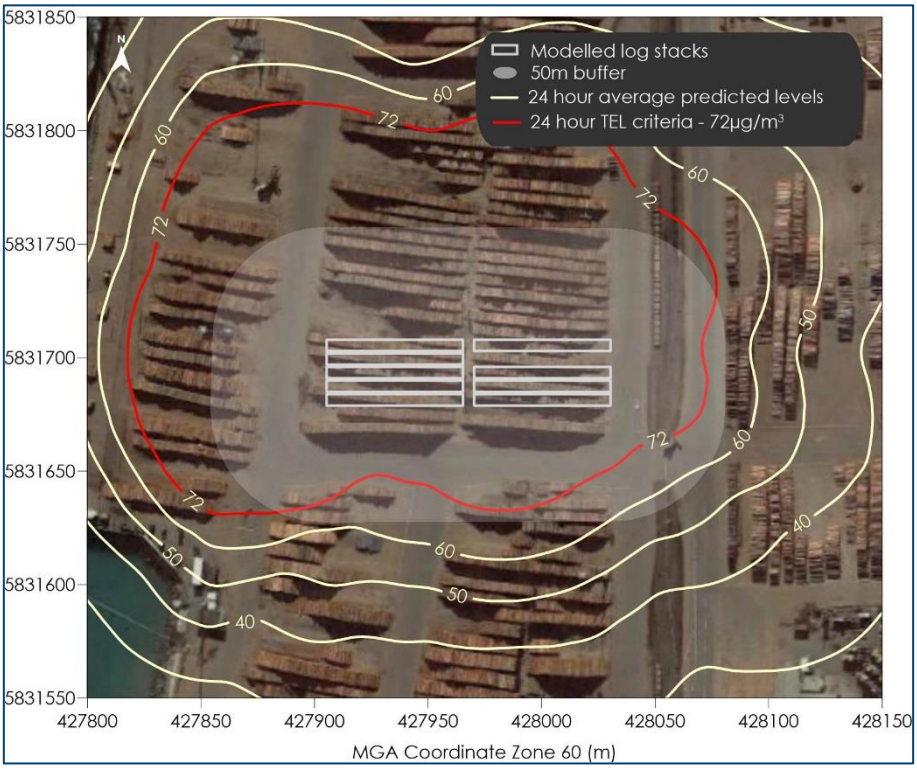


Figure B-24: Maximum predicted EDN concentrations (µg/m³) - Nine log stacks scenario, 24-hour averages, 1,000ppm

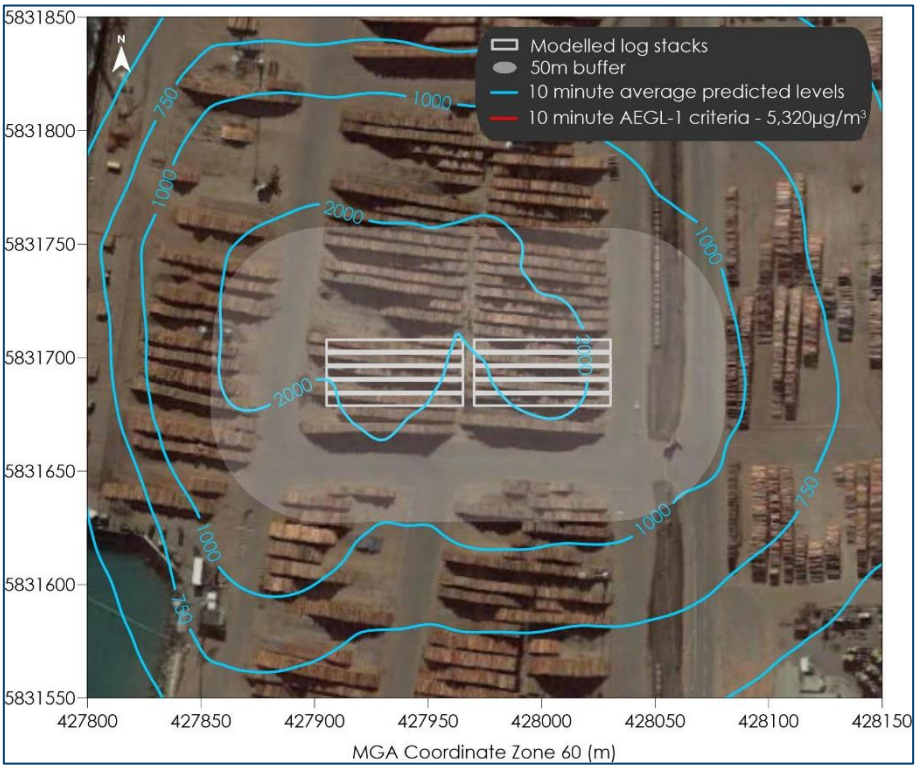


Figure B-25: Maximum predicted EDN concentrations (µg/m3) – Ten log stacks scenario, 10-minute averages, 500ppm

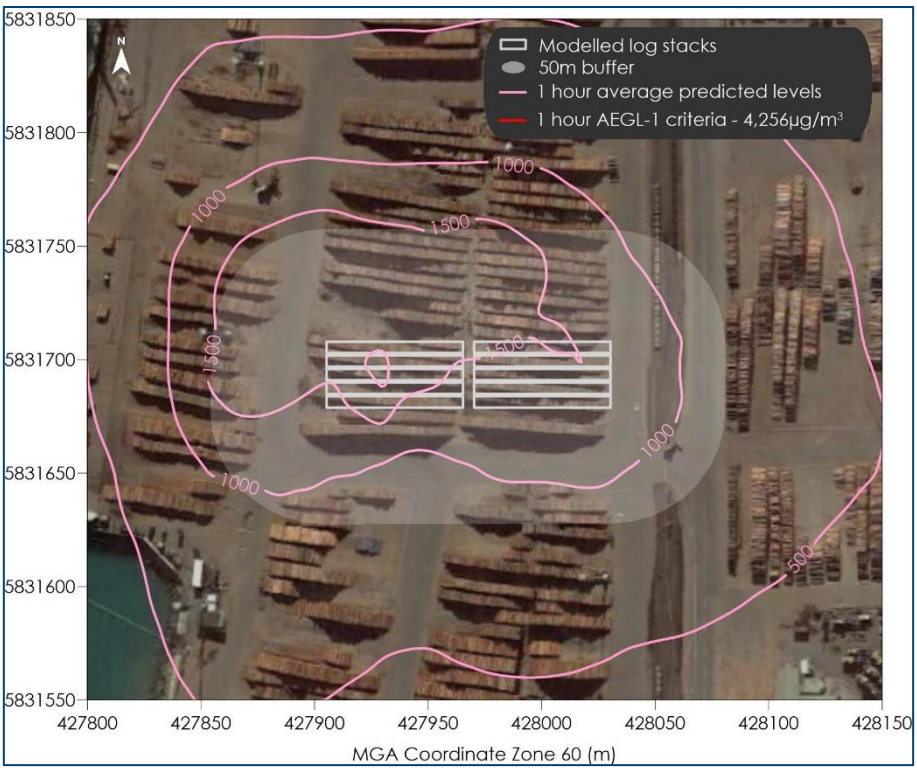


Figure B-26: Maximum predicted EDN concentrations (µg/m3) – Ten log stacks scenario, 1-hour averages, 500ppm

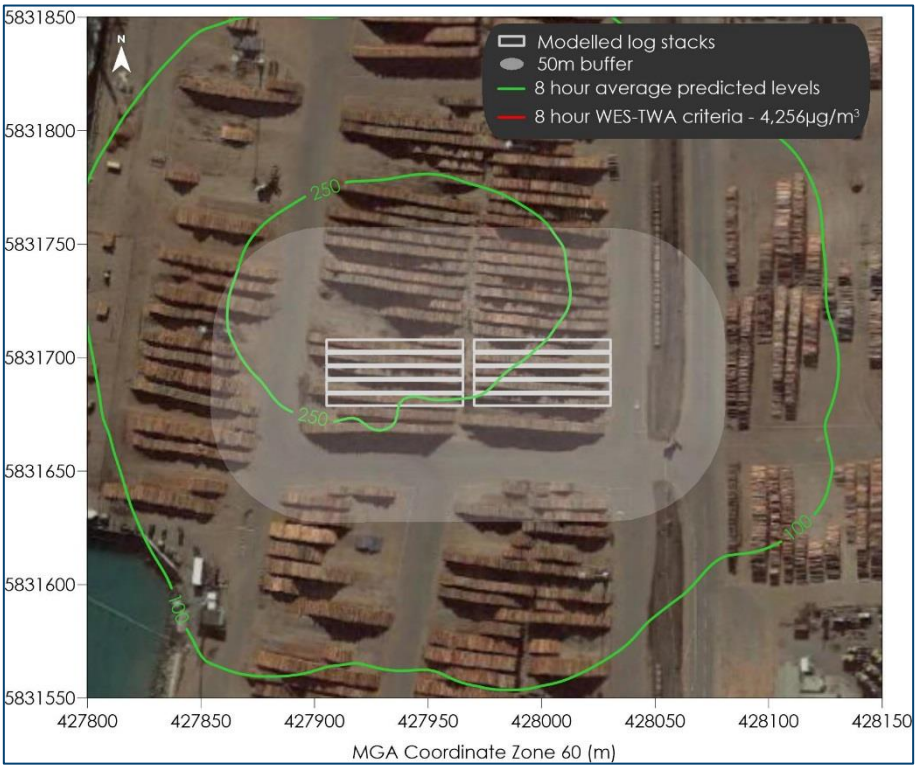


Figure B-27: Maximum predicted EDN concentrations (µg/m³) – Ten log stacks scenario, 8-hour averages, 500ppm

