REPORT

Air Quality Impact Assessment

Proposed Industrial Development

Submitted to:

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Abbreviation Table

Acronym	Description
CDP	Comprehensive development plan
USEPA	United States Environmental Protection Agency
RCS	Respirable crystalline silica
MW	Megawatt
T	Tonne
PHA	Polyhydroxy-alkenoates
PLA	Polylactic acid
VKT	Vehicle kilometre travelled
ADT	Annual daily traffic
VEPM	Vehicle emission prediction model
EPA	Environmental protection authority
MoT	Ministry of Transport
BFB	Biomass fired boiler
NES	National Environmental Standard
AAQG	Ambient Air Quality Guidelines
MfE	Ministry for the Environment
MoH	Ministry of Health
WHO	World Health Organization
GLC	Ground level concentration
ACS	American Cancer Society

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1.0 INTRODUCTION

This report[1] provides an assessment of potential air quality impacts within the vicinity of a proposed, approximately sixty-two-hectare industrial zone, which would be located at the southeast fringe of Marton, Rangitikei District of Manawatu-Whanganui. The assessment has a primary focus on ambient respirable particulate (i.e., PM_{10} and $PM_{2.5}$) levels, as well as the potential for odour and construction dust effects. To enable the development, a plan change is being sought by the Rangitikei District Council to rezone land from rural to industrial under its District Plan. A Comprehensive Development Plan (CDP) for the entire industrial area is a prerequisite to any future industrial activities obtaining resource consent. The CDP site is known as the "Marton Rail Hub".

Cumulative and incremental levels of ambient PM_{10} and $PM_{2.5}$ are assessed at Fraser Auret Racing, Marton, and at the nearest two residential dwellings due to the Marton Rail Hub being established and the proposed industrial activities are all operational. Fraser Auret Racing is a privately owned horse training facility located to the north of the proposed CDP, whose owners have appealed the proposed District Plan change.

For potential dust generation during the CDP's construction phase, and future odour sources within the CDP site, the risk of adverse effects upon surrounding neighbours is assessed as well as the ability to mitigate these risks to a level which is minor, or less.

This report, in the event that the rule framework set out in the Commissioners decision on the proposed Plan Change is confirmed but applied to the development area now proposed, will then inform the parties to the appeal of the expected level of air quality effects from the zoning of that land to industrial by assessing a scenario of industrial activities and the proposed CDP that is required to be submitted for resource consent approval.

The ambient PM_{10} and $PM_{2.5}$ assessment was based on the modelling of air quality impacts resulting from estimated CDP related respirable particulate emissions and combining these with existing background levels. Existing ambient background levels of PM_{10} and $PM_{2.5}$ are due to natural and anthropogenic sources, and these typically occur at levels which are a significant portion of human health-based criteria. These existing background levels, and those for other common pollutants, have been previously established for the Fraser Auret Racing location at Marton by Golder (2021) [2]. These reported background levels would also be representative of existing air quality experienced at isolated rural residential dwellings, which surround the proposed CDP site.

The establishment of a reliable inventory of respirable particulate emissions, due to activities within the CDP, was an essential input to the modelling-based assessment. These were established using available emission factor equations for combustion exhaust, and/or stoichiometric calculations and vehicle generated dust emissions. Activities for which emissions were established included train movements at the railway siding, truck and loader movements, log debarking, pet food production and a realistic worst-case scenario for the combustion of biomass to produce thermal energy and electricity. Note that the proposed bioplastics manufacturing plants within the CDP are expected to discharge minimal respirable particulate to atmosphere.

The operational CDP site will also emit other air quality contaminants such as, nitrogen dioxide, carbon monoxide and sulphur dioxide due to combustion of biomass and diesel fuel. However, the increase in the ambient levels of these and other air contaminants will have far less potential to cause any adverse health effects compared to respirable particulate emissions. Therefore, cumulative ambient exposure levels of PM_{10}

[1] This report is subject to the limitations detailed in Appendix A.

[2] Golder 2021. Marton Proposed Industrial Development – Baseline Air Quality Assessment. Submitted to Rangitikei District Council. May 2021. Golder report reference number: 21464670-002-R-Rev0.

and $PM_{2.5}$ are the primary focus of this assessment. By comparison, other air contaminants associated with biomass/diesel combustion and dust erosion, have a much lower potential to cause any material air quality impacts. With respect to the two respirable particulate size fractions, the exposure to increased ambient levels of $PM_{2.5}$ has the greatest potential for causing any ill-health effects in humans or animals.

For construction dust and future odour discharges, the potential ambient levels were not predicted. Instead, we assessed the risk of significant adverse effects (based on site activities and off-site sensitive receptor locations) and ability to mitigate these effects to minor levels, when employing standard mitigation technologies.

2.0 METHODOLOGY

2.1 General

2.1.1 Respirable particulate

The potential increase in ambient particulate levels was assessed using a standard source emissions estimation and atmospheric dispersion modelling process for all the main combustion sources and dust generating activities during the operational phase.

2.1.2 Odour

For the assessment of potential odour effects from the CDP site the meteorological data reported by Golder (2021) was used to estimate the frequency that off-site sensitive receptor locations would be downwind of the key odour source (the proposed food producer). A similar but smaller scale plant is currently operated in Marton. This site was visited in July 2021 by Golder air quality staff to enable existing processing to be observed and off-site odour character and intensity to be observed. Combined with wind pattern information and location of nearest residential dwellings, the risk of significant odour effects was established as well as an assessment of potential for standard odour abatement control technologies to ensure no objectionable or offensive odour effects.

Golder also investigated the potential for the bioplastics manufacturing plants to discharge odour and also assess the potential for standard odour abatement control technologies to ensure no objectionable or offensive odour effects. General information about the bioplastic manufacturing process, the nature and scale of processes, and experiences from an existing site in San Francisco, USA was obtained from a meeting with a director of Plentyful Limited[3]. At this meeting, a PowerPoint presentation showing the general process flows and process stages was presented.

2.1.3 Construction dust

For the assessment of the potential for nuisance and health effects from construction dust when the CDP site is developed was undertaken using the UK Institute of Air Quality Management's (IAQM) risk assessment methodology[4] for the assessment of dust from demolition and construction. This document is recommended by the MfE's good practice guide for dust management[5]. We also utilised relevant sections of the IAQM's risk assessment guide for mineral dust impacts for planning[6]. While this guide is targeted to the aggregate quarrying industry, the aspects relating to on-site and off-site transportation, site preparation, and stockpiles

[3] Plentyful Limited. The organisation which is proposing the installation and operation of a 20 Tonne/day bioplastics manufacturing plant within the proposed for the CDP site.

[4] IAQM 2014. Guidance on the Assessment of Dust from Demolition and Construction, Version 1.1 (Institute of Air Quality Management, 2014). www.iaqm.co.uk

[5] MfE 2016. Good Practice Guide for Assessing and Managing Dust. Wellington: Ministry for the Environment.

[6] IAQM 2016. Guidance on the Assessment of Minerals Dust Impacts for Planning, Version 1.1 (Institute of Air Quality Management, 2016). www.iaqm.co.uk

was considered useful and appropriate for this assessment. This guide also makes use of site-specific wind patterns which the IAQM's guide for demolition and construction dust assessments does not utilise.

2.2 Particulate Emissions Modelling

2.2.1 Overview

Particulate emissions were established for combustion and crustal sources based on realistic worst-case activity rates and/or capacity for the rail siding, log debarking, energy production and truck/loader movements. These activities produced either stack (point source), line and volume sources of PM_{10} and $PM_{2.5}$ discharge to air. Having quantified the emission rates for all activities and source parameters, the CALPUFF/CALMET modelling system was used to predict incremental ambient PM_{10} and $PM_{2.5}$ concentrations. These included both the increments of 24-hour and annual PM_{10} and $PM_{2.5}$ concentration impacts at offsite sensitive receptor locations due to the CDP and the associated fractions of diesel particulate matter (DPM) and crustal based particulate.

The cumulative ambient concentrations of PM_{10} and $PM_{2.5}$ were established using the modelled incremental offsite ambient concentrations of these size fractions (as a result of activities within the CDP), and then combining these values with existing background ambient PM_{10} and $PM_{2.5}$ levels, which Golder established previously for the area[2].

The development of realistic worst-case contaminant emission rates assumptions for the CDP activities is detailed in Appendix B and summarised in Section 5.2.

2.2.2 Diesel powered vehicles/trains and onsite machinery

US EPA and other credible sources of emission factors were used to establish DPM emission rates (broken down into PM_{10} and $PM_{2.5}$) from diesel powered trucks, trains and onsite loading equipment. The type of vehicles/trains/machinery, rated power and distance travel assumptions, which are applied to emission factors, are detailed in Section 5.2.

We note that there would be emissions associated with forklift and truck movements within each industrial site. However, compared the main truck and loader movements which are accounted for in the assessment, these would be relatively minor. Furthermore, the conservatism allowed for via the assumed truck arrival/departure movements per day, would adequately account for the small contributions (due to vehicle movements at the individual sites within the CDP) to the total site wide emission of particulate to atmosphere.

2.2.3 Biomass fired energy plant

For onsite biomass fired boilers, the use of full bag-house filter treatment was assumed, and that this system would readily achieve a maximum in-stack PM_{10} discharge concentration of 30 mg/Nm^3 at 12 vol. % CO_2 and dry basis.

Exhaust air flows were established using combustion stoichiometric calculations. This required compositional information for wood including calorific value (MJ/kg) as a function of moisture content, carbon, nitrogen, oxygen, hydrogen, sulphur (CNOHS), and ash content, combined with the assumption of discharge exhaust residual oxygen levels of 7.0 vol. % dry basis.

Fuel consumption for the boilers is based on our assessment of worst case thermal (20 MW combustion) for the pet food plant and electrical/steam energy generation (50 MW combustion side) demand for the CDP.

2.2.4 Crustal dust

Crustal dust derived PM_{10} and $PM_{2.5}$ emissions from surfaces were established using US EPA emission factors for wheel generated dust from onsite surfaces. This required an assessment of vehicle kilometres travelled (VKT) associated with machinery used to unload/load logs from and from trains and trucks, supply the log debarker, unload/load containers and truck arrival/departure movements on the CDP's main internal access roads.

Erosion of dust from bark and log stockpiles is expected to be minor compared to onsite truck/loader movements and the operation of the log debarker. Therefore, emissions from stockpiles were not included in the crustal particulate emission inventory.

2.3 Ambient Particulate Impact Modelling

Dispersion modelling was carried out using CALPUFF, version 7.2.1. This atmospheric dispersion model is used commonly in Australasia, Asia and North America to model air quality impacts due to industry, transport, mining and associated point source and fugitive emissions. The dispersion model utilises hourly 3-dimensional meteorological inputs developed using CALMET version 6.5. For this assessment the hourly, 3-dimensional meteorological data set was developed for the period January 2016 to December 2017.

Key inputs required by CALMET for creating hourly complex meteorology for the years 2016 and 2017 includes hourly vertical profiles of various meteorological parameters (e.g., wind speed, direction, temperature, etc.), which were developed using the prognostic meteorological model TAPM which uses synoptic atmospheric profiles published by CSIRO for the modelling period. CALMET also requires land use and terrain information, which was obtained from the LINZ database. Finally, surface-based hourly average measurements of wind speed, direction, temperature etc were also incorporated into the CALMET inputs. These hourly surface data for 2016 and 2017 were obtained from Ohakea Aero (supplied by MetService).

The details of the CALPUFF dispersion model set-up and the CALMET meteorological modelling are provided in Appendix B and Appendix C, respectively.

2.4 Assessment of Incremental Ambient Particulate

Both combustion (diesel and biomass) and crustal derived ambient particulate have subfractions of PM_{10} and $PM_{2.5}$, although combustion is mostly discharged within the finer respirable particulate size range. The potential health risk is assessed from the total concentrations (combustion + crustal) of PM_{10} and $PM_{2.5}$, predicted to result from the CDP. The concentration increases due to the CDP (and the breakdown into DMP and crustal components) combined with existing background concentrations are assessed at the location of horse training facility and nearest two residential dwelling.

The assessed cumulative concentrations (CDP + background) are compared to relevant human health-based ambient concentration criteria. If incremental impacts due to the CDP are very low against ambient criteria, then it is assumed that both horse and human health would not be subject to any significant increase in health risk. The cumulative concentrations can also be compared to health-based criteria to ascertain whether the cumulative effects are minor, or otherwise. Noting that existing background levels of respirable particulate can often be at more than minor levels within many urban areas of New Zealand.

3.0 ENVIRONMENTAL SETTING

3.1 General

Figure 1 below highlights the area of the proposed CDP (white shaded area). The horse training facility is located on the eastern fringe of Marton's urban area and approximately 1,000 m north of the CDP. The main trunk railway line from Wellington to Auckland runs along the west side of the CDP and into the southeastern area of Marton before swinging north eastwards up the Rangitikei River valley to Hunterville. Marton has a population of approximately 5,200 people based on 2018 New Zealand census.

Figure 2 provides the proposed layout of the CDP and locations of key activities, including railway siding, internal access road and industrial activities. This identifies around eight isolated rural residential dwellings surrounding the proposed CDP site.

Figure 1: Map of Marton and surrounding areas including the proposed CDP.