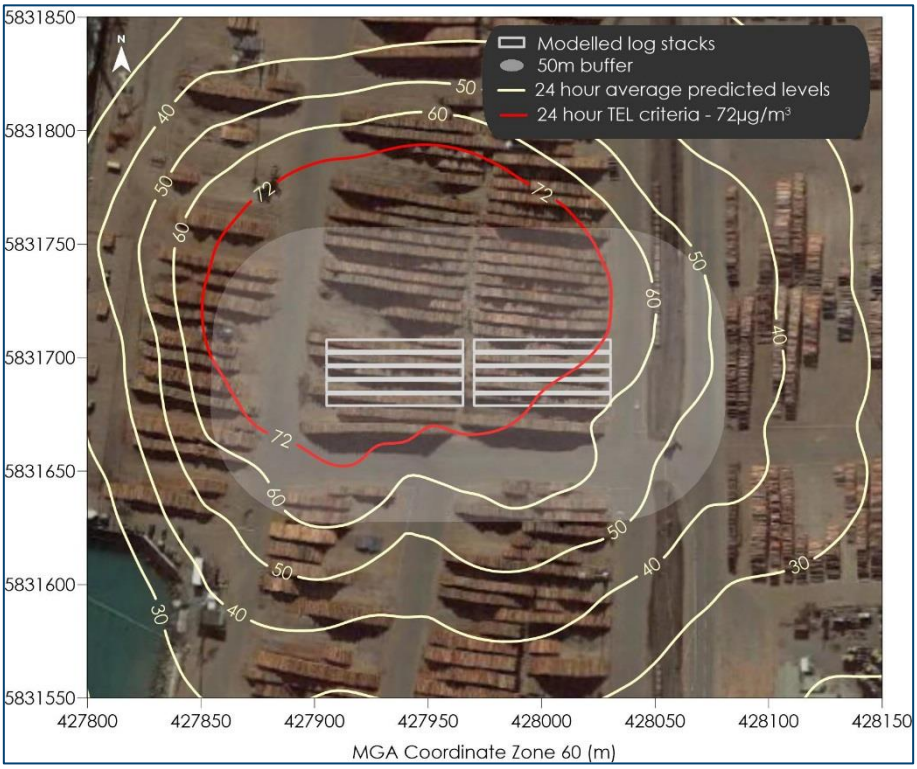


Figure B-28: Maximum predicted EDN concentrations (µg/m³) – Ten log stacks scenario, 24-hour averages, 500ppm

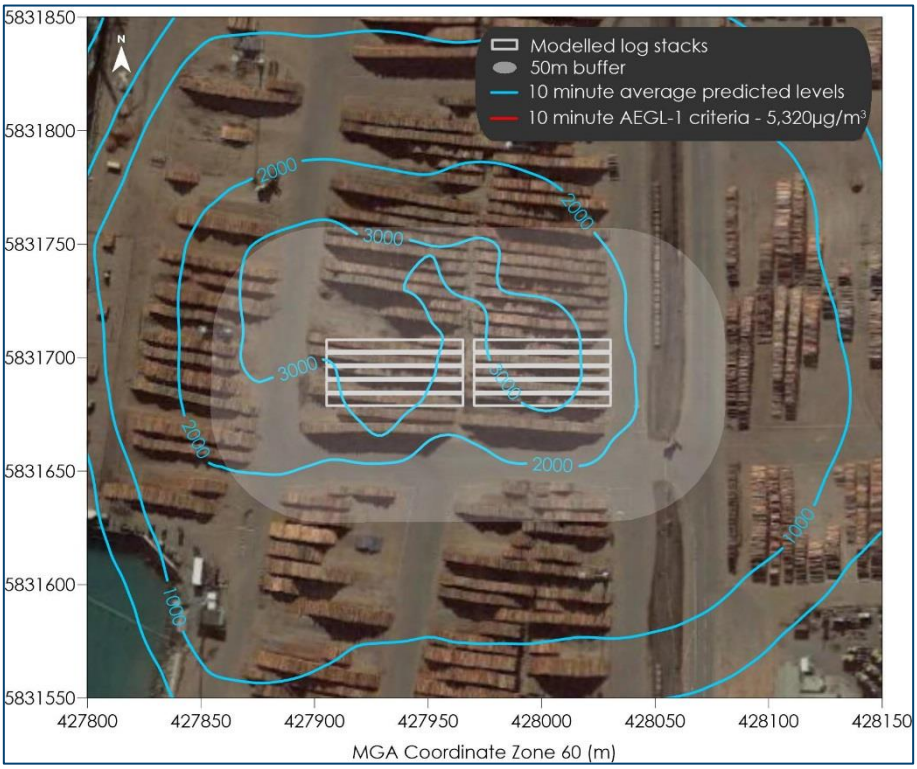


Figure B-29: Maximum predicted EDN concentrations (µg/m³) - Ten log stacks scenario, 10-minute averages, 700ppm

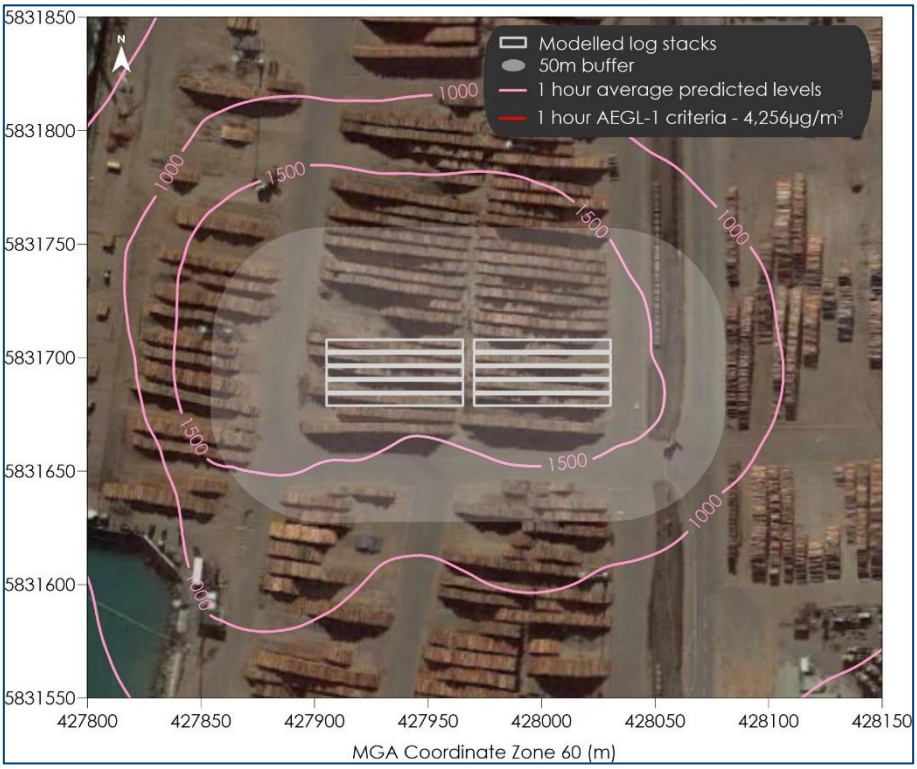


Figure B-30: Maximum predicted EDN concentrations (µg/m³) - Ten log stacks scenario, 1-hour averages, 700ppm

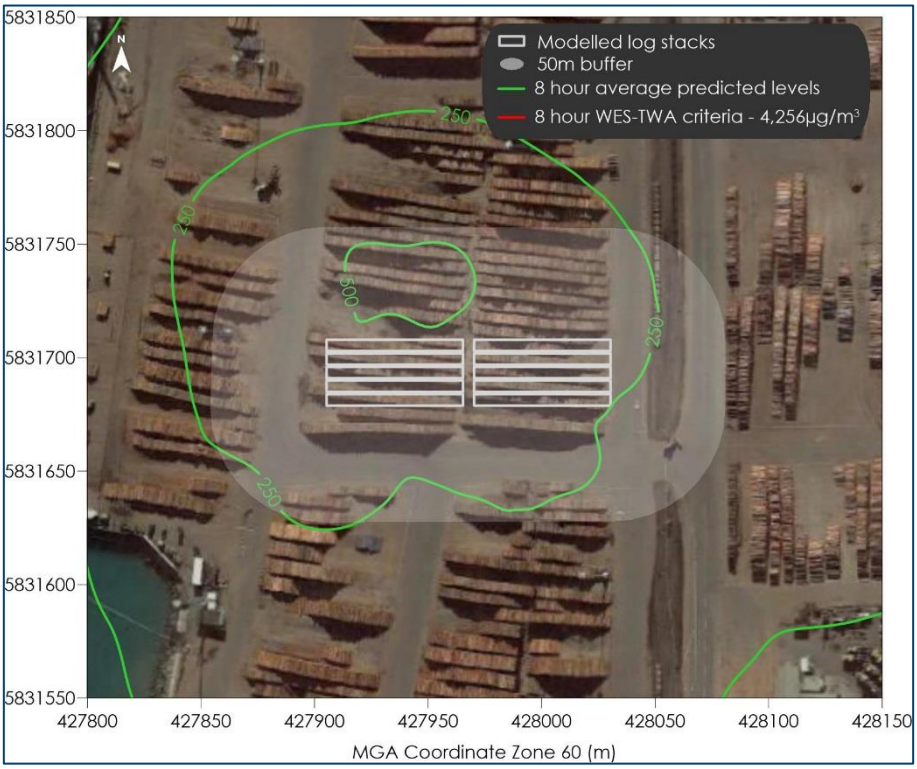


Figure B-31: Maximum predicted EDN concentrations (µg/m³) - Ten log stacks scenario, 8-hour averages, 700ppm

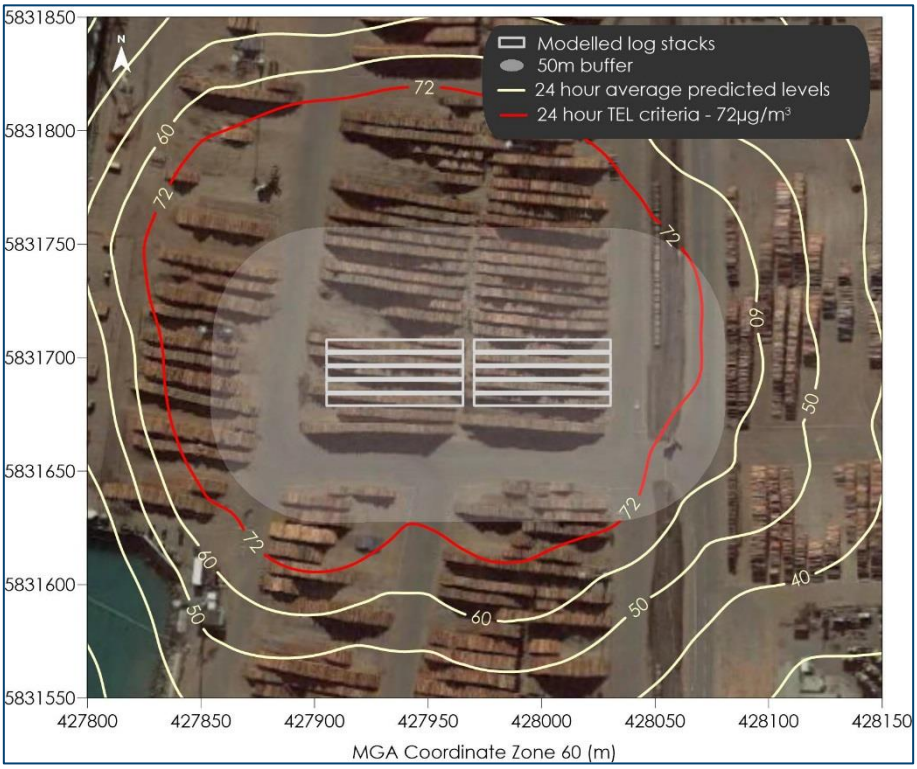


Figure B-32: Maximum predicted EDN concentrations (µg/m³) - Ten log stacks scenario, 24-hour averages, 700ppm

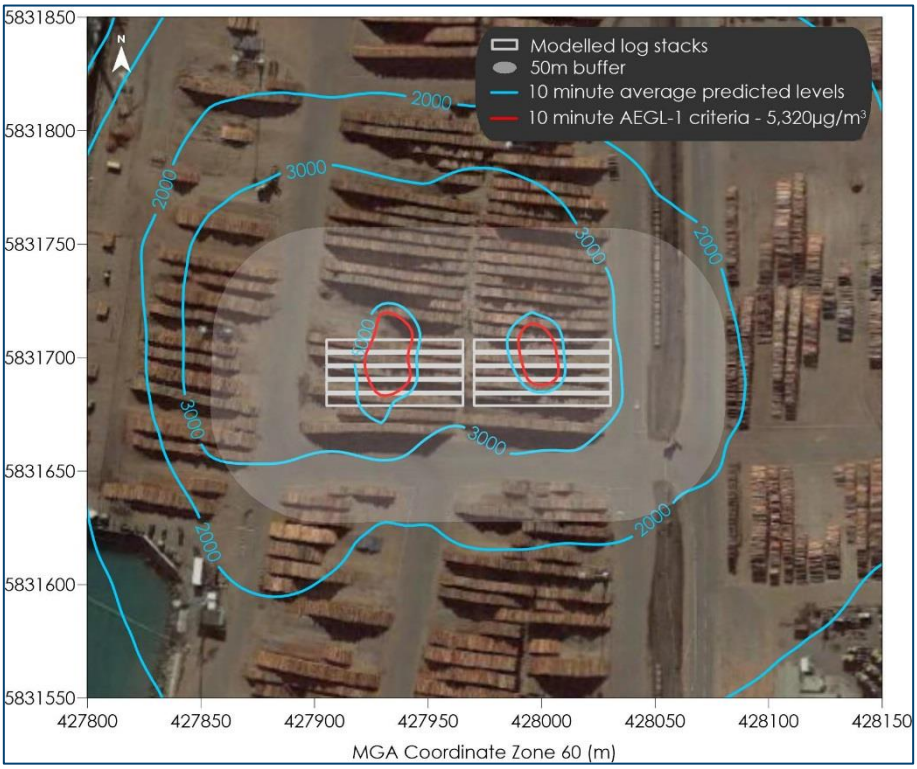


Figure B-33: Maximum predicted EDN concentrations (µg/m3) - Ten log stacks scenario, 10-minute averages, 1,000ppm

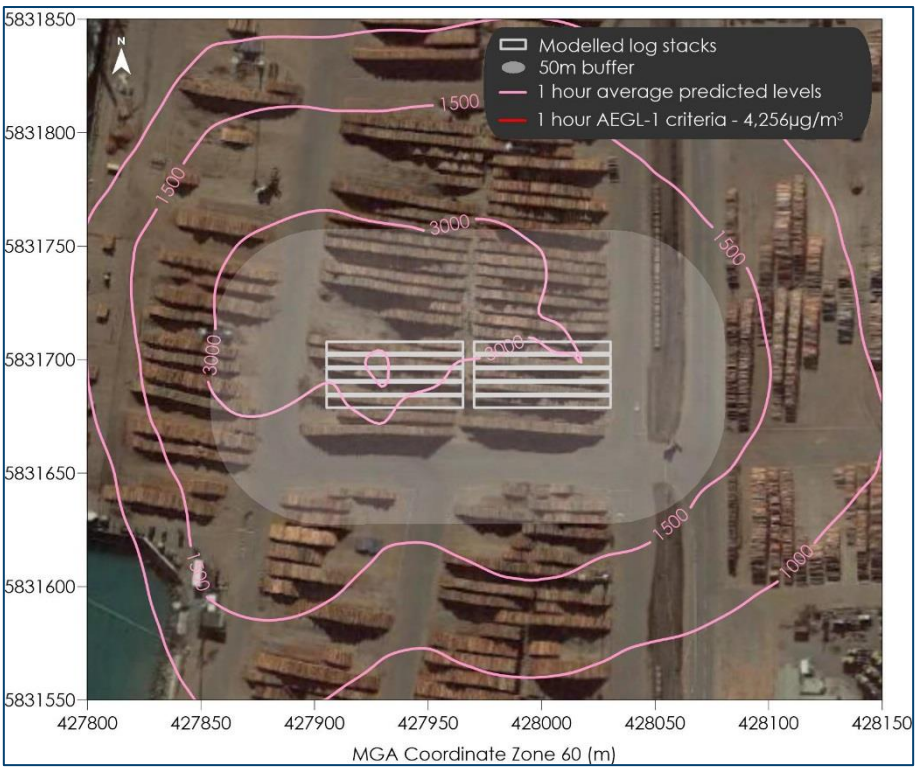


Figure B-34: Maximum predicted EDN concentrations (µg/m3) - Ten log stacks scenario, 1-hour averages, 1,000ppm

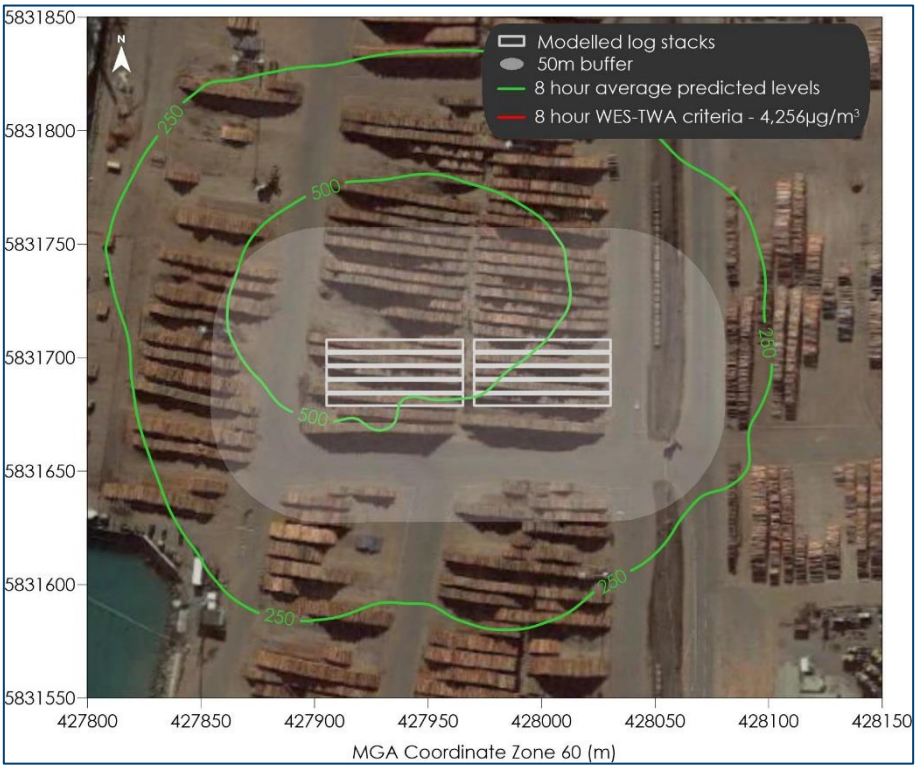


Figure B-35: Maximum predicted EDN concentrations (µg/m³) - Ten log stacks scenario, 8-hour averages, 1,000ppm