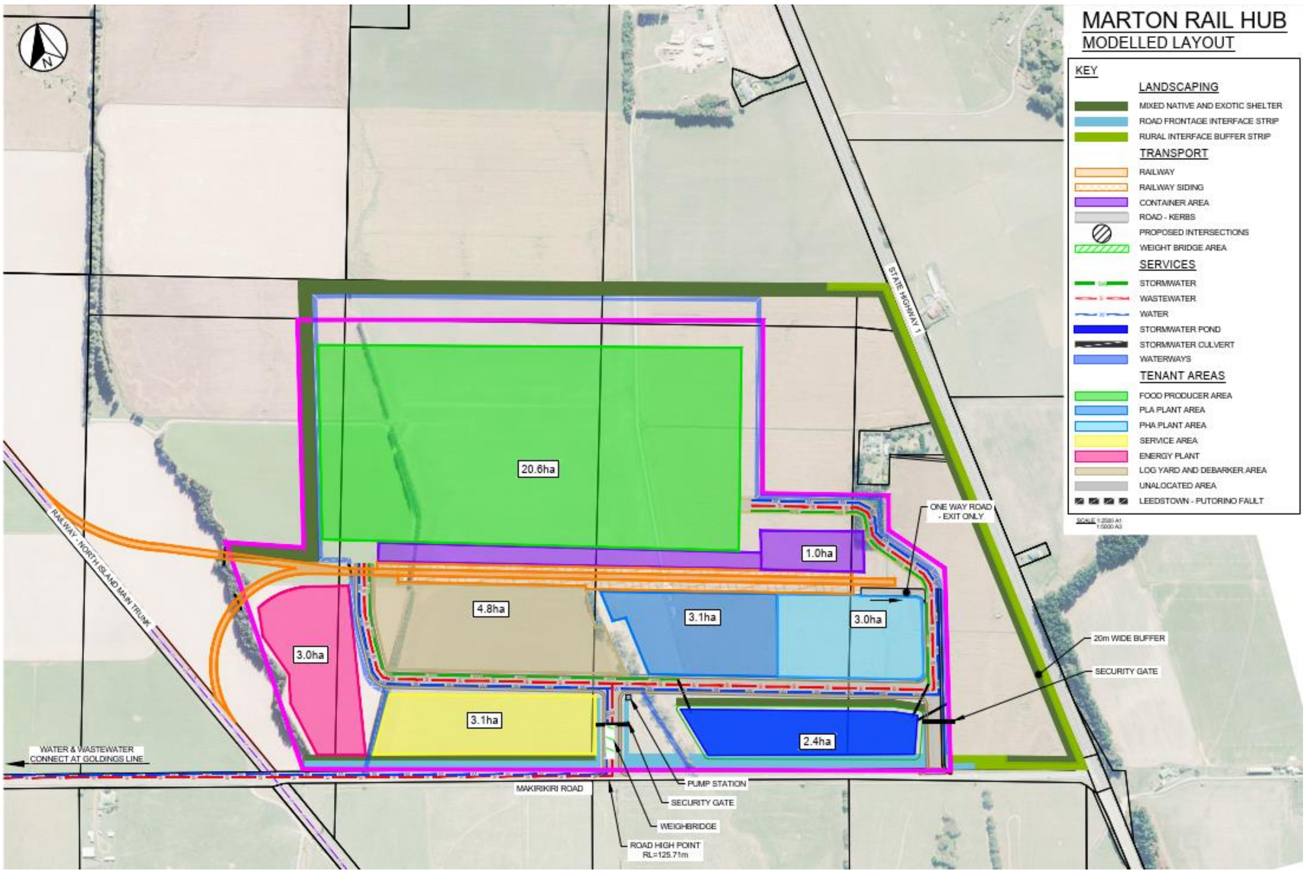

Figure 2: Proposed location of activities & infrastructure (proposed CDP).

3.2 Sensitive Receptors

The proposed CDP is approximately 1 km to the south of the horse training facility and 1.3 km to the southern edge of the Marton township. The immediate land use surrounding the proposed CDP is dominated by rural land uses, which include isolated residential dwellings. There are approximately eight residential dwellings within 500 m to the proposed CDP boundary.

There are four residential dwellings which are within 250 m of the CDP boundary. Three are located toward the north-east and respectively 70 m, 100 m and 250 m away. The third dwelling is located 250 m from southwest boundary of the CDP. All other nearby residential dwellings are located at greater distances from the boundary.

The Marton school is more than 3.5 km to the north of the proposed CDP.

3.3 Existing Air Quality

3.3.1 Respirable particulate

The existing air quality in Marton has been assessed by Golder (2021)[2] and the findings are summarised in Table 1. The report concluded that PM_{10} and $PM_{2.5}$ background concentrations in the Marton township are likely to be in the 'degraded category' due to the home heating in winter. However, it is expected that the horse training facility would be less exposed to winter-time domestic heating emissions and this location is likely to have air quality meeting the 'acceptable' category for PM_{10} and $PM_{2.5}$.

In the absence of site-specific monitoring data, the background PM_{10} and $PM_{2.5}$ concentrations at the Marton township, horse training facility and the proposed CDP are estimated based on the NIWA and Waka Kotahi's model, as described in the Golder (2021) report. A summary of the background air quality is presented in Table 1. Note that the 24-hour average $PM_{2.5}$ background concentrations were estimated based on the ratio of annual $PM_{2.5}$ to annual PM_{10} concentrations. Furthermore, the 24-hour concentrations in Table 1 are the anticipated maximum values and therefore much higher than the average 24-hour concentration which is otherwise indicated by the annual average values.

Table 1: Estimates of PM_{10} and $PM_{2.5}$ concentrations in the township of Marton, horse training facility and proposed CDP (in µg/m^3).

Location	PM_{10}				$PM_{2.5}$			
	Annual average#		24-hour average@		Annual average#		24-hour average	
	Estimated	AAQG target	Estimated	NES target	Estimated	WHO target	Estimated	NES target
Marton township	13	20	35	50	8	10	21.5*	25
Horse training facility and proposed CDP	8	20	19	50	3.2	10	7.6†	25

#Estimate from the NIWA model. @Estimate from the Waka Kotahi model. * Estimate from the assumption of 61 % of the 24-hour PM_{10} is in $PM_{2.5}$ size fraction. †Estimate from the assumption of 40 % of the 24-hour PM_{10} is in $PM_{2.5}$ size fraction.

3.3.2 Nuisance dust

The rural areas to south and east of the Marton Township (i.e., locations of isolated rural residential dwellings shown in Figure 1, which are closest to the CDP site) are expected to be exposed to similar, albeit marginally lower ambient levels of PM_{10} and $PM_{2.5}$, than those anticipated in Table 1 for the horse training facility. As such, the ambient particulate (which is indicative of total dust levels) is expected to meet the 'acceptable' category or better within surrounding rural areas to the east and south of the Marton township. Because of this, levels of total suspended dust (which can also include suspended particulate, which are larger typically no larger than 30 microns) are expected to be very low.

3.3.3 Odour

The locations of isolated rural residential dwellings shown in Figure 1 are not expected to have any significant exposure to existing food producing related odour discharges. Existing odour sources such as the food producing plant in Marton and Malteurop (as shown in Figure 1) may be noticeable on occasion at the horse training facility. However, these sources are likely to be rarely noticeable and at weak levels (if noticeable at all) at the residential dwellings shown to surround the CDP site in Figure 1.

3.4 Terrain and Meteorology

The Manawatu-Whanganui Region contains some important topographic features, such as the Ruahine Range running northeast to southwest for about 110 km, and the Matemateaonga Range on the western side of the Whanganui River. The north part of Marton is surrounded by rugged hills between these two ranges.

The Rangitikei River is approximately 5 km to the west of Marton, flowing from northeast to southwest. The coast is approximately 20 km to the west of Marton.

The Golder (2021) report has discussed the local wind pattern which is derived from the 11-year wind data obtained from the nearest weather station at RNZAF Base Ohakea.

To provide wind data that is more representative of Marton, data has been extracted for the location of the horse training facility from a 3-dimensional meteorological model dataset developed using the CALMET model, as described in Section 2.3. The wind rose constructed from the CALMET dataset is shown in Figure 3 on the left, while the wind pattern for Ohakea weather station is shown on the right. These two wind roses are very similar, both showing prevailing strong winds from the west-northwest and east-southeast directions. They also show that drainage flows are likely to be associated with lighter winds (1 m/s to 3 m/s) from north and north-northeast directions. Therefore, it is considered the local wind patterns presented in the Golder (2021) represent the general wind conditions in Marton.

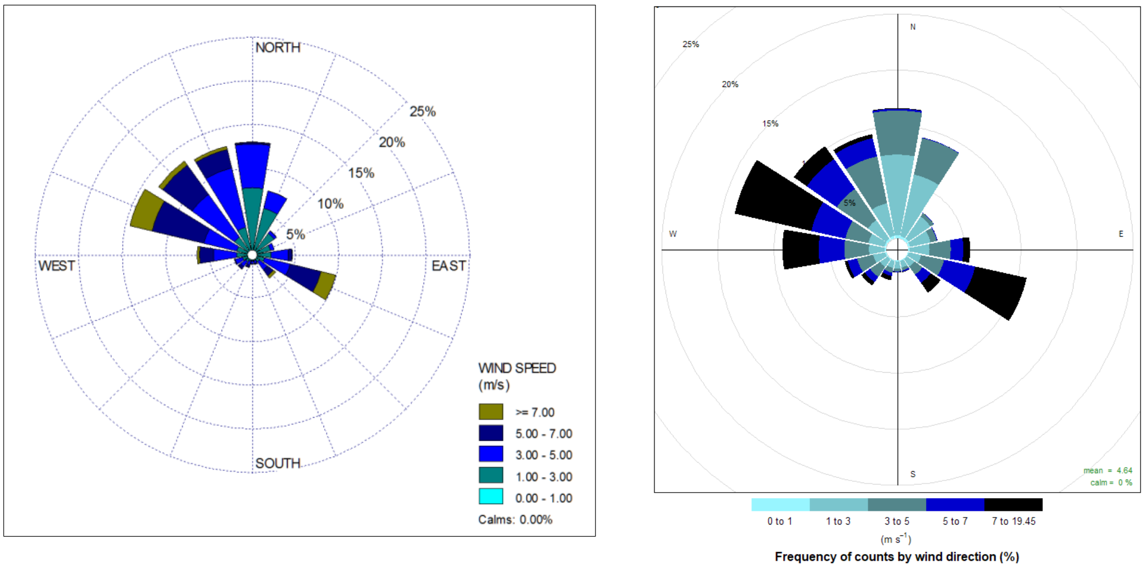

Figure 3: Wind rose for the location of the horse training facility, generated by CALMET for 2016-2017 (left) and wind rose for Ohakea AWS January 2010 to January 2021 (right).

4.0 DESCRIPTION OF ACTIVITIES

4.1 Overview

The approximately sixty-two-hectare CDP site has a planned layout for various activities and supporting infrastructure, as highlighted in Figure 2. The proposed CDP site includes operation of a rail siding, a log yard, a container yard, plastic manufacturing, food and energy production. The infrastructure (include rail siding, log yard, container yard and internal access) would enable the operation of key processing/duction enterprises, which are planned for the site.

Details of each development areas are described in below sections.

4.2 Rail Siding

A new rail siding is proposed to allow the import and export of logs, containers and other goods from the proposed CDP site. Twin-engine locomotives with thirty wagons (typical pay load of 50 tonnes/wagon) will bring in logs and other goods to the site every day. Locomotives can access the rail siding from the North Island Main Trunk either coming from the north or south.

It is assumed that up to six trains with 30 wagons would arrive and depart on each operational day. The long-term plan is for 1,500 tonnes/day of logs to arrive at the site (via train and trucks) for storage/de-barking and to provide feedstock for the bioplastic plants.

Train speed at the rail siding is expected to be less than 10 km/h, therefore it would take approximately 10 minutes for a train to access the siding and come to a complete stop. Upon its arrival, the train will be tested with running engine for approximately 30 minutes to one hour on each end of the siding. After the testing is completed, the train will be switched off, or dispatched to the north or south. It is assumed that no shunting activities would occur at the rail siding.

4.3 Heavy Vehicle Access Road

Heavy vehicles (trucks and trailers) will enter and leave the proposed CDP site via a proposed 22 m wide internal access road.

For a realistic worst-case scenario, we assumed that a total of 155 trucks and trailer units would enter and leave the site each day via the main vehicle access road. This is approximately one truck/trailer unit arriving every 5 minutes over a 12-hour operational day. The total number of trucks movements per day is based on assumptions of truck movements (arrival and departure) as listed in Table 2.

Table 2: Assumptions of truck movements per day at CDP site.

Location	Truck movements per day
Log yard	130
Container yard	60
Food producer	40
Plastic manufacturing plants	80
Total	**310**

4.4 Container Area

The container yard is located to the northeast of the rail siding, with access across the entire northern area of the rail siding. The container area would have areas allocated for food and malt containers, logs, and other products. This is estimated to have 600 to 800 tonnes/day of materials arrive at the site via container. Two container stackers (wheeled top-lift hoists) would be used to unload/load containers on to trucks and wagons at the rail siding.

4.5 Log Yard

The log yard area is located adjacent to the rail siding to allow for loading and unloading of log wagons. There could eventually be 1,500 tonnes logs per day arriving at the log yard via trucks and train. Most of the logs would be debarked by a Nicholson A8 ring debarker. Two L260 loaders will be used for loading and unloading logs from trucks and trains.

The A8 debarker would be located outside and is automatically loaded with a stacker infeed which is supplied by the L260 loaders. A conveyor system will remove bark and discharge to temporary stockpiles.