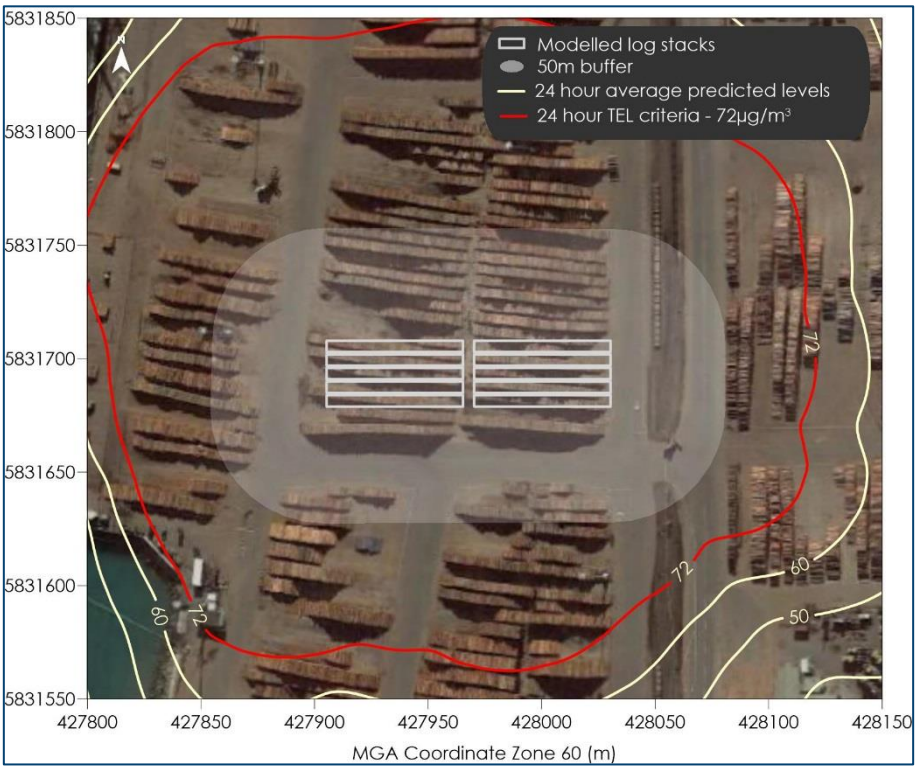


Figure B-36: Maximum predicted EDN concentrations (µg/m³) - Ten log stacks scenario, 24-hour averages, 1,000ppm

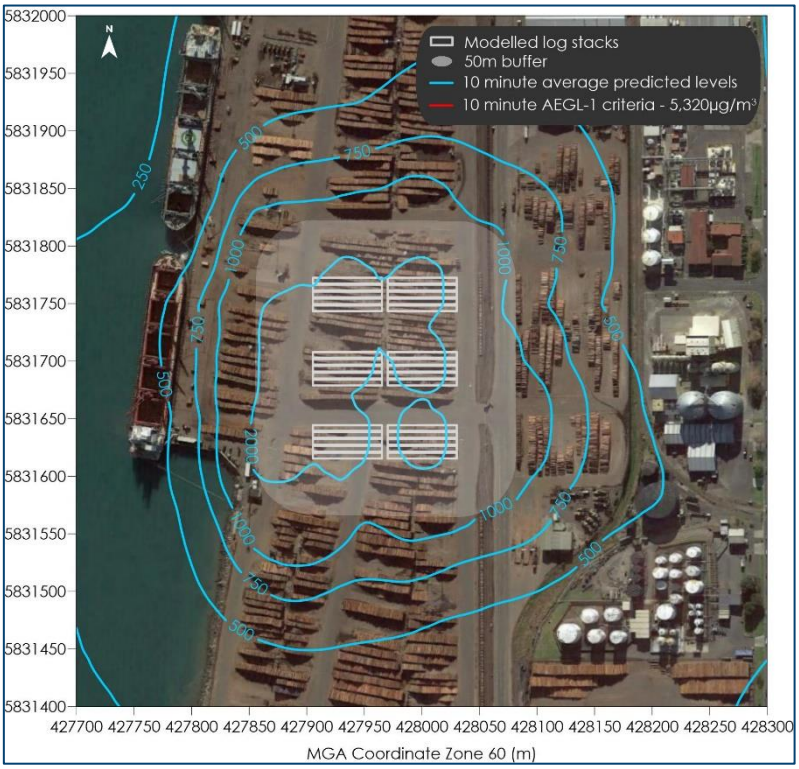


Figure B-37: Maximum predicted EDN concentrations (µg/m³) – Thirty log stacks (over an 8.5-hour period) scenario, 10-minute averages, 500ppm

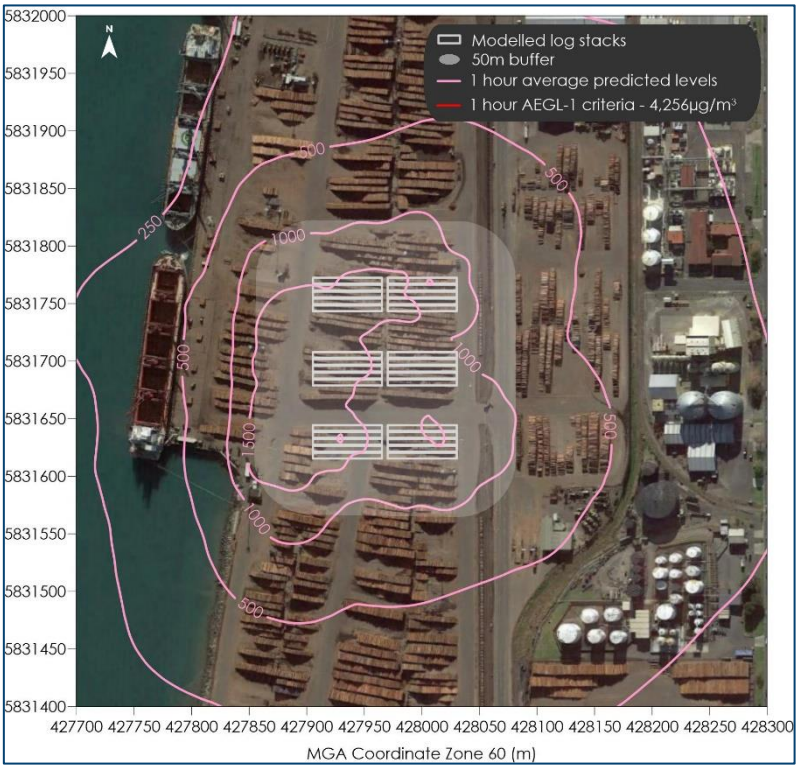


Figure B-38: Maximum predicted EDN concentrations (µg/m³) – Thirty log stacks (over an 8.5-hour period) scenario, 1-hour averages, 500ppm

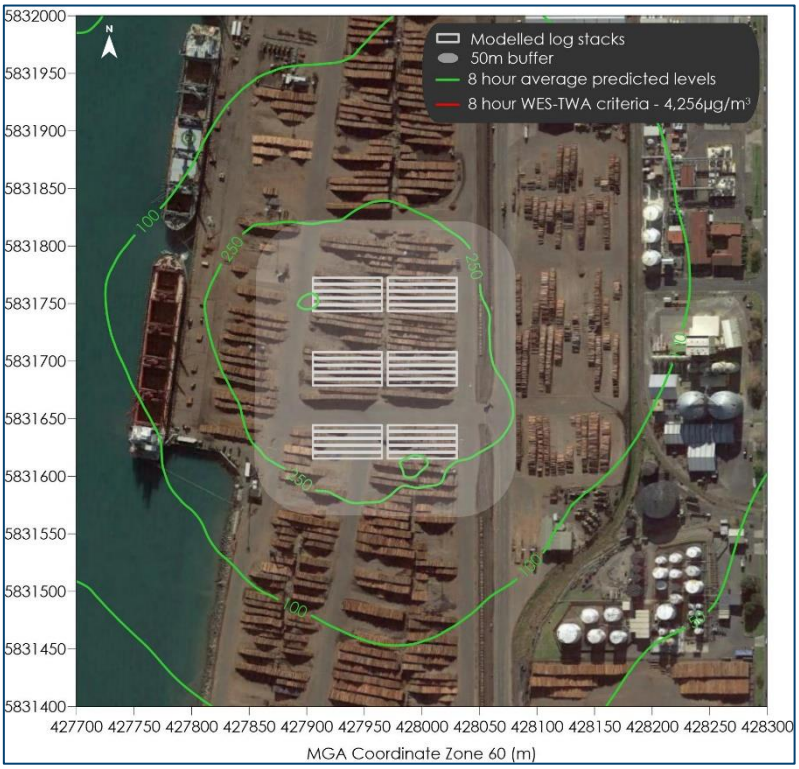


Figure B-39: Maximum predicted EDN concentrations (µg/m³) – Thirty log stacks (over an 8.5-hour period) scenario, 8-hour averages, 500ppm

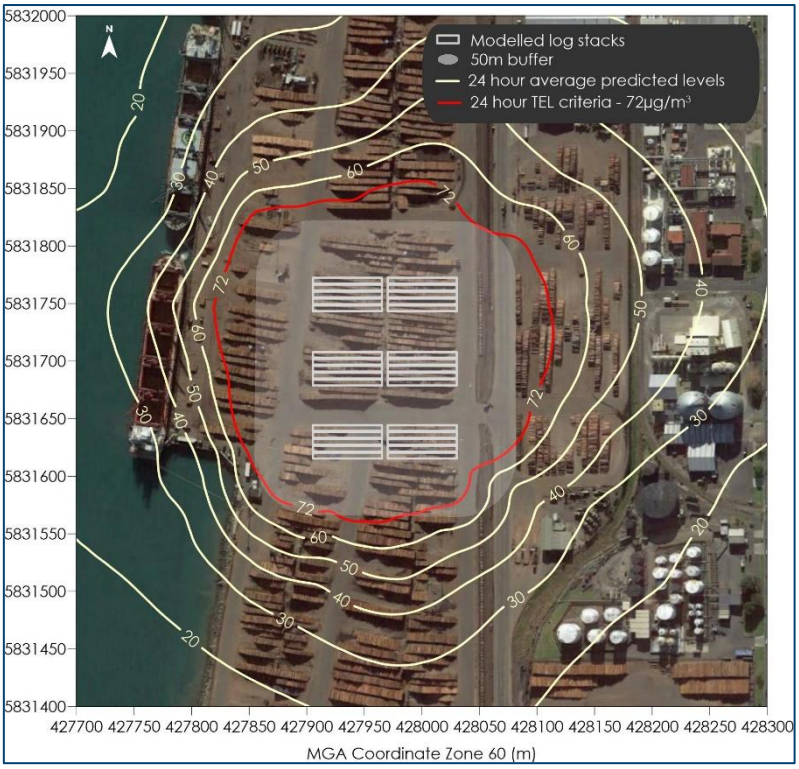


Figure B-40: Maximum predicted EDN concentrations (µg/m³) – Thirty log stacks (over an 8.5-hour period) scenario, 24-hour averages, 500ppm