The bark which is generated could be either pumped as a slurry to the bioplastics plant for processing, or else directed to the energy plant.

4.6 Food Producer

4.6.1 Description

A food producing facility is planned for the northern portion of the site and adjacent to the container area. The site is assumed to operate a biomass fired boiler with an estimated maximum energy input of 20 MW. The site will also have natural gas fired dryers. There is an existing petfood producing site within the industrial area of Marton (shown in Figure 1).

This plant produces the same type of dried pet food product as proposed for the CDP, using a similar process. The main ingredients include tallow, wheat and meat & bone meal. These are blended and pressed into product shapes followed by baking/drying these via long retention time baking ovens to produce cooked/drier products. The existing plant produces approximately 15,000 Tonnes/annual of product (when operating 24/7). This indicates a nominal average manufacturing rate of 1.5 to 2.0 T/hr of drier petfood product. The exhausted air associated with the slow baking process is approximately 5,000 m^3/hr.

It is understood that the proposed new food producer plant located at the CDP site would produce up to 90,000 tonnes/year of drier petfood product (when operating 24 hours per day/five days per week). This indicates a nominal average manufacturing rate of 15 T/hr of drier petfood product. It is anticipated that the exhausted air associated with the product drying process would be in the approximate order of 50,000 m^3/hr.

The new process at the CDP site would involve a similar type of process to the existing facility except some of the cooking process would occur as part of the formation of product shapes (involving higher pressure) and this would allow for a short product drying phase. Despite the process differences, the new process is likely to have a similar quantity per unit of production, of dryer exhaust air and with a similar odour intensity and character to that of the existing process.

4.6.2 Discharges to air

Respirable particulate emissions would be the primary air contaminant associated with the operation of the energy plant, which are accounted for in this assessment. Whereas the drying stage would contain very minor respirable particulate emissions to air which can be ignored. However, the meal/biscuit type odour associated with the final product dryer exhaust (in the order of 50,000 m^3/hr) is likely to require an abatement system to ensure minor odour effects beyond the site boundary.

4.7 Bioplastic Manufacturing Plants

4.7.1 Description

The bioplastic manufacturing plants (producing polyhydroxy-alkanoates (PHA) and polylactic acid (PLA) based biodegradable plastics) would be located at the south of the rail siding and adjacent to the log yard. These plants require raw biomass, which can be supplied via imported materials, such as milk processing sludge, debarked logs, malt, etc.

These plants could receive up to 200 tonnes/day of biomass (wood, waste sludge, etc.) and from this produce around 20 tonnes/day of product. Therefore, the plants would produce a significant waste biomass stream which is likely to supply the energy plant.

4.7.2 Discharges to air

These plants mainly discharge volatile organic compounds to air, as a consequence of their separation and drying processes. However, these emissions are not expected to contribute materially to the total particulate emission that would be generated from all other CDP site activities and mobile plant (trucks, trains, and loaders).

The receipt, storage and transfer of raw dairy industry waste sludge, or similar slurries at the site, has the potential to cause fugitive odour emissions. However, these emissions are expected to be minor compared to process related odour emissions, as these waste streams would be stored within enclosed tanks and transferred and processed within fully enclosed systems. Displacement of storage tank head space air as a result of sludge being pumped from tankers, etc., has the potential to cause periodic fugitive odour emissions.

The manufacturing processes involve the conversion of organic molecules into polymers via a fermentation process and subsequent separation of product via centrifuges – this would produce a very low flow of odorous process air. The partial drying of product streams could produce an odorous exhaust stream in the approximate order of 2000 m^3/hr. This would create source of odour discharge which has the potential to cause nuisance odour at the nearby residential dwellings if untreated.

4.8 Energy Plant

The site aims to generate its own energy requirements (e.g., for log debarking, food and bioplastics manufacture) from waste biomass generated from the log debarking and bioplastics manufacture and dairy waste from offsite. It is also planned to meet some of the site electricity demand via a nearby solar farm (estimated to generate 3.5 MWe).

The long-term electricity and thermal energy demand of the food and plastics manufacturing sites is not clear at this stage. Therefore, a realistic worse-case scenario is assumed for the combustion of biomass (assumed to be mostly wood waste) to generate electricity. This involves 50 MW of wood combustion. It is noted that in order of 100 tonnes/day of bark could be generated from debarking of logs. Furthermore, in order of 200 tonnes/day of waste biomass could be generated from the PHA and PLA. These waste bark and biomass tonnages indicate that the assumption of 50 MW of combustion is conservatively high.

5.0 SOURCES AND PARTICULATE EMISSION RATES

5.1 Sources

The following activities have been identified and considered as major sources of particulate emissions:

- Wheel generated crustal dust from trucks movements on internal paved roads, log/container loader movements on paved surface at the log yard and container yard.
- Exhaust emissions from diesel powered trucks and onsite machinery (i.e., log loaders and container stackers).
- Wood dust generated from the log debarker.
- Exhaust emissions from diesel powered locomotives (including trains on duty cycle and idling cycle).
- Combustion of biomass fuel in the food producer boiler.
- Combustion of biomass fuel in the energy plant.

5.2 Particulate Emission Rates

5.2.1 General

A summary of the key assumptions for each particulate emission source (listed in Section 5.1), is provided in the following sections. The detailed summary of the calculations and methods are provided Appendix D.

5.2.2 Wheel generated crustal dust

Trucks movements on the internal access road

The frequency of trucks movements, working hours, travel distance and information related to the trucks are established from the following assumptions. The calculation of PM emissions utilises these assumptions and USEPA's AP-42 equations for paved roads.

- A total of 155 trucks/day carrying the logs and other goods travel along the internal road from 6 am to 6 pm.
- The average vehicle kilometre travelled (VKT) per day (travelled round trip) is approximately 224.
- Vacuum sweeping is to be applied to the paved internal road during dry conditions, which provides an 80 % dust reduction.
- The truck tare weight is assumed to be 20 tonnes, and the fully loaded weight is 50 tonnes (with 30 tonnes logs). Assuming 100 % trucks arrive with full load, and 50 % leave empty, the average truck weight is 42.5 tonnes.
- A road surface silt loading rate of 0.6 g/m^2 is assumed for the internal road.

Log loaders and container stackers movement at log yard and container yard

The frequency of loader/stacker movements, working hours, travel distance and information related to the loaders/stackers are established from the following assumptions. The calculation of PM emissions utilises these assumptions and USEPA's AP-42 equations for paved roads.

- Two log loaders (L260H) and two container stackers operate at the log yard and container yard respectively, for 10 hours per day (7 am to 5 pm) with an average speed of 10 km/hr.

- The average vehicle kilometre travelled (VKT) per day for both loader and stackers is 200.
- The loader tare weight is assumed to be 24 tonnes, and the fully loaded weight is 39 tonnes. The average loader weight is 31.5 tonnes.
- The stacker tare weight is assumed to be 11 tonnes, and the fully loaded weight is 41 tonnes. The average stacker weight is 26 tonnes.
- Water flushing is to be applied to the paved log yard and container yard during dry conditions – this provides an 80 % dust reduction.
- A road surface silt loading rate of 0.6 g/m² is assumed for the internal road.

5.2.3 Exhaust from diesel powered vehicle and onsite machinery

Truck exhaust (from internal access road)

The frequency of trucks movements, working hours, travel distance and information related to the trucks are established from the assumptions for trucks in Section 5.2.1. The calculation of PM emissions utilises these assumptions and the New Zealand Transport Agent (NZTA) Vehicle Emission Prediction Model (VEPM) 6.1 emission factors.

Loaders and container stacker exhaust

The assumption of the log loaders' and container stackers' rated power and operational hours is listed as follows. The US EPA exhaust and crankcase emission factors for nonroad engine modelling has been used to calculate their respective PM emission rates.

- 2 x 421 horsepower (hp) L260H loaders (US EPA Tier 3) operating 10 hr/day.
- 2 x 355 hp DCG 400/410 GS container stackers (US EPA Tier 3) operating 10 hr/day.

5.2.4 Crustal dust from log debarker

One Nicholson A8 debarker is planned to operate at the log yard for 10 hr/day (7 am to 5 pm) with a throughput of 1300 tonnes logs per day. No control measures have been assumed for the log debarking operation. The US EPA WebFire database PM emission factors have been used to derive the PM emission rates.

5.2.5 Exhaust from diesel powered trains

The arrival and departure of twin-engine locomotives with thirty wagons will increase respirable particulate emissions into the local environment from the combustion of diesel and braking. The particulate emissions related to the locomotive output power and the operational speed. The Stage IIIA European Emission Standards for trains are used to derive the PM emissions from trains arriving at, idling and departing from the hub, and existing trains passing through the CDP site. This assessment focuses on the emissions from the rail siding and the main trunk for approximately 8 km long. To quantify a realistic upper limit to these emissions, realistic operational assumptions (number of trains per day, power output and train speed) are defined as follows:

- It is assumed three trains will arrive at the new rail hub from the south and north respectively, from 6 am to 6 pm.
- Each train is expected to be equipped with two DL Class locomotive engines. Each locomotive engine has a maximum power output rate of 2,700 kW. It is assumed that trains are operated at 100 % rated power when departing the rail hub, while at 5 % of the rated power when they arrive at the hub.

- For a train in idling cycle at the rail hub, it is assumed to be operated at 0.2 % of the maximum rated power, i.e., 5.4 kW. It is also assumed each train will idle for two hours (1 hour on each end of the siding).
- KiwiRail currently operates 32 trains per day through Marton. Assume these trains are operated at 50 % of the rated power on average for 24 hours/day.
- It is assumed the average train speed at the rail siding is 10 km/h, and it increases to 20 km/h – 40 km/h at the main trunk. Detailed train speed assumptions are shown in Appendix D.

5.2.6 Energy production and food producer

The energy input, fuel, working hours of the Biomass-Fired Boilers (BFBs) at the energy plant and food producer are developed from the following assumptions:

- The energy plant is assumed to operate a BFB with a maximum energy input of 50 MW. The proposed fuel is made up of waste biomass (mainly wood) with an assumed moisture content of 30 %. The assumed fuel property is shown in Table 3. The boiler will operate continuously 24 hours a day and 7 days a week.
- The food producer is assumed to have a BFB with a maximum energy input of 20 MW. It is also assumed this BFB will be fired on wood with 30 % moisture content and operate continuously 24 hours a day and 7 days a week. The assumed wood composition is shown in Table 3.

Table 3: Wood composition.

Property	Value
Moisture	30 % wt. %
Ash	0.56 wt. %
Carbon (dry ash free basis)	50.3 wt. %
Hydrogen (dry ash free basis)	6.24 wt. %
Oxygen (dry ash free basis)	43.3 wt. %
Nitrogen (dry ash free basis)	0.2 wt. %
Sulphur (dry ash free basis)	0 wt. %
Net calorific value (as received basis)	12,500 kJ/kg

The BFBs combustion exhaust flow rates were calculated using stoichiometric equations with fuel property assumptions in Table 3 and a nominal value of exhaust oxygen content of 7 vol. % dry. A summary of the stoichiometry calculations is presented in Appendix E. The estimated and assumed stack parameters for both BFBs are provided in Table 4. The PM_{10} emission rate was calculated based on an assumed in-stack PM_{10} concentration of 30 mg/Nm^3 (corrected to 12 vol. % CO_2 dry basis) with the use of baghouse filter. The detailed calculations and results of emission rates are presented in Appendix E.

Table 4: Stack parameters for the energy plant and food producer BFBs.

Parameter	Energy plant BFB	Food producer BFB
Maximum energy input (MW)	50	20
Assumed stack height (m)	30	20
Stack diameter (m)	1.7	1.2
Efflux velocity (m/s)	15.7	15.7
Stack oxygen (vol. % dry)	7	7
Assumed efflux temperature (ºC)	150	150
Assumed fuel consumption	4 kg/s (as received basis)	2 kg/s (as received basis)

5.3 Summary of Emissions

Table 5 presents a summary of the above estimated particulate PM_{10} and $PM_{2.5}$ emission rates. Whereas the assumed 24-hour time series profile of these emissions is presented in Figure 4 and Figure 5 for PM_{10} and $PM_{2.5}$ respectively.

Table 5: Summary of estimated working day average particulate emission rates (g/s).

Area	Emission source	Emission ID	Activity description	PM_{10} emission rate (g/s)	$PM_{2.5}$ emission rate (g/s)	Hours
Heavy vehicle access road	Truck	T1	Wheels movement on paved road	0.02	0.005	6 am to 6 pm
			Exhaust	0.0017	0.0012	6 am to 6 pm
Log yard	Log loaders and trucks	L1	Wheels movement on paved road	0.016	0.004	7 am to 5 pm
			Exhaust	0.06	0.06	7 am to 5 pm
	Debarker	L2	Debarking operation	0.20	0.001	7 am to 5 pm
Container area	Container stackers and trucks	C1	Wheels movement on paved road	0.013	0.003	7 am to 5 pm
			Exhaust	0.05	0.05	7 am to 5 pm
Rail siding & main trunk	Existing trains passing through	RB	Train exhaust	0.055	0.055	12 am to 12 pm
	New trains arriving from/departing to north	RN1	Train exhaust	0.006/0.096	0.006/0.096	6 am to 6 pm
	New trains arriving from/departing to south	RN2	Train exhaust	0.003/0.049	0.003/0.049	6 am to 6 pm
	Idling trains	RI	Train exhaust	0.006	0.006	6 am to 6 pm
Energy plant	Wood combustion	B1	Combustion of biomass	0.65	0.59	12 am to 12 pm
Food producer	Wood combustion	B2	Combustion of biomass	0.33	0.29	12 am to 12 pm

Note: * The first emission rate relates to trains arriving at the site, the latter one is associated with trains leaving the site.

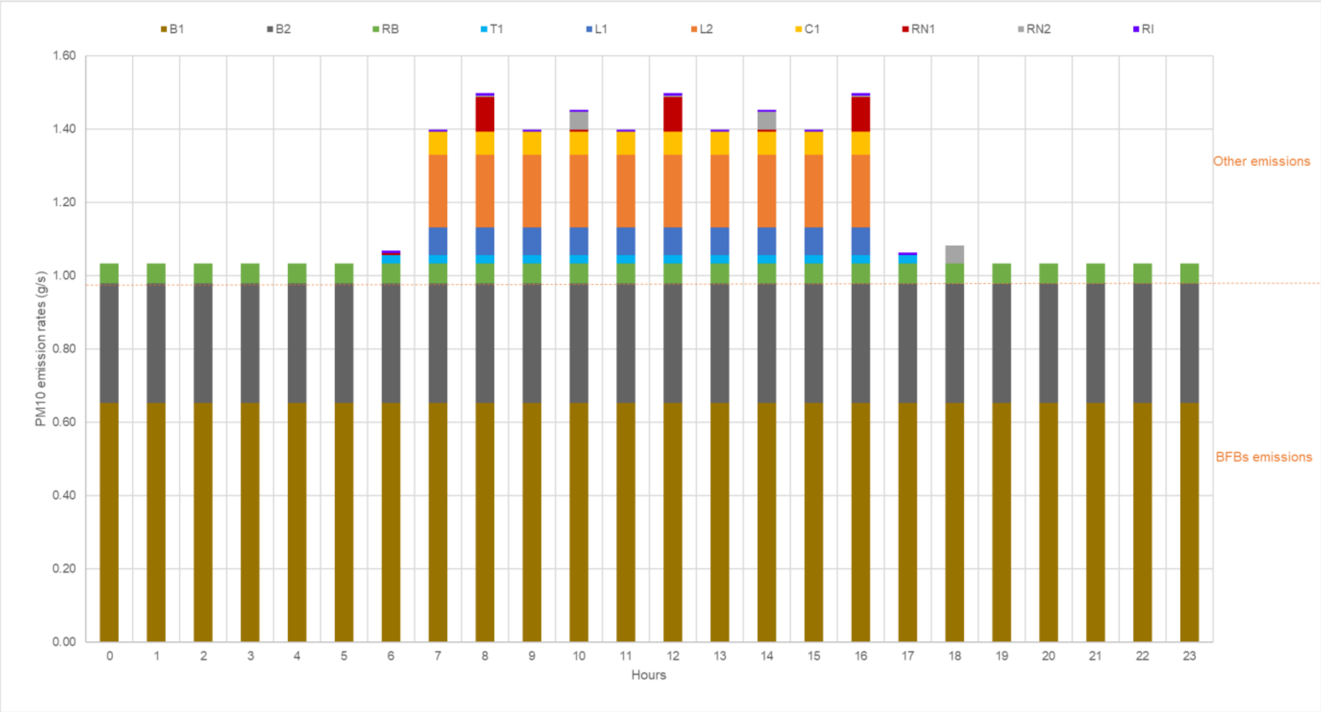

Figure 4: Daily PM_{10} emission (g/s) versus hour of day profile (all sources).

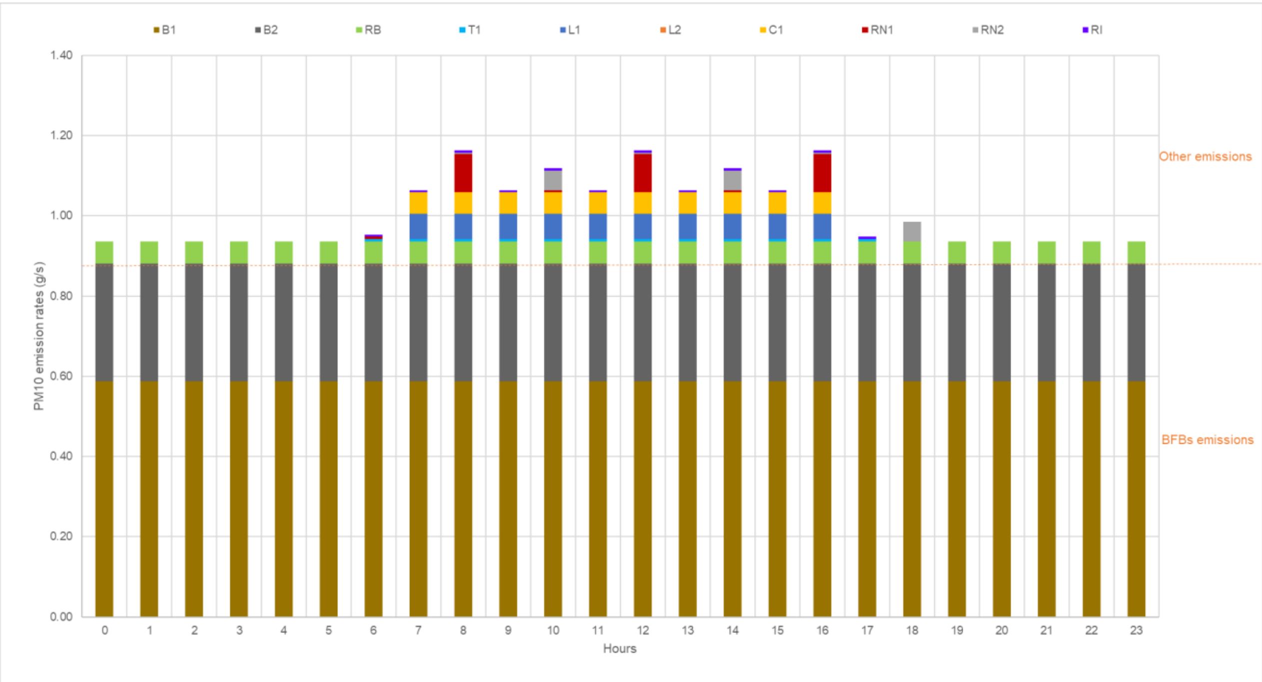

Figure 5: Daily $PM_{2.5}$ emission (g/s) versus hour of day profile (all sources).

6.0 MODELLING PARTICULATE IMPACTS

6.1 Introduction

CALPUFF dispersion model (Version 7.2) has been used to predict the contaminated ground level concentrations (GLCs) of PM_{10} and $PM_{2.5}$ over a two-year period (2016-2017) of hourly meteorological data. This section discusses the setting up of the emission sources in CALPUFF.

6.2 Model Setup

The emission sources discussed in Section 5.2 have been characterised as either point sources, volume sources or line-volume sources. These emission sources configurations are summarised as follows:

- Point sources: the BFBs at the energy plant and food producer are set as point sources. The exhaust assumptions are shown in Table 4.
- Tall buildings that have the potential to affect the dispersion of the plume discharged from the stack are assumed and configurated in the model. The following assumptions were made:
  - The energy plant will have a 25 m high building with a footprint of 25 m by 20 m. The BFB stack is assumed to be situated at the middle of the building.
  - The food producer will have a 10 m high building with a footprint of 20 m by 15 m. The BFB stack is assumed to be situated at the middle of the building.
- Volume sources: volume sources are bulky diffuse sources that emit or release pollutants over large area in three dimensions. The emissions from the log loader, debarker, container stackers and trains in idling cycle were identified as volume sources.
- Line-volume sources: the emissions from the trucks and trains running on the main trunk/rail siding were expressed in the model as long, narrow line-volume sources.

These sources were input into the CALPUFF model, as shown in Appendix B. The model was run for each emission inventory category listed in Table 5, and their individual model results were then summed to derive the overall increase of the ground level concentrations due to the CDP site.

7.0 AMBIENT AIR QUALITY CRITERIA

7.1 General

The Ministry for the Environment (MfE 2008) provides recommendations regarding the priority of the various sources of air quality criteria. Compliance with the National Environmental Standards for air quality (NESAQs) are mandatory, where these apply (i.e., where people are likely to be exposed when in open air except in areas where exposure is permitted by a resource consent and where this consent applies to. The Ministry for the Environment's ambient air quality guidelines (AAQGs) are not mandatory but are recommended for contaminants and averaging time frames not captured by the NESAQs. Following this, the use of ambient criteria listed in local regional plans is recommended. The World Health Organisation guidelines and California reference levels (OEHAA 2012) should be used for criteria that is not covered by either the NESAQs, AAQGs, or criteria listed within Regional Plans).

Therefore, the hierarchy of relevant air quality assessment criteria is as follows:

- New Zealand's ambient air quality standards (NESAQs)

- New Zealand's Ambient Air Quality Guidelines (AAQGs)
- The Regional Air Quality Plan for MWRC (unless more stringent than above criteria)
- World Health Organization (WHO 2005)
- California reference levels (OEHAA 2012).

7.2 National Environmental Standards

The MfE's NES regulations include criteria for air pollutants that are relevant to the boiler discharges, that is SO_2, NO_2, CO, and PM_{10}. The associated concentration limits, averaging periods and maximum numbers of allowable exceedances are summarised in Table 6 for each air contaminant.

Regulation 14 of the NES sets out the locations that ambient air quality standards apply, as follows:

"14 Application of standards

(1) The ambient air quality standard for a contaminant applies at any place –

(a) that is in an airshed; and

(b) that is in the open air; and

(c) where people are likely to be exposed to the contaminant.

(2) However, if the discharge of a contaminant is permitted by a resource consent, the ambient air quality standard for the contaminant does not apply to area that the resource consent applies to."

"Airsheds" include parts of the region of a regional council that are specifically gazetted as airshed, and any remaining areas of the region that are not gazetted. Marton is not gazetted as a polluted airshed by the MfE.

Therefore, the key areas for this assessment in terms of NESAQ compliance are the residential dwellings surrounding the proposed CDP site and areas of work and recreation. For PM_{10} to $PM_{2.5}$ the NESAQ often does not apply to uninhabited areas of rural land where people are not likely to be exposed for periods longer than several hours.

It is noted that amendments to the NES, changing the focus from PM_{10} to $PM_{2.5}$ have been proposed and these amendments have been released for public consultation.

7.3 National Ambient Air Quality Guidelines

The AAQGs applicable to this assessment include some of the same contaminants as covered by the NES but for longer averaging periods. The AAQGs are not linked to specific airsheds, or regulations which could require a regulatory authority to decline a consent application if there is non-compliance. The relevant MfE AAQGs are summarised in Table 6.

7.4 The Regional Air Quality Plan

There are no AAQGs within the Manawatu-Whanganui regional air quality plan for respirable particulate, which require consideration for this assessment.

7.5 World Health Organization

The World Health Organization (WHO 2006) has guidelines for annual and 24-hour $PM_{2.5}$. For this assessment, the WHO guidelines (2006) for particulate matter less than 2.5 µm in diameter ($PM_{2.5}$) have been considered for comparison with ambient monitoring results. MfE is proposing to adopt these ambient guidelines as NESAQ values.

7.6 Summary of Criteria

A summary of air quality criteria considered most applicable to this assessment are presented in Table 6.

Table 6: Summary of standards and guidelines relevant to this application.

Contaminant	Guideline/standard (µg/m³)	Averaging period	Allowable exceedances per year	Source
PM_{10}	50	24-hour	1	NES
	20	Annual	0	MfE AAQG
$PM_{2.5}$	25	24-hour	3*	WHO, proposed NES
	10	Annual	0*	WHO, proposed NES

Notes: * Proposed in update to NES.

8.0 ASSESSMENT OF RESPIRABLE PARTICULATE IMPACTS

8.1 Introduction

This section provides a summary of the dispersion modelling predictions for ground level concentrations (GLCs) of respirable particulates, when discharged at rates estimated for the operational CDP site. The model results are summarised for the two most impacted house locations (#1 and #5, as shown in Figure 7), and the horse training facility.

8.2 Coarse Respirable Particulate (PM_{10})

8.2.1 Incremental PM_{10} impact of the CDP

The predicted maximum 24-hour PM_{10} ground level concentrations (GLCs) due to the CDP and occurring at the two most impacted houses, and the horse training facility are presented in Table 7. This shows a breakdown of contributions from each emission source category. Impacts at these locations are as follows:

- At House #1, the predicted maximum 24-hour PM_{10} GLC is dominated by DPM from trucks/loaders and trains (37 % of the total GLC), followed by crustal dust emissions from the log debarker (33 %), truck/loader wheel generated dust (24 %), and combustion exhaust from the two BFB stacks (6 %).
- At House #5, the maximum 24-hour PM_{10} GLC is dominated by combustion exhaust from the two BFB stacks BFBs (45 % of the total GLC), followed by crustal dust from the log debarker (32 %), DPM from trucks/loaders and trains (15 %), and truck/loader wheel generated crustal dust (8 %).
- At the horse training facility, the maximum 24-hour PM_{10} GLC is dominated by crustal dust due to the log debarker (48 %), followed by DPM from trucks/loaders and trains (34 %), truck/loader wheel generated crustal dust (15 %) and combustion exhaust from the two BFB stacks (3%).

Figure 6shows the cumulative distribution of increment impacts of 24-hour PM_{10} due to all CDP sources. This shows that for 99 % of days, the increase in 24-hour PM_{10} GLCs at House #1 and #5 due to the CDP is <2 µg/m³, and <0.5 µg/m³ at the horse training facility.