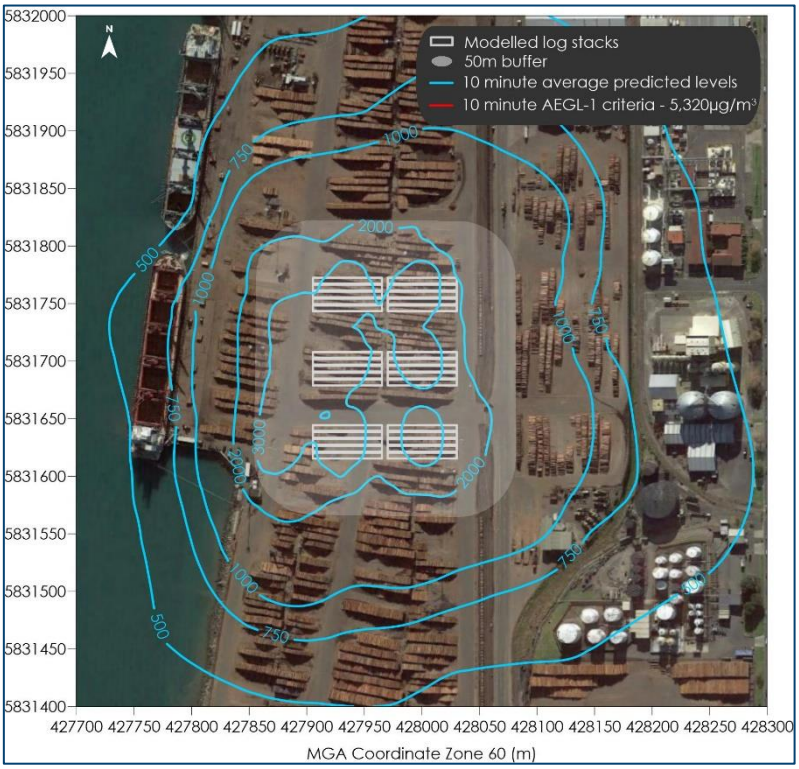


Figure B-41: Maximum predicted EDN concentrations (µg/m³) - Thirty log stacks (over an 8.5-hour period) scenario, 10-minute averages, 700ppm

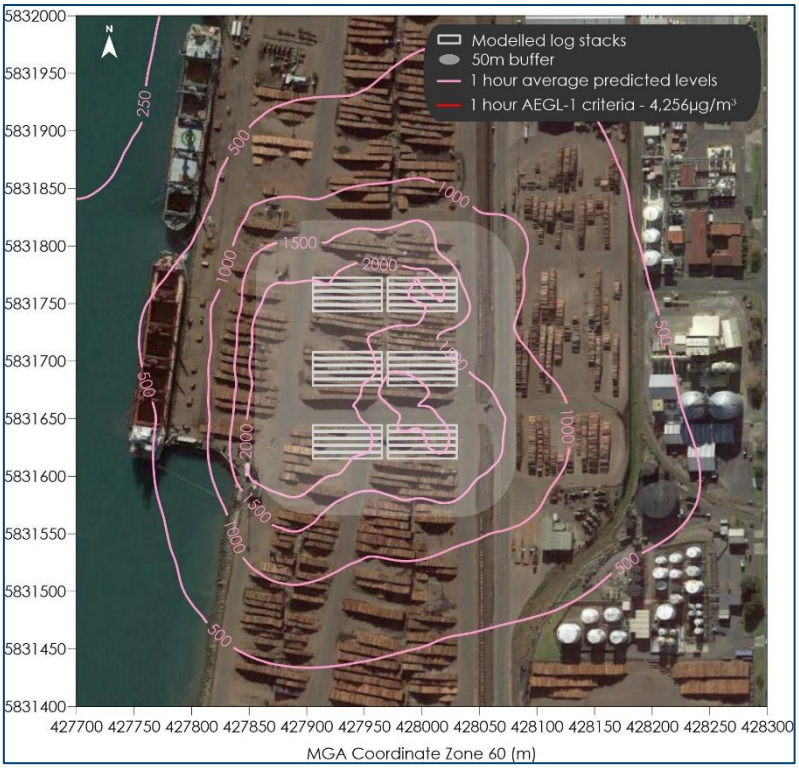


Figure B-42: Maximum predicted EDN concentrations (µg/m³) - Thirty log stacks (over an 8.5-hour period) scenario, 1-hour averages, 700ppm

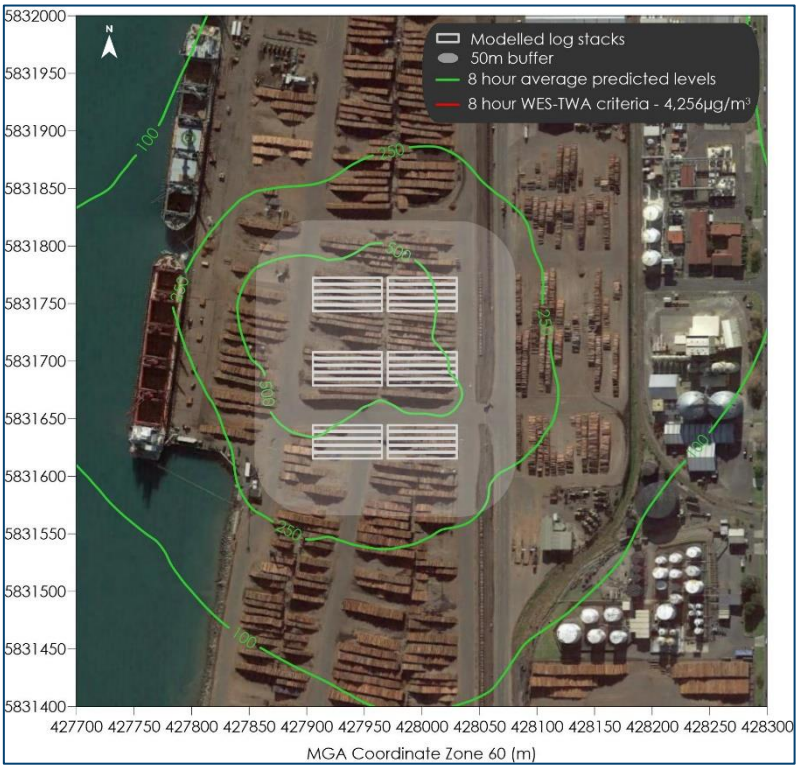


Figure B-43: Maximum predicted EDN concentrations (µg/m³) - Thirty log stacks (over an 8.5-hour period) scenario, 8-hour averages, 700ppm

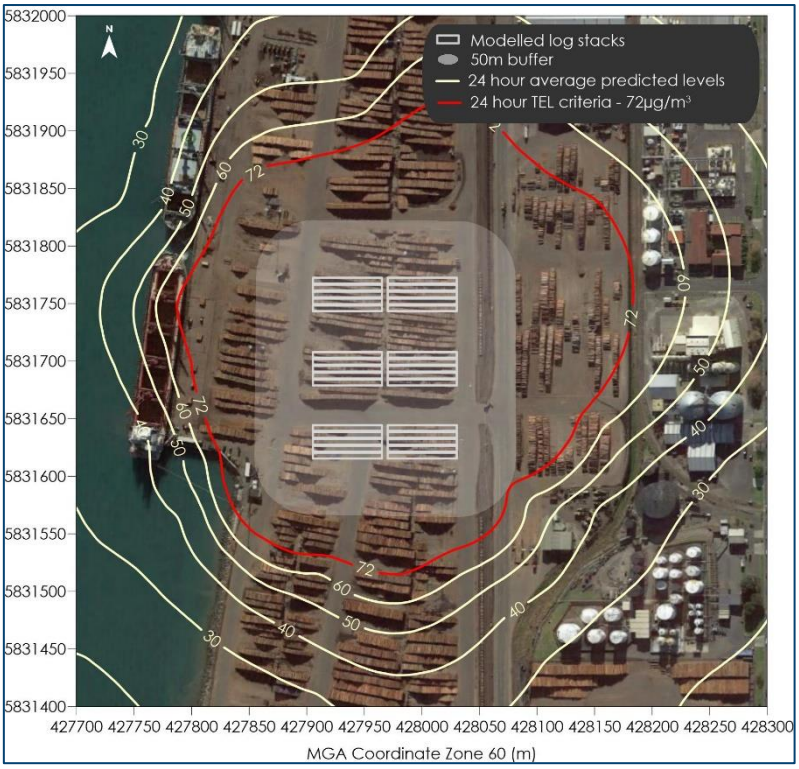


Figure B-44: Maximum predicted EDN concentrations (µg/m³) - Thirty log stacks (over an 8.5-hour period) scenario, 24-hour averages, 700ppm

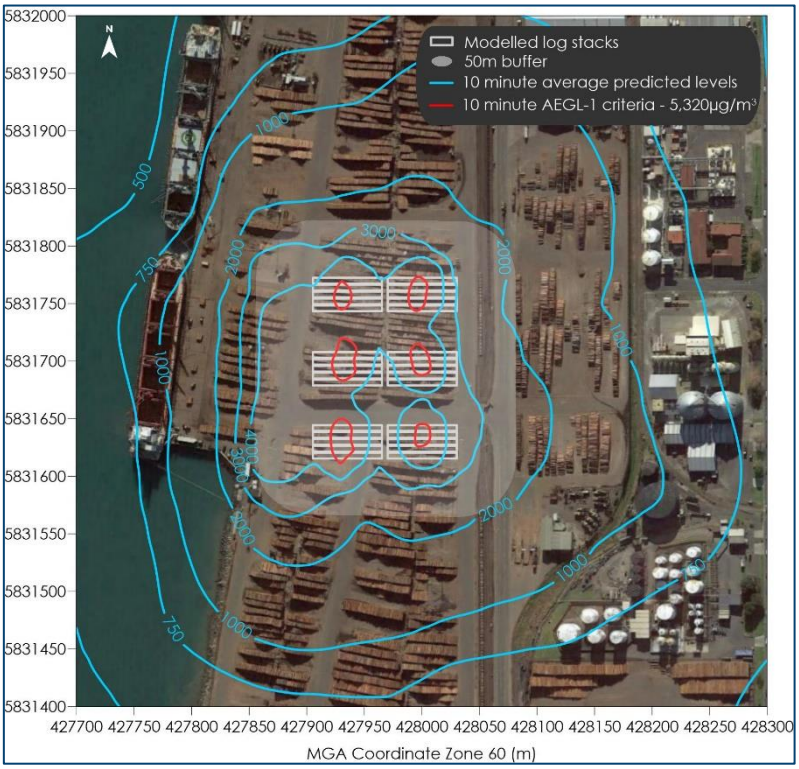


Figure B-45: Maximum predicted EDN concentrations (µg/m³) - Thirty log stacks (over an 8.5-hour period) scenario, 10-minute averages, 1,000ppm