The spatial patterns of the incremental increase in 24-hour and annual average of PM_{10} concentration (due the CDP) are shown in Figure 7 and Figure 8 respectively. These show that exposures levels rapidly decay beyond the CDP site boundary.

Table 7: Predicted maximum 24 hr average PM_{10} GLCs at two most impacted houses and the horse training facility due to all emission sources (µg/m³).

Contributions from	NE house #1	SW house #5	Horse training facility
BFBs	**0.2**	**1.71**	**0.03**
Log debarker	**1.24**	**1.21**	**0.5**
Diesel powered vehicles/machinery			
- trains	0.1	0.08	0.11
- trucks	0.05	0.01	0.01
- log loaders	0.3	0.4	0.1

Contributions from	NE house #1	SW house #5	Horse training facility
- container loader	0.9	0.1	0.1
	1.40	**0.6**	**0.34**
Crustal dust			
- trucks	0.58	0.17	0.09
- log loaders	0.1	0.1	0.04
- container loader	0.2	0.02	0.02
	0.91	**0.3**	**0.15**
Total	**4.0**	**4.0**	**1.0**

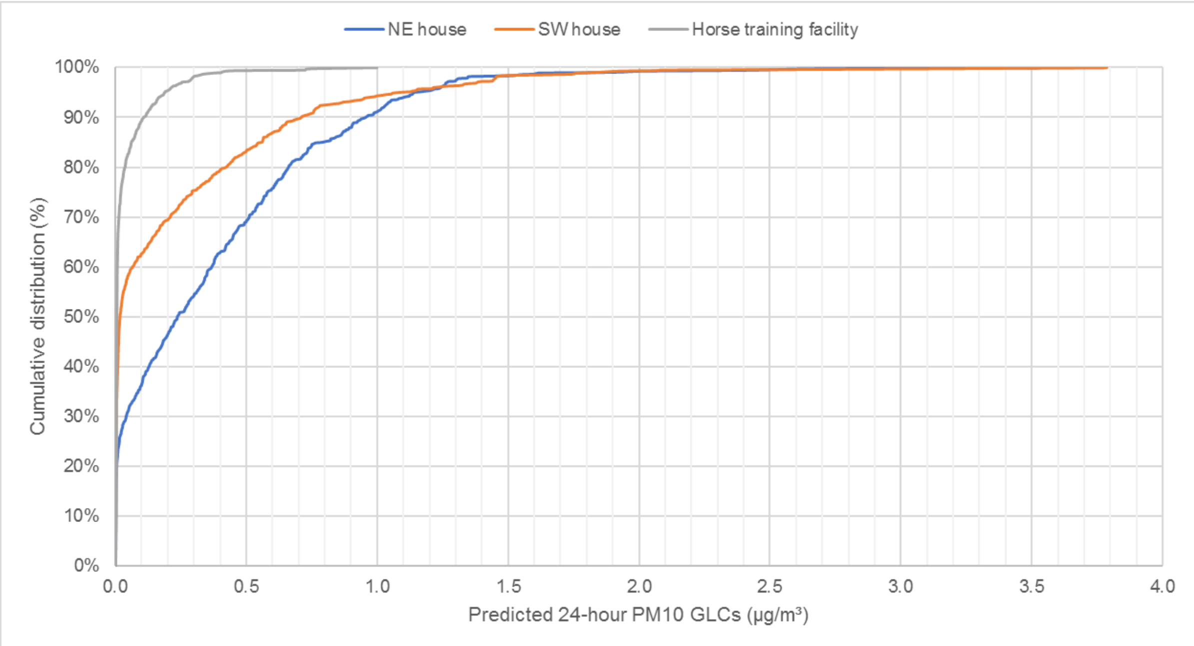

Figure 6: Cumulative predicted 24-hour PM_{10} GLCs due to all emission sources at the two most impacted houses and horse training facility (µg/m³), excluding background.

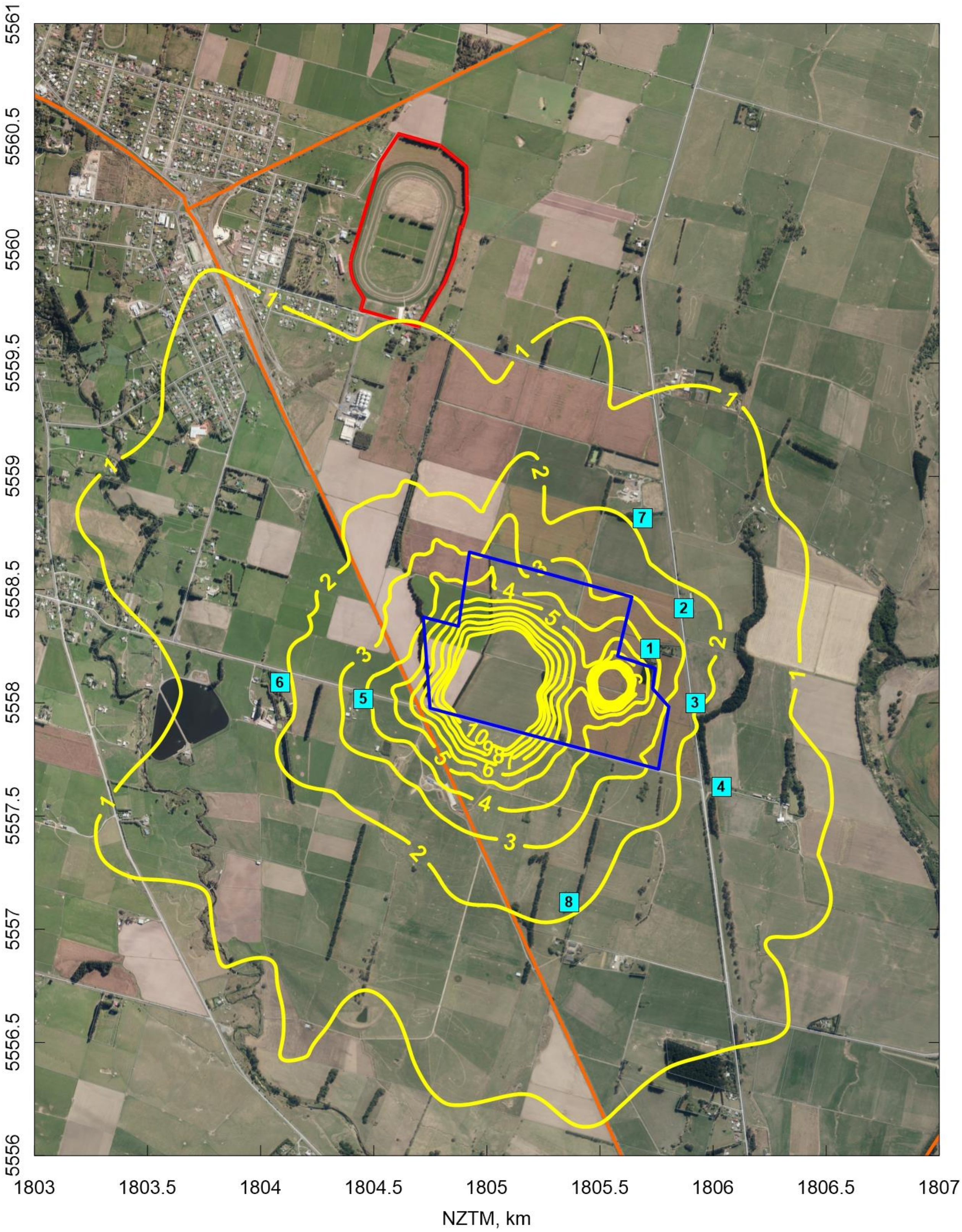

Figure 7: Contour plot of predicted maximum 24-hour average PM_{10} GLCs due to all emission sources(µg/m³), excluding background.

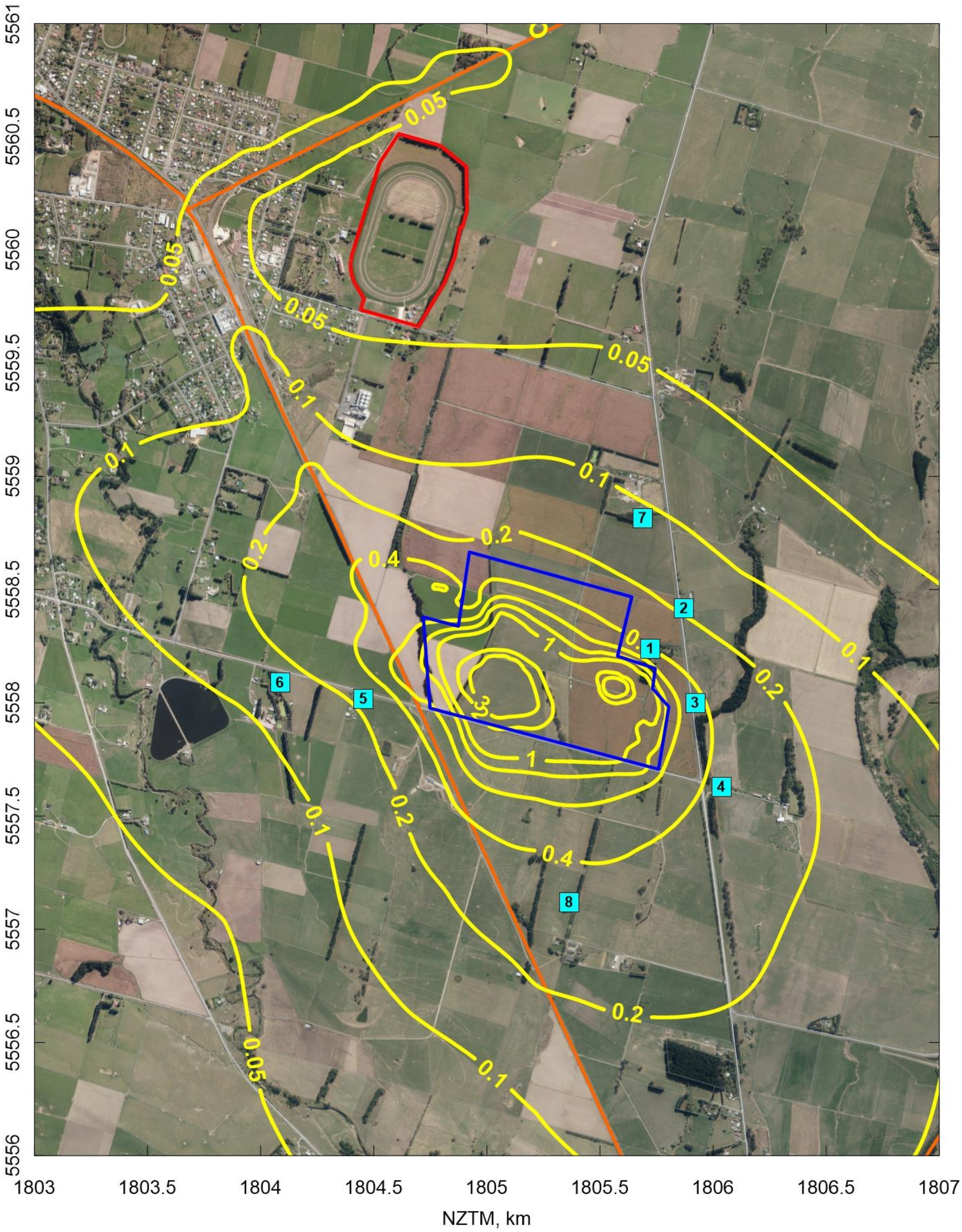

Figure 8: Contour plot of predicted maximum annual average PM_{10} GLCs due to all emission sources(µg/m³), excluding background.

8.2.2 Cumulative PM_{10} Impacts (CDP + Background)

Table 8 and Table 9 respectively show the predicted cumulative 24-hour and annual average PM_{10} GLCs at the two most impacted houses and horse training facility. These allow for estimated background concentrations (detailed in Section 3.3) and existing Kiwi Rail train movements past Marton (32 per day).

The cumulative 24-hour PM_{10} GLCs are approximately 23 µg/m³ at the two houses, and 20 µg/m³ at the horse training facility and their annual average PM_{10} GLCs are less than 8.5 µg/m³. These cumulative levels are heavily dominated by the background concentrations (>80 % of total) and are all well within the NESAQ and AAQG health-based standards and guidelines (<50 % of the NESAQ criterion for 24-hour PM_{10}).

The CDP emissions cause <20 % of cumulative 24-hour PM_{10} impacts at the nearest houses and <5 % of cumulative impact at the horse training facility.

The annual average PM_{10} exposure due to the CDP at the nearest houses and the horse training facility are respectively <5 % and <1 % of the total cumulative exposure.

Table 8: Predicted maximum 24 hr average PM_{10} GLCs at two nearest houses and the horse training facility (µg/m³).

Predicted 24 hr average	NE house #1	SW house #5	Horse training facility
Due to CDP	4	4	1
Due to existing trains	0.1	0.5	0.4
Assumed background	19		
Cumulative maximum 24 hr GLCs*	**23**	**23**	**20**

Note: The NES assessment criteria for 24 hr PM_{10} is 50 µg/m³ (1 allowable exceedance per year).

Table 9: Predicted maximum annual average PM_{10} GLCs at two nearest houses and the horse training facility (µg/m³).

Predicted annual average	NE house #1	SW house #5	Horse training facility
Due to CDP	0.4	0.2	0.05
Due to existing trains	0.02	0.01	0.06
Assumed background	8		
Cumulative maximum annual GLCs*	**8.4**	**8.2**	**8.1**

Note: *The AAQG assessment criteria for annual average PM_{10} is 20 µg/m³.

8.3 Fine Respirable Particulate ($PM_{2.5}$)

8.3.1 Incremental $PM_{2.5}$ impact of the CDP

The predicted maximum 24-hour $PM_{2.5}$ (GLCs) due to the CDP and occurring at the two nearest houses, and the horse training facility are presented in Table 10. This shows a breakdown of contributions from each emission source category as follows:

- At House #1, the predicted maximum 24-hour $PM_{2.5}$ GLC is dominated by DPM from trucks/loaders and trains (69 % of the total GLC), followed by truck/loader wheel generated dust (21 %), combustion exhaust from the two BFB stacks (10 %) and crustal dust emissions from the log debarker (0.3 %).
- At House #5, the maximum 24-hour $PM_{2.5}$ GLC is dominated by combustion exhaust from the two BFB stacks (64 % of the total GLC), followed by DPM from trucks/loaders and trains (23 %), crustal dust (13 %) and crustal dust emissions from the log debarker (0.2 %).
- At the horse training facility, the maximum 24-hour PM_{10} GLC is dominated by the combustion exhaust from the two BFB stacks (84 % of the total GLC), followed by DPM from trucks/loaders and trains (12 %), crustal dust (4 %) and crustal dust emissions from the log debarker (0.1 %).

Figure 9 shows the cumulative distribution of increment impacts of 24-hour $PM_{2.5}$ due to all CDP sources. This shows that for 99 % of days, the 24-hour $PM_{2.5}$ GLCs at Houses #1 and #5 due to the CDP is <1.5 µg/m³, and <0.3 µg/m³ at the horse training facility. The spatial patterns of the incremental increase in 24-hour and annual average of $PM_{2.5}$ (due to the CDP) are shown in Figure 10 and Figure 11 respectively. As with PM_{10}, these also show that exposures levels rapidly decay beyond the CDP site boundary.

Table 10: Predicted maximum 24 hr average $PM_{2.5}$ GLCs at two nearest houses and the horse training facility due to all emission sources (µg/m³).

Contributions from	NE house #1	SW house #5	Horse training facility
BFBs	**0.20**	**1.54**	**0.48**
Debarker	**0.01**	**0.005**	**0.0004**
Diesel powered vehicles/machinery			
- trains	0.1	0.081	0.031
- trucks	0.03	0.01	0.001
- log loaders	0.3	0.4	0.03
- container loader	0.9	0.1	0.01
	1.4	**0.6**	**0.1**
Crustal dust			
- trucks	0.14	0.04	0.004
- log loaders	0.22	0.26	0.02
- container loader	0.1	0.005	0.001
	0.41	**0.31**	**0.023**
Sum	**2.0**	**2.4**	**0.6**

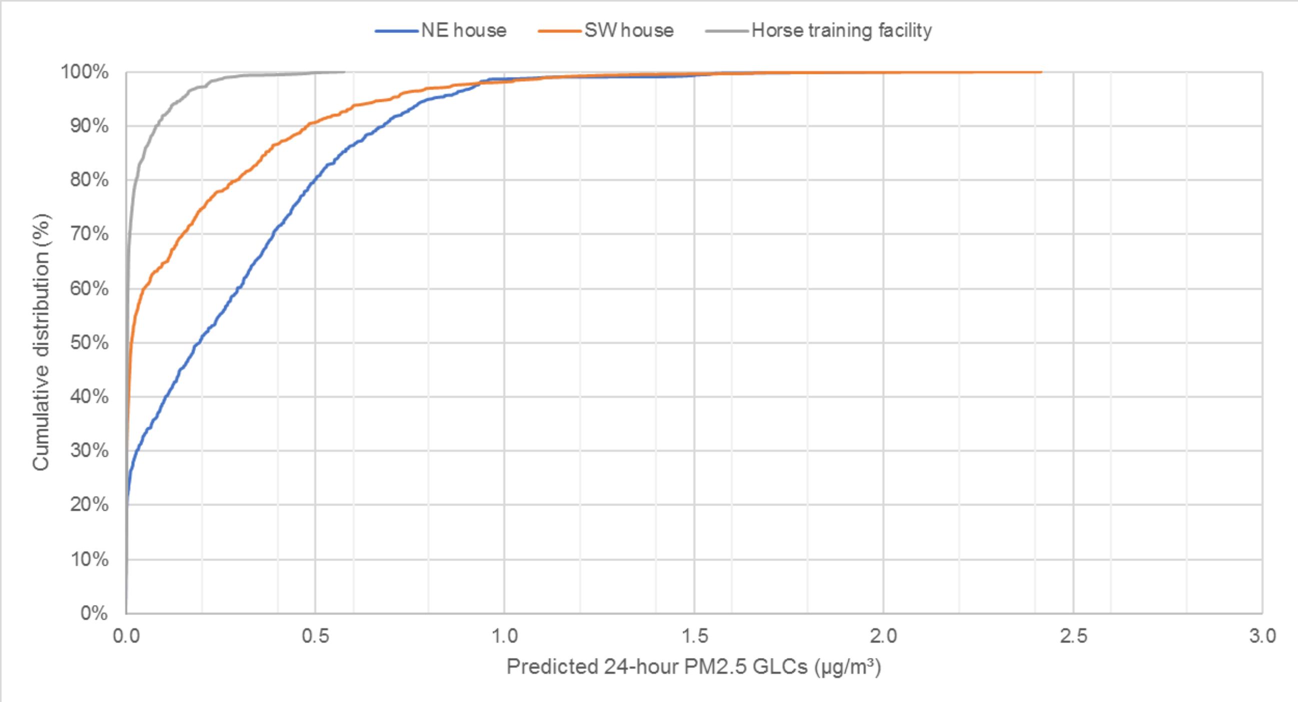

Figure 9: Cumulative predicted 24-hour $PM_{2.5}$ GLCs due to all emission sources at the nearest two houses and horse training facility (µg/m³), excluding background.

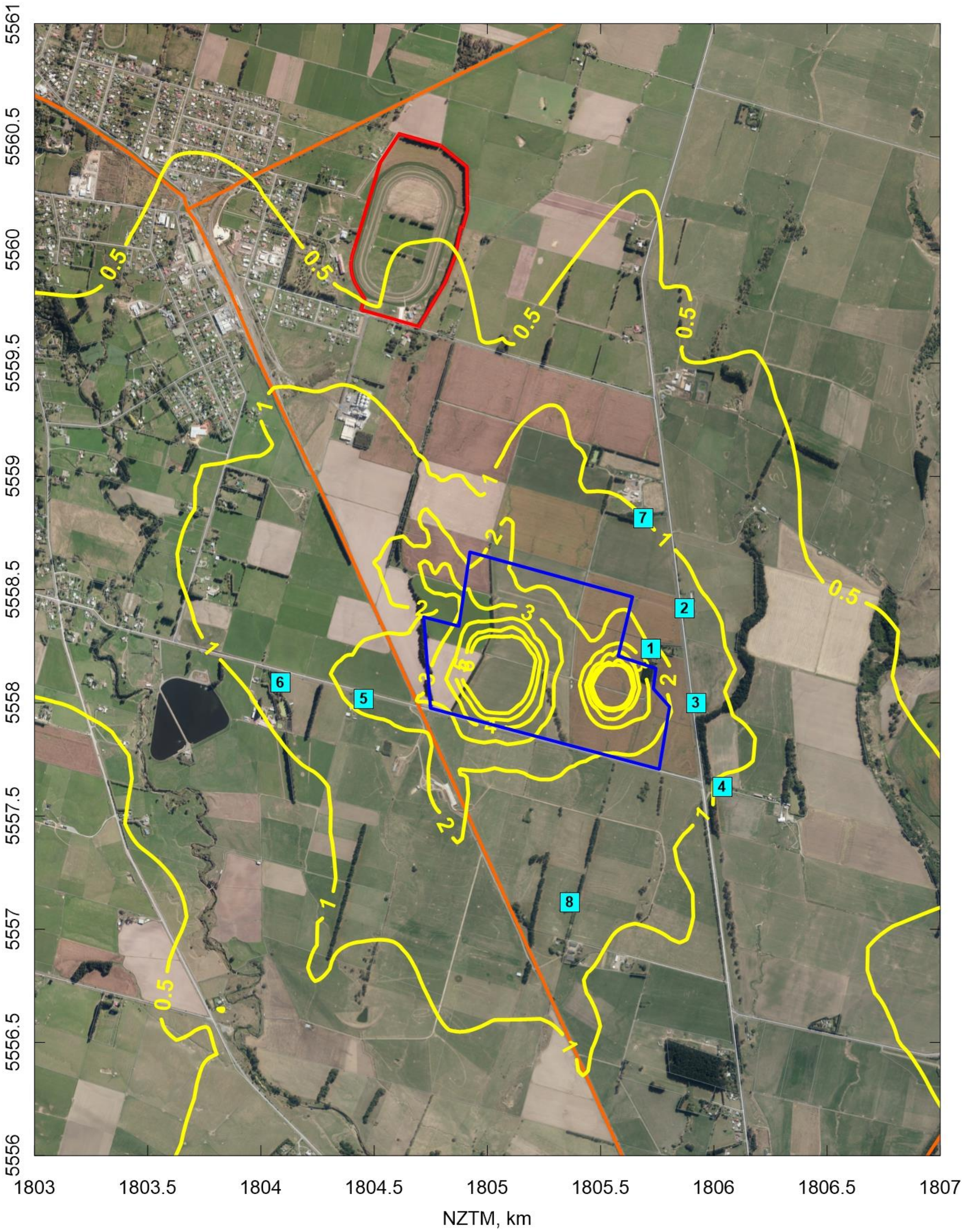

Figure 10: Contour plot of predicted maximum 24-hour average $PM_{2.5}$ GLCs due to all emission sources(µg/m³), excluding background.

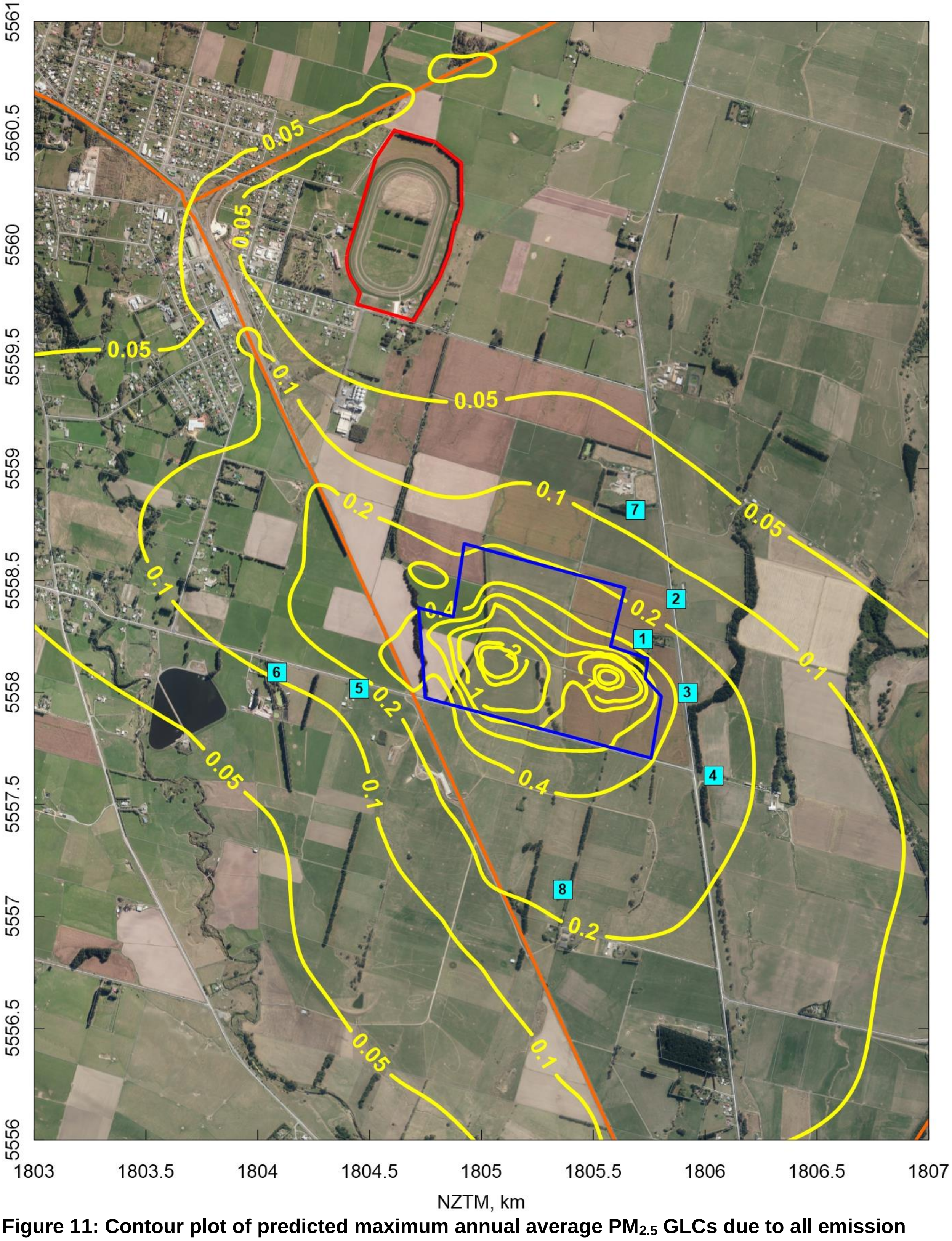

Figure 11: Contour plot of predicted maximum annual average $PM_{2.5}$ GLCs due to all emission sources(µg/m³), excluding background.