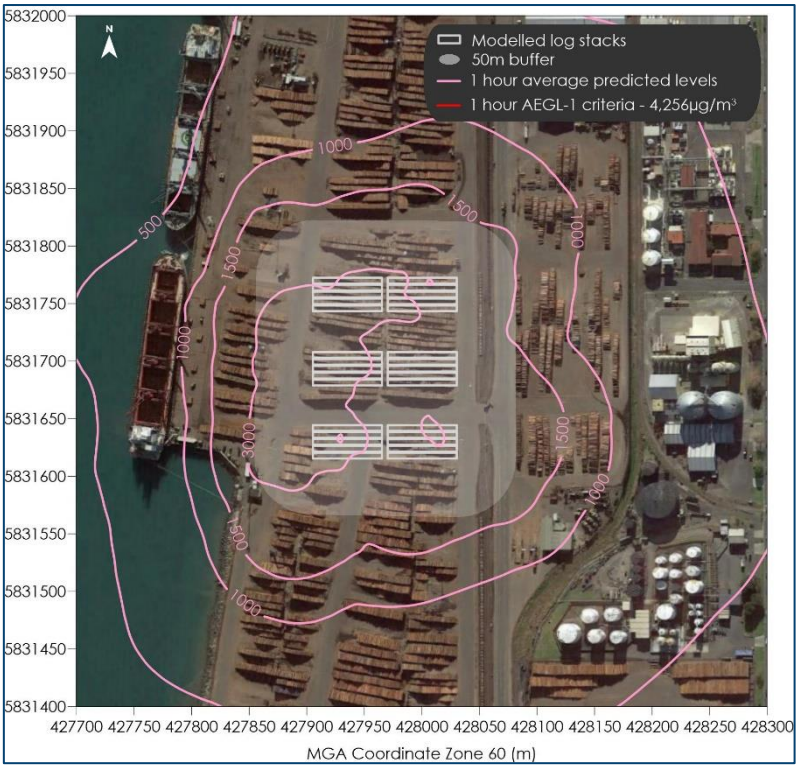


Figure B-46: Maximum predicted EDN concentrations (µg/m³) - Thirty log stacks (over an 8.5-hour period) scenario, 1-hour averages, 1,000ppm

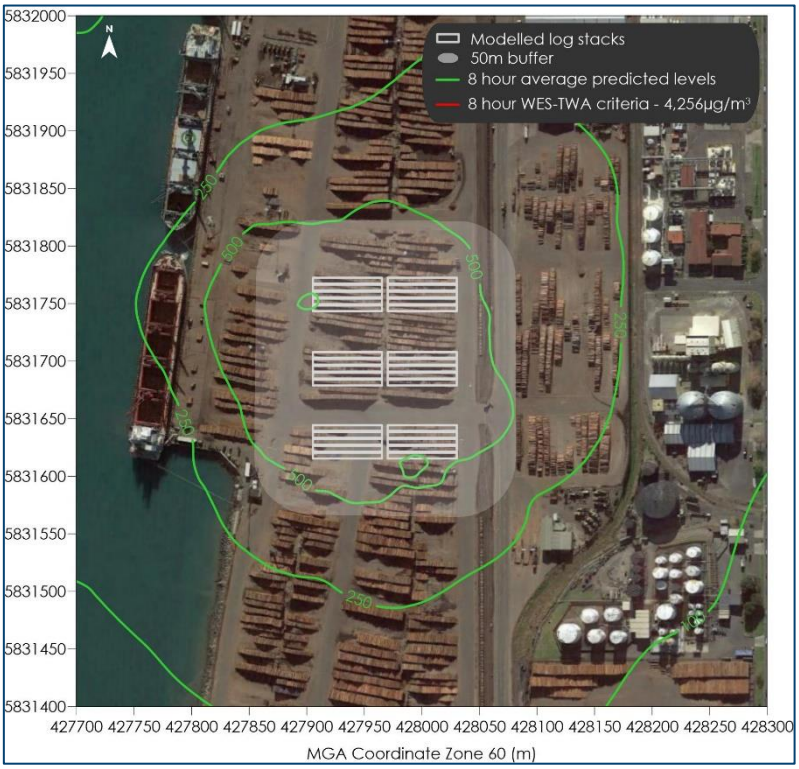


Figure B-47: Maximum predicted EDN concentrations (µg/m³) - Thirty log stacks (over an 8.5-hour period) scenario, 8-hour averages, 1,000ppm

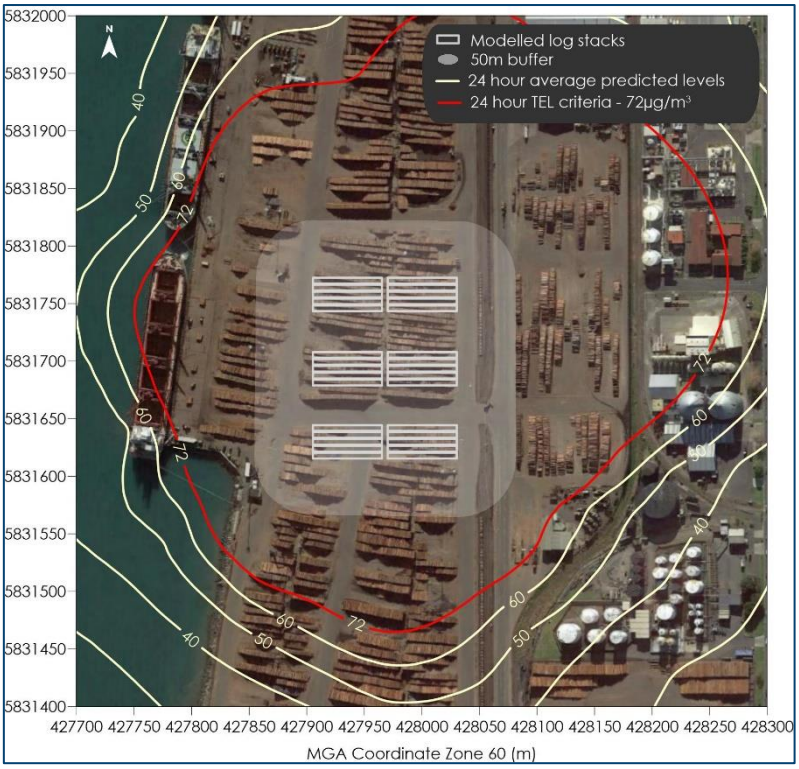


Figure B-48: Maximum predicted EDN concentrations (µg/m³) - Thirty log stacks (over an 8.5-hour period) scenario, 24-hour averages, 1,000ppm

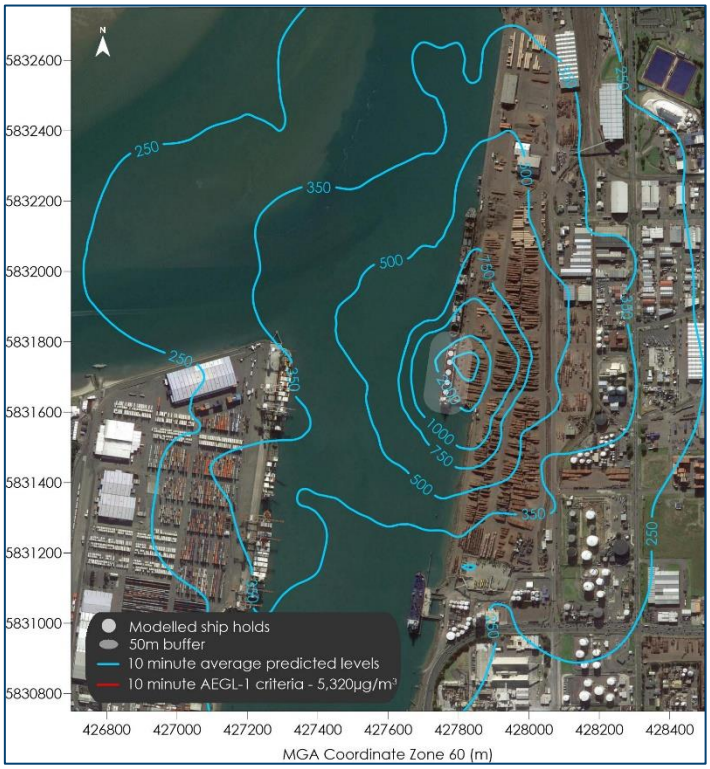


Figure B-49: Maximum predicted EDN concentrations (µg/m³) – Ship holds, 10-minute averages, 500ppm

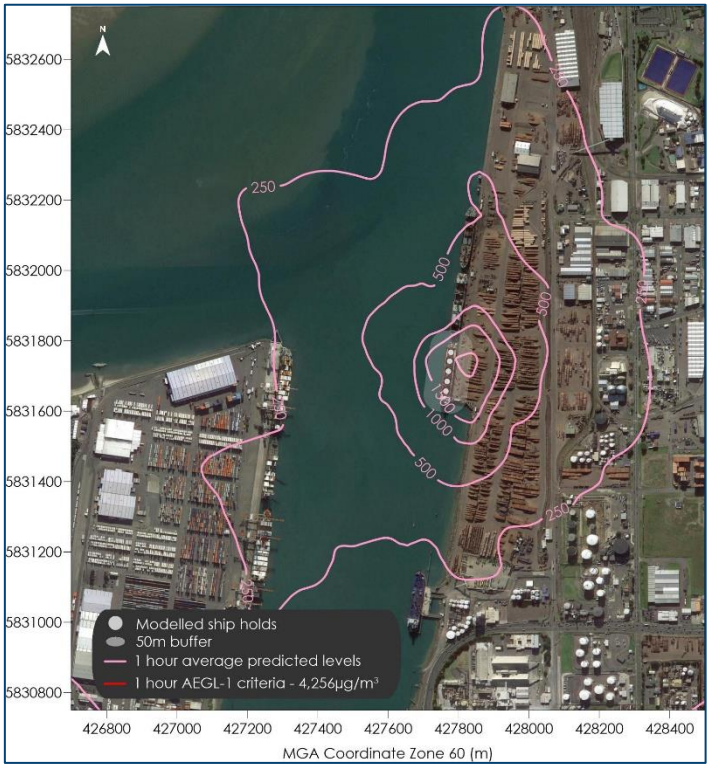


Figure B-50: Maximum predicted EDN concentrations (µg/m³) – Ship holds, 1-hour averages, 500ppm

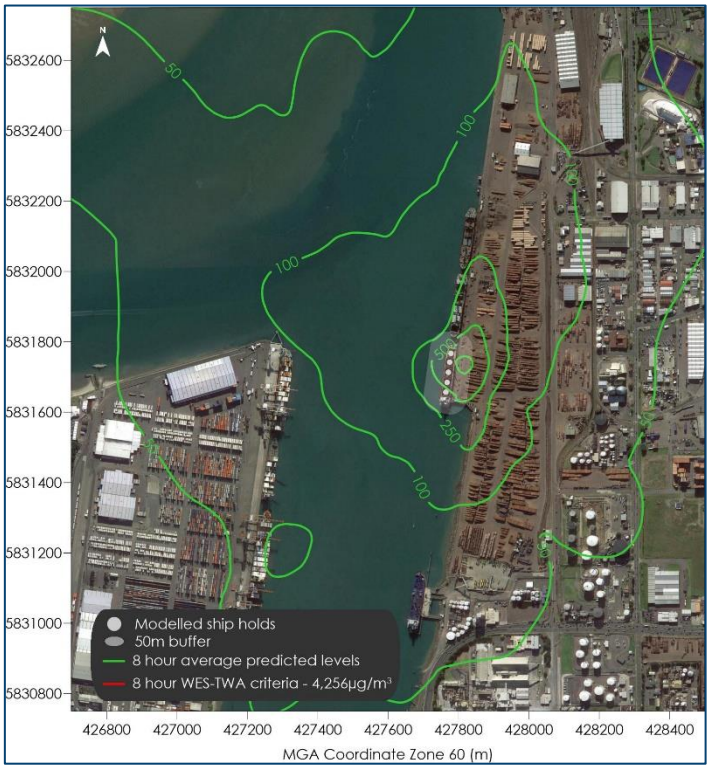


Figure B-51: Maximum predicted EDN concentrations (µg/m³) – Ship holds, 8-hour averages, 500ppm

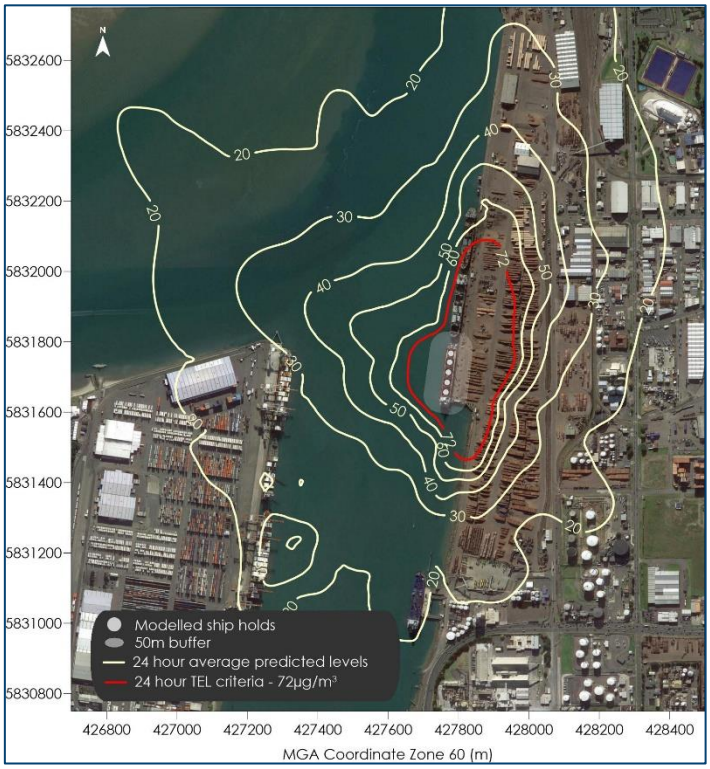


Figure B-52: Maximum predicted EDN concentrations (µg/m³) – Ship holds, 24-hour averages, 500ppm

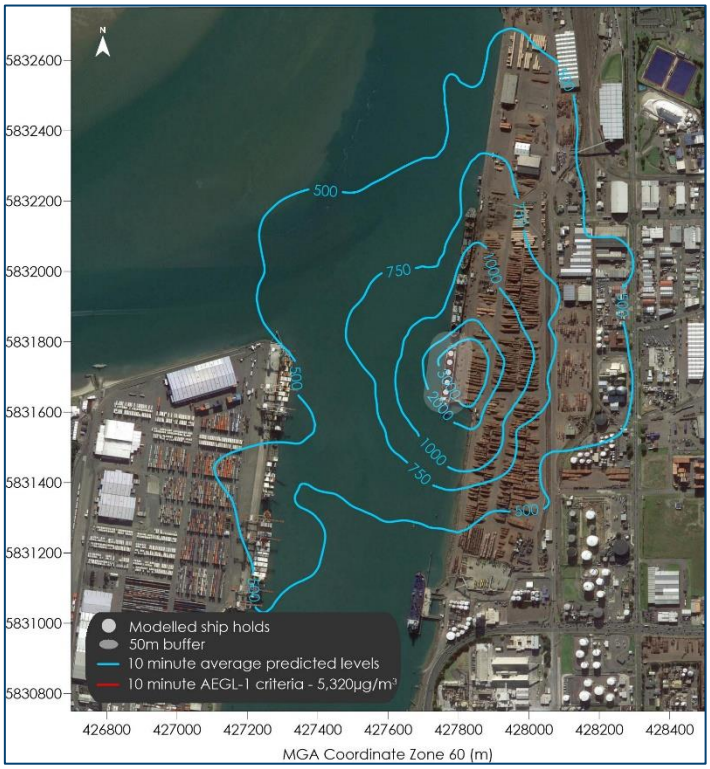


Figure B-53: Maximum predicted EDN concentrations (µg/m³) - Ship holds, 10-minute averages, 700ppm

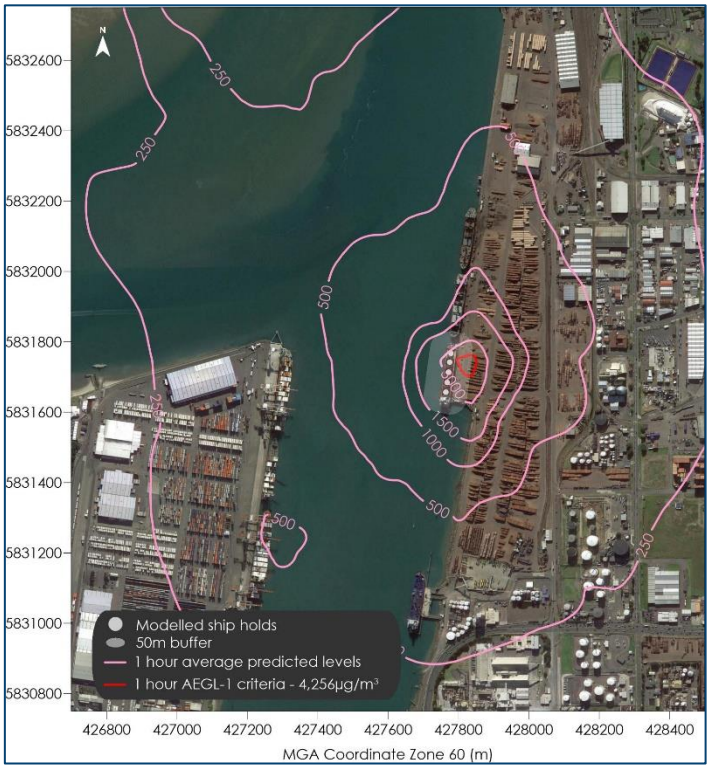


Figure B-54: Maximum predicted EDN concentrations (µg/m³) - Ship holds, 1-hour averages, 700ppm

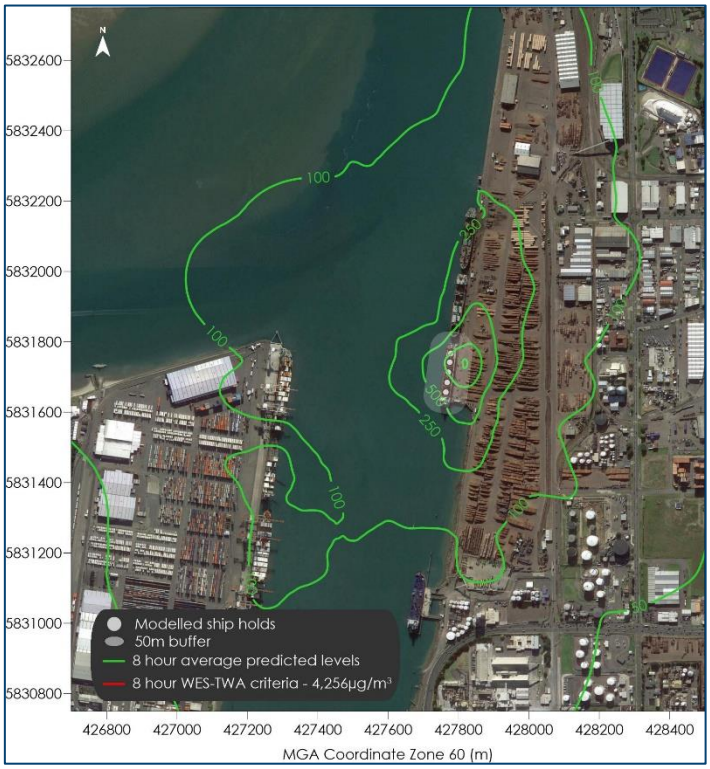


Figure B-55: Maximum predicted EDN concentrations (µg/m³) - Ship holds, 8-hour averages, 700ppm