8.3.2 Cumulative $PM_{2.5}$ Impacts (CDP + Background)

Table 11 and Table 12 respectively show the cumulative 24-hour and annual average $PM_{2.5}$ GLCs at the two nearest houses and horse training facility. These allow for estimated background concentrations (detailed in Section 3.3) and existing Kiwi Rail train movements past Marton (32 per day).

The cumulative 24-hour $PM_{2.5}$ GLCs are approximately 11 µg/m³ at the two houses, and 9 µg/m³ at the horse training facility and their annual average $PM_{2.5}$ GLCs are <3.5 µg/m³. These cumulative levels are heavily dominated by the background concentrations (almost 80 % of total) and are all well within the NESAQ and AAQG health-based standards and guidelines (<50 % of the WHO and proposed NESAQ criterion for 24 hour $PM_{2.5}$).

The CDP emissions cause approximately 20 % or less, of the cumulative 24 hour $PM_{2.5}$ impacts at the nearest houses and 7 % of cumulative 24 hour $PM_{2.5}$ impact at the horse training facility.

The annual average $PM_{2.5}$ exposure due to the CDP at the nearest houses and the horse training facility are respectively <9 % and approximately 1 % of the total cumulative annual average $PM_{2.5}$ exposure.

Table 11: Predicted maximum 24 hr average $PM_{2.5}$ GLCs at two nearest houses and the horse training facility (µg/m³).

	NE house #1	SW house #5	Horse training facility
Due to CDP	2	2.4	0.6
Due to existing trains	0.12	0.5	0.4
Assumed background (excluding trains)	7.6		
Cumulative maximum 24 hr GLCs*	**10**	**11**	**9**

Note: *The proposed NES and WHO guideline assessment criteria for 24 hr average $PM_{2.5}$ is 25 µg/m³ (3 allowable exceedances per year).

Table 12: Predicted annual average $PM_{2.5}$ GLCs at two nearest houses and the horse training facility (µg/m³).

	NE house #1	SW house #5	Horse training facility
Due to CDP	0.3	0.2	0.04
Due to existing trains	0.02	0.1	0.06
Assumed background (excluding trains)	3.2		
Cumulative maximum annual GLCs*	**3.5**	**3.5**	**3.3**

Note: * The proposed NES and WHO guideline assessment criteria for annual average $PM_{2.5}$ is 10 µg/m³.

9.0 POTENTIAL CONSTRUCTION DUST EFFECTS

9.1 Introduction

With reference to Figure 2, it is anticipated that the CDP site would be developed via three stages of site works, which are undertaken in different years. Therefore, when considering the risk of construction dust, we have assumed site work to progress on the basis of the following three stages:

- **Stage 1:** This stage is assumed to include the construction of the access road entry and sections running east-west opposite the rail siding, the log yard, the service area, the platform for the future energy plant and railway siding itself. This area within the overall CDP envelop is effectively encompassed by the 10 ha of land within the southwestern corner of the CDP and including the yellow, pink and brown shaded areas in Figure 2.
- Note that the installation of the stormwater pond at the south-eastern corner of the CDP site would also occur at the commencement of site work (Stage 1). The work required for this infrastructure would occur over a short time frame (in the order of a month) and given the area of 2 ha and nature of work involved, it would have a short life and low potential to cause construction dust effects. It has therefore been excluded from further consideration.
- **Stage 2:** This stage is assumed to include the access road entry extending to the combined container area and platforms for the bioplastic manufacturing. This area within the overall CDP envelop is effectively encompassed by the 7 ha of land within the eastern extent of the CDP and including the two light blue shaded areas and the adjacent area assigned for combined container storage. This is the 1 ha square of purple shaded area in Figure 2.
- **Stage 3:** This stage is assumed to include the construction of the platform and buildings for the food processing area. This area within the overall CDP envelop is encompassed by the 20 ha of land within the north extent of the CDP and the adjacent area assigned for container storage. This is the rectangle of purple shaded area (approximately 2 ha) in Figure 2, which runs along the southern boundary of the 20 ha food plant area.

For the above three stages, we have applied the IAQM dust risk assessment procedures for both construction[4] and mineral dust effects[6]. The first tool is most appropriate to use for this assessment as the minerals dust effects risk assessment tool appears to be applicable to aggregate quarrying operations. However, this tool covers relevant activities such as earthworks and haul truck movements, while taking into consideration the site wind patterns (specifically dry days with wind above 5 m/s). As such, we have considered both tools, as well as Golder’s own analysis of winds on dry days to assess the potential risk of construction dust related effects on sensitive receptors offsite.

We note that the IAQM dust risk assessment tools are effectively screening tools to indicate the need for a more detailed assessment of dust mitigation measures for a specific site. Given this, we have also considered light to moderate and strong wind patterns during dry conditions to infer dust risk potential and not rely solely on the IAQM methods.

The separation distance between each receptor, as detailed in Figure 2, to the nearest Stage of the CDP site development (Stages 1, 2 and 3) are summarised in Table 13.

Table 13: Distances to sensitive receptor locations.

Receptor	Longitude	Latitude	Nearest Stage #	Separation Distance (m)	
2	*365010.01*	*5559607.42*	2	433	
	365010.01	*5559607.42*	3	255	
3	*364919.44*	*5560004.33*	2	156	
	364919.44	*5560004.33*	3	395	
4	*365115.48*	*5559233.85*	2	378	
5	*363513.11*	*5559556.17*	1	310	
6	*363148.81*	*5559598.87*	1	661	
7	*364712.42*	*5560396.35*	3	385	
Horse training	*363618.2*	*5561221.74*	3	1200	

All receptors are assumed to have a *High Sensitivity* to dust impacts.

9.2 Dust Risk

9.2.1 IAQM assessment for demolition and construction dust

The first step of the risk assessment process for construction/demolition dust is to specify the relative scale of different activities as being small, medium or large following the guidance provided[4].

For the development of the CDP, the three stages have had their relative scales (as defined by IAQM[4]) to be conservatively assessed as follows:

- Earthworks: Medium scale (Stages 2), and Large scale (Stages 1 and 3)
- Construction: Medium scale (Stages 1 and 3), and Small (Stage 2)
- Track-out: Large scale (Stages 1 and 3), and Medium (Stage 2)

The second step of the risk assessment process for construction/demolition dust is to specify the relative scale of different receptor sensitivities. We have selected the highest category of "*Highly Sensitive*" for all residential receptors and the horse training facility.

The third and fourth steps in the assessment account for the surrounding population density and distance for stages of construction to specify the risk of dust deposition effects on property and people. Given the distances in Table 13 and population density of 1 – 10 receptors (or there were 1- 100 receptors), a *"Low Risk"* of dust deposition effects and human health impacts is assigned. This low risk also accounts for good air quality with respect to annual PM_{10} levels assessed by Golder (2021).

In summary, the risk of dust effects (deposition and health related) due the *earthworks, construction* of buildings and infrastructure and *tracking out* of mud onto the external road is assessed (using the IAQM method for demolition and construction dust), as being "*Low Risk*" for receptor at locations 2, 3 and 5 in Figure 1. Note this risk is associated with no dust mitigation measures being put in place.

Because of their distance from the construction works, this tool also assesses the risk of deposition or health effects on receptor locations 4, 6, 7, 8 and the horse training facility in Figure 1, is assessed a "*Negligible Risk*".

9.2.2 IAQM assessment for mineral dust

The IAQM risk assessment process for minerals dust effects[6] relates to dust impacts during windy conditions and therefore when erosion from surfaces can be significant sources of dust. The method accounts various factors to ascertain the potential adverse dust effects (ranging from negligible to significant adverse effects) for specific off-site receptor locations. These factors include the following:

- The relative magnitude of onsite sources of dust (referred to as Residual Source Emissions by IAQM)
- Percentage of time that receptor is downwind activities during winds <5 m/s and on dry days
- The proximity of the receptor to a dust generating source
- Receptor sensitivity

The key source of mineral dust identified by IAQM relevant to the construction of the CDP site and their relative magnitude are as follows:

- Site preparation and restoration: Small
- Onsite transportation: Large
- Stockpiles and exposed surfaces: Medium
- Offsite transportation: Small

The relative magnitude of the above dust sources assigned by IAQM[6] are consistent with our own assessment of these dust sources during the construction of the CDP site.

Table 14 provides a summary of the risk assessment factors for each receptor when assuming all receptors have a "*High*" sensitivity and when assessing for dust sources with relative magnitude of Large. The ten-year wind data set from Ohakea air based and rainfall data was used to assess the percentage of time receptors are downwind of the nearest construction stage during wind speeds >5 m/s and during dry conditions.

For the assumption of all receptors having a high sensitivity and accounting for their respective proximity and downwind frequencies in Table 14, the IAQM method indicates that the horse training facility (Receptor 9) and the residential dwelling (Receptor 6) would have negligible potential for adverse dust effects for all stages of the CDP site development.

All other residential dwellings (Receptors 2, 3, 4, 5 and 7) could experience slight adverse effects from one of the development stages and therefore some standard dust mitigation measures would be justified to ensure effects are minor or less than minor.

The assessment of potential dust effects for each receptor location and for each stage of the CDP site development are shown in the last column of Table 14.

Table 14: Mineral dust risk assessment (Large Source Assumption).

Receptor	CDP Stage	%-time >5m/s (dry days)	Relative frequency	Distance to receptor (m)	Pathway Effectiveness	Dust Impact Risk	Magnitude of dust effects#
2	2	0.6	Infrequent	433	Ineffective	Low Risk	Negligible
2	3	4.1	Infrequent	255	Ineffective	Low Risk	Slight Adverse
3	2	3.9	Infrequent	156	Ineffective	Low Risk	Slight Adverse
3	3	6.8	**Moderate**	395	Ineffective	Low Risk	Slight Adverse
4	2	3.8	Infrequent	380	Ineffective	Low Risk	Slight Adverse
5	1	1.0	Infrequent	310	Ineffective	Low Risk	Slight Adverse
6	1	0.8	Infrequent	660	Ineffective	Low Risk	Negligible
7	3	1.1	Infrequent	385	Ineffective	Low Risk	Slight Adverse
9	3	0.3	Infrequent	1200	Ineffective	Low Risk	Negligible

All receptors are assumed to have a *High Sensitivity* to dust impacts.

9.2.3 Impacts of soil dust erosion - windy day frequency and duration

In this section an analysis of windy day frequency and duration are assessed, and results presented in Table 15. This information relates to the risk of dust effects during to erosion of dust from exposed areas during dry windy days. For these conditions the wind speed threshold of ≥6 m/s has been assumed as this a more accepted threshold wind speed for mobilisation of surface dust in New Zealand.

Based on the results in Table 15 our assessment of erosion related dust risk is consistent with the results of the IAQM assessments for each receptor above. However, this analysis does indicate that receptor location 3 is likely to be most prone to dust erosion effects, and therefore the need for some dust mitigation during Stage 2 of the CDP construction.

Table 15: Windy dry day frequency, durations, buffer and relative dust risk.

Receptor	CDP Stage	%-time ≥6 m/s	1-6 hours Durations (no./year)	7-12 hours Durations (no./year)	13-25 hours Durations (no./year)	Distance to receptor (m)	Relative Buffer	Erosion Dust Risk#
2	2	0.3	10	>0.5	0	433	Large	Very Low
2	3	2.8	72	7	<0.5	255	Medium	Low-Moderate
3	2	2.7	70	7	<0.2	156	Small	Moderate
3	3	5.3	89	12	7	395	Large	Low

Receptor	CDP Stage	%-time ≥6 m/s	1-6 hours Durations (no./year)	7-12 hours Durations (no./year)	13-25 hours Durations (no./year)	Distance to receptor (m)	Relative Buffer	Erosion Dust Risk#
4	2	2.7	27	2	<0.2	380	Large	Low
5	1	0.54	26	1	<0.5	310	Medium	Very Low
6	1	0.45	23	1	0	660	Large	Negligible
7	3	0.6	22	>0.5	0	385	Large	Very Low
9	3	0.2	8	>0.5	<0.2	1200	Very Large	Negligible

 # Golder assessment of dust nuisance risk from wind erosions at offsite receptors.

9.2.4 Impacts from onsite dust sources - light to moderate wind frequency and duration

In this section an analysis of dry day frequency and duration when the wind is of moderate strength, or less. These conditions can cause worst case offsite impacts due to dust from truck movements onsite, concrete batch and other dust sources which are not related to wind speed. The results are presented in Table 16 for wind speed threshold of <6 m/s.

Based on the results in Table 16 our assessment of erosion related dust risk is consistent with the results of the IAQM assessments for each receptor above. However, this analysis does indicate that receptor location 3 is likely to be most prone to dust erosion effects, and therefore the need for some dust mitigation during Stage 2 of the CDP construction.

Table 16: Non windy dry day frequency, durations, buffer and relative dust risk.