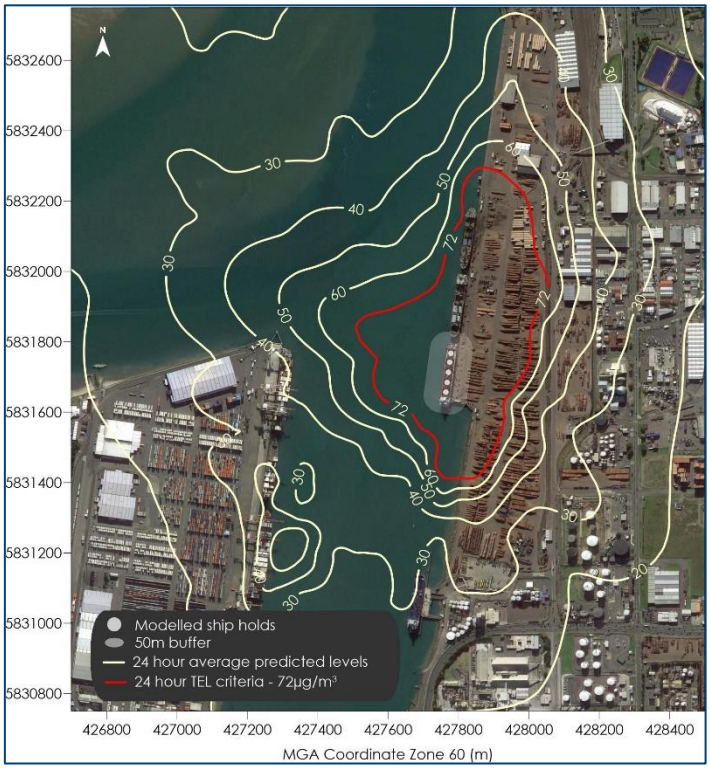


Figure B-56: Maximum predicted EDN concentrations (µg/m³) - Ship holds, 24-hour averages, 700ppm

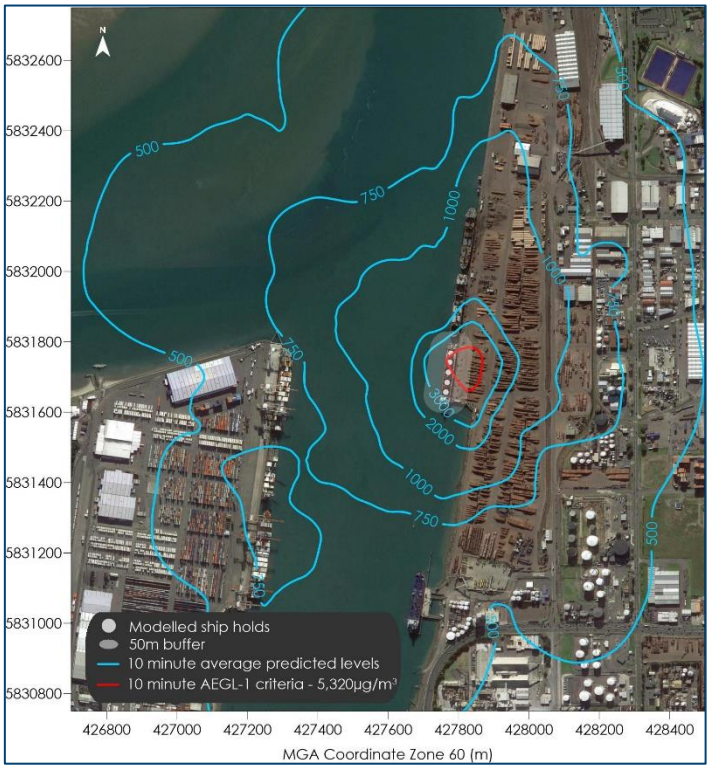


Figure B-57: Maximum predicted EDN concentrations (µg/m³) - Ship holds, 10-minute averages, 1,000ppm

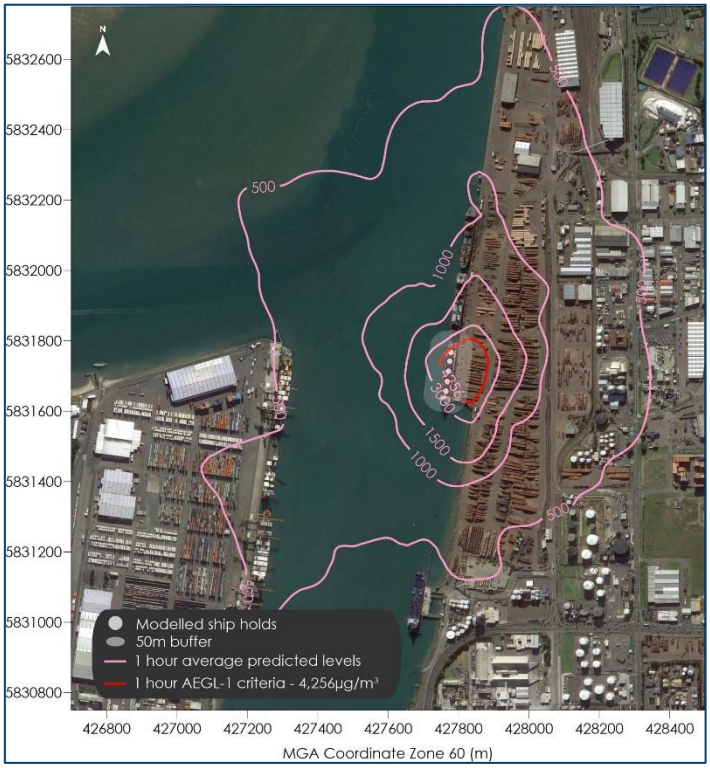


Figure B-58: Maximum predicted EDN concentrations (µg/m³) - Ship holds, 1-hour averages, 1,000ppm

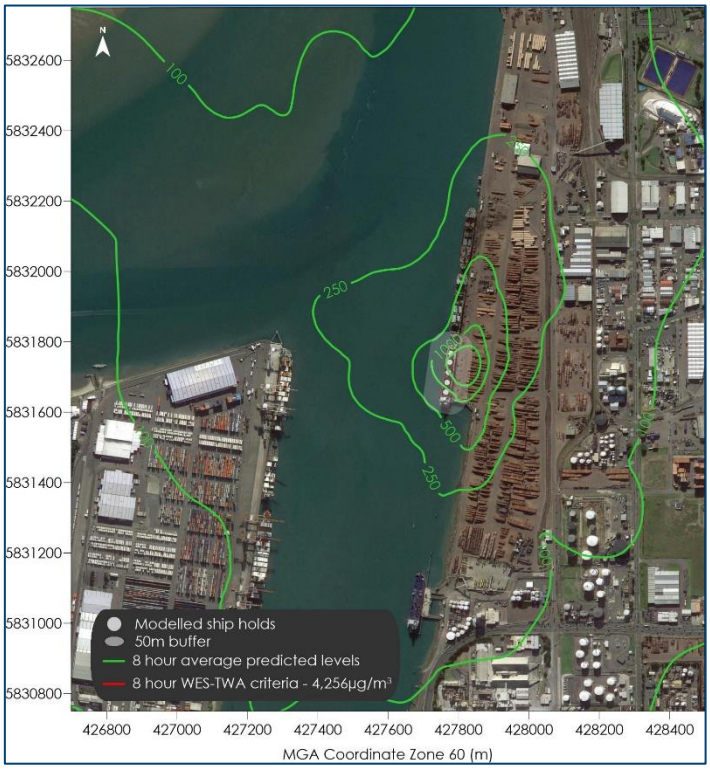


Figure B-59: Maximum predicted EDN concentrations (µg/m³) - Ship holds, 8-hour averages, 1,000ppm

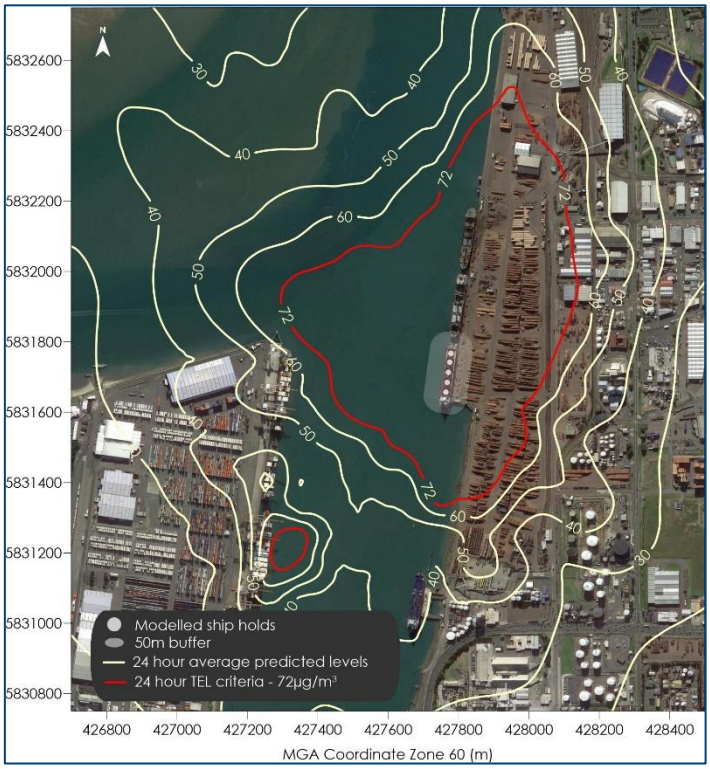


Figure B-60: Maximum predicted EDN concentrations (µg/m³) - Ship holds, 24-hour averages, 1,000ppm