Receptor	CDP Stage	%-time <6 m/s	1-6 hours Durations (no./year)	7-12 hours Durations (no./year)	13-25 hours Durations (no./year)	Distance to receptor (m)	Relative Buffer	Erosion Dust Risk#
2	2	2.3	80	5	0	433	Large	Low
2	3	6.0	160	20	0	255	Medium	Moderate
3	2	5.4	160	15	1	156	Small	Moderate
3	3	5.9	250	<10	<5	395	Large	Low
4	2	4.1	210	5	1	380	Large	Low
5	1	4.3	156	8	0	310	Medium	Low
6	1	2.7	127	3	0	660	Large	Negligible
7	3	3.8	110	5	0	385	Large	Low
9	3	1.1	60	1	0	1200	Very Large	Negligible

 # Golder assessment of dust nuisance risk from wind erosions at offsite receptors.

9.2.5 Impacts during operational hours

Consideration of dry day frequency and duration for all wind during operation hours is the final analysis which can help confirm receptor location risk to construction dust impacts. The hours of operation (assuming between 7 am and 6 pm) are more likely to cause dust impacts due to active sources such as concrete batch and especially truck movements. The results are presented in Table 17 for all wind speeds but restricted to the hours when construction activities are likely to occur. As for the other assessments for dust risk, the focus on operational hours also highlights receptor locations 2 and 3 as having a moderate risk to construction dust effects and therefore standard practices to reduce construction dust effects will be justified to ensure minor, or less than minor effects at these two locations at least.

Table 17: Operational hours wind frequency, buffer and relative dust risk (7 am – 6 pm).

Receptor	CDP Stage	%-time m/s	Distance to receptor (m)	Relative Buffer	Erosion Dust Risk[#]
2	2	4.1	433	Large	Low
2	3	13.9	255	Medium	Moderate
3	2	12.8	156	Small	Moderate
3	3	11.8	395	Large	Low-Moderate
4	2	6.5	380	Large	Low
5	1	0.5	310	Medium	Negligible
6	1	0.5	660	Large	Negligible
7	3	7.0	385	Large	Low
9	3	1.6	1200	Very Large	Negligible

 # Golder assessment of dust nuisance risk from wind erosions at offsite receptors.

9.3 Construction Dust Mitigation

Construction dust mitigation measures are likely to be necessary to ensure only minor, or less construction dust effects and be included within a construction dust management plan (DMP). Note that a detailed assessment of potential dust effects, with the benefit of detailed construction plans, methods, material volumes and site soil conditions, would be necessary to reliably assess the necessary mitigation measures for achieving *less than minor* nuisance effects due to construction dust. Even with this information, it would be difficult to reliably assess the necessary practical measures, which would achieve this environmental endpoint, unless sensitive receptors are well over 500 m from the construction area in this instance. However, it is our view that achieving a minor potential for nuisance effects is very likely to ensure a *less than minor*, if not *negligible* potential for any adverse health effects due to construction dust related impacts.

Recommended measures and other additional measures, which may be necessary to achieve a minor potential for adverse nuisance effects from construction dust, are listed below.

9.3.1 Recommended dust mitigation measures

- Earthworks, including excavation, haulage and loading/unloading activities within the construction area, cease when houses are downwind on dry days when wind speeds reach 7 m/s or higher.
- Use of several low-cost ambient particulate sensors[7] to monitor boundary dust levels in real time and provide alarms of high levels in conjunction with small automatic wind speed-direction monitor.
- Regular liaison with surrounding neighbours.
- Onsite vehicle speed restriction to <20 km/hr.
- Polymer covering of soil stockpiles when experience shows these produce dust emissions.
- Delivery of cement and fine materials within enclosed tankers and stored in silos.
- Use watercart to dampen surfaces which generate visual dust plume which extend beyond the CDP site boundary.
- Don’t use dust sweepers, which themselves generate dust, unless they are water assisted.
- Use water and sweeping to remove any material tracked onto public road.
- Ensure vehicles entering and leaving site with dusts are covered to prevent escape of materials during transport.

9.3.2 Additional dust mitigation for consideration

The following list of measures (recommended by IAQM[6]) are probably not required, but depending on site conditions these may prove to be necessary:

- Implement a wheel washing system with rumble grids to dislodge accumulated dust and mud prior to leaving the site, wherever reasonably practicable.
- Install a truck wheel wash facility to remove mud from tyres leaving the site.
- Ensure there is an adequate area of hard surfaced road between the wheel wash facility and the site exit, wherever site size and layout permits.
- Install hard surfaced haul routes, which are regularly damped down with fixed or mobile sprinkler systems, or mobile water bowsers, and regularly cleaned.

[7] An example being the Modulair-PM units supplied by Quant-AQ, https://www.quant-aq.com/

10.0 POTENTIAL ODOUR EFFECTS

10.1 Introduction

10.1.1 Main sources

As with the assessment of potential dust effects, an analysis of separation distances from odour sources and downwind frequency of specific sensitive locations helps to establish the risk of odour effects from the two proposed processing plants.

The proposed food processing plant is very likely to be the most significant potential source of odour discharge, and far more significant than the bioplastics processing plants. For the proposed food producing plant, a 50 m x 200 m area of odour generation was assumed at centre of the food producer area shown in Figure 2. This was to represent multiple dryer discharge vents for multiple processing lines within the 10 ha site. This area was used to establish representative downwind frequencies for the sensitive receptor locations (as shown in Figure 1) with respect to the food producing plant.

A similar downwind frequency assessment was not undertaken for the smaller bioplastics plant whose output (approximately 20 t/day) would be an order of magnitude lower than the food processing plant’s daily production.

10.1.2 Pine odours from logs

The storage, handling and debarking of logs at the site (up 1500 t/day entering the site via truck and railway wagons) will create a pine type odour due to release of pinenes and other natural wood volatiles. Given the location of the log yard at the western side of the CDP site (shown in Figure 2), and local wind patterns (shown in Figure 3), occupants of nearby residential dwellings (i.e., receptors 5 and 6 in Figure 1) could notice a pine type of odour on infrequent occasions. Given the low frequency of exposure to this relatively pleasant to neutral type of odour, then no further consideration is given to odours associated with log storage, processing and handling at the site.

10.2 Odour Risk

10.2.1 Wind speed categories

To assess the risk of odour effects from the proposed pet food processing facility, the downwind frequency (%-time) for the following wind speed categories listed below were assessed:

- <1 m/s (all hours)
- <1 m/s (night hours)
- <3 m/s (all hours)
- <7 m/s (all hours)
- <7 m/s (daylight hours only)

The lowest wind speed category (less than 1 m/s) is the worst-case for odour dispersion (i.e., least dilution with distance from the source) and often relate to cold air drainage flows, which result when the ground temperature falls below the above air temperature as the sun sets. They may start before sunset and persist after sunrise. Identifying which residential dwellings are likely to be downwind of the food producing plant during these worst-case conditions and the separation/buffer distance is necessary for the odour risk analysis, and further examination of these conditions is provided in Section 10.2.2.

Wind speeds below 3 m/s are light wind conditions. These are most common and also provide restriction on dilution of odour which are discharged from the source. Down-valley drainage flows can travel at these wind speeds – depending on the steepness of the valley. Some of the northerlies and north-northeasterlies in this range seen in Figure 3 (right) are likely to represent flows draining down the Rangitikei River valley.

An upper wind speed category of 7 m/s has been specified, because hourly average wind speeds above this value, result in rapid dilution of odour with distance from its point of release at the site. As such, odour complaints associated with food processing sites are typically associated with wind speeds below 7 m/s.

10.2.2 Drainage flows

Wind directions in the Ohakea meteorological data which are less than 1 m/s to 2 m/s are likely to be associated with drainage flows, especially if these occur during night-time hours (including just before sunset and just after sunrise). Drainage flow directions are influenced by the regional and local topography, and the recorded wind directions for these at Ohakea are likely to be in an opposite direction to those occurring at the CDP site, under light wind conditions. At the CDP site it is expected that these drainage flows would be associated with the air mass near ground level (i.e., the first 20 m – 50 m layer of air above the ground) drifting from the CDP site towards the southeast of the site (as terrain slopes in this direction towards the Rangitikei River). On the slightly larger scale, down-valley differences in terrain elevation may lead to drainage flows at higher wind speeds (up to, say, 2 m/s). These have their signature in Figure 3 for both the Ohakea site (observations), and the modelled Marton site. The direction of the larger-scale drainage flow is likely to be similar at both locations, being the down-valley direction.

10.2.3 Downwind frequency results

Table 18 provides a summary of downwind frequency and distances from the proposed food producing site when located within the area for this activity shown in Figure 1. This indicates a significant odour risk to occupants of dwellings at receptor locations 2 and 7 because of the moderate buffer distance and downwind frequency over 3 % of the time, for which the majority occurring during daylight hours. Receptor locations 3 and 4 have a moderate odour risk for different reasons.

Receptor 3 has a moderate buffer distance and 3.5 % downwind (again the majority of which relates to daylight hours).

Receptors 4 and 5 have a significant buffer distance from the food production location, but either location could be downwind of the food production plant during worst-case drainage flow conditions, which occur mainly at night-time. The Ohakea wind information can only be used to provide indicative estimates of what the frequency of drainage flows could be at the CDP site, but its directions are not likely to reflect what would occur at the CDP area.

Given the above, we have estimated the % time for receptors 4 and 5 being downwind of the food production plant during drainage flows. These results are shown in Table 18 and are based on the total frequency of winds below 0.5 m/s (for all directions), plus the frequency of wind speeds occurring between 0.5 m/s and 1.5 m/s at Ohakea, which drift from the NE to SE directions. Based on the slope of the terrain, we expect very light and localised drainage flows at Ohakea airbase to drift from these directions. During these conditions at Ohakea, there is also likely to be similar drainage flow conditions occurring at the CDP area, but based on terrain at CDP location, these flows are likely to drift more towards a southeast to southwest direction range (i.e., moving from the CDP area and towards the general direction of either of receptors 4 or 5, or in between). Therefore, the < 1 m/s frequency values in Table 18 for these two receptors are only indicative of what could occur in practice in terms of exposure to the food production plant odour emissions during drainage flow conditions. Site specific wind flow measurements using low wind speed and direction threshold instruments would be necessary to obtain accurate drainage flow behaviour at the CDP site.

Table 18: Downwind frequencies (% of time) versus wind speed thresholds.

Receptor	Distance from source (m)	Relative Buffer	Percentage time (%) downwind versus wind speed thresholds				
			<1 m/s (all-hours)[*]	<3 m/s (all-hours)	<7m/s (all-hours)	<7 m/s (daylight)	<1 m/s (night)[*]
2	450	Moderate	0.05	0.8	3.2	2.8	0.03
3	600	Moderate	0.08	0.8	3.6	1.9	0.05
4	980	Large	≈1.5	2.5	5.8	2.3	≈1.2
5	800	Large	≈1.5	3.1	3.4	1.1	≈1.3
6	1100	Large	0.07	1.0	1.4	0.5	0.04
7	460	Moderate	0.1	1.3	3.4	2.8	0.07
9	1300	Large	0.04	0.4	0.6	0.5	0.02

[*] These winds are mostly related to cold air drainage flow conditions.

Note: daylight and night-time cases are fractions of all hours, not daylight or night-time hours.

10.3 Odour Mitigation

10.3.1 Summary

To avoid objectionable odour beyond the CDP site boundary, the proposed petfood processing plant is likely to require odour capture and treatment systems for its discharges to air from the final product drying stage. The close proximity of the bioplastic manufacturing plant to houses located to the east, is also likely to require the capture of process and drying air streams, which are otherwise discharged to atmosphere. The options for achieving effective mitigation are discussed below.

10.3.2 Food production plant

The options for treating dryer exhaust air streams for odour include odour scrubbing and biofiltering/scrubbing type odour abatement systems. For a flow of 50,000 m^3/hr, a biofilter bed in the order of 1000 m^2 would be required. This scale of an odour control biofilter would require a buffer distance to residential dwellings in the order of 100 m to 200 m, so that its own bark/earthy odour is not frequently recognised by occupants and cause some nuisance. Likewise, if using the chemical scrubbing option for odour control at the proposed food production plant (e.g., an ozone/water scrubbing system), then this is also likely to require a similar minimum buffer distance to the nearest residential dwellings to avoid nuisance (both residential odour and from a visible cloudy plume). The location of the food production plant in Figure 2 would readily allow for such buffer distances.

Direct ozone injection into the drying process or the dryer discharge stack is another odour abatement option that the industry does employ, however the effectiveness of this option is not well established in New Zealand. This option would need to be trialled and the effectiveness established should it be contemplated as the primary odour abatement system in this instance.

10.3.3 Bioplastics plant

It is proposed to use a Biofilter system to treat odorous drying exhaust air streams and carbon filter type cannisters for removing odour from low flow airstreams which are discharged from the centrifuges. These are both standard odour abatement methods which are appropriate for low (cannister filters) and high flow (Biofilter) odorous streams. Both approaches can effectively eliminate process odour emissions when sized and operated to good practice, although biofilters to impart their own earthy/bark odour requiring a small buffer distance to the nearest houses (discussed below).

With regards .to ventilation/displacement air from sludge storage tanks, the use of cannister filters is also a practical technology that can be applied to abate odour emissions from this source if necessary.

Compared to the food production plant, the bioplastics plant should require a much smaller buffer distance to nearby residential dwellings (i.e., in the order of 50 m) given the smaller scale of its air discharges and much smaller biofilter that is likely to be required at this site.

10.3.4 Summary

In summary, it is considered that both the petfood and bioplastics processing plants which are proposed for the CDP site, have sufficient buffer distance to sensitive offsite receptors to ensure that standard odour extraction and treatment system could be employed to ensure that residual odour exposure at sensitive locations offs-site, are minor, or less than minor.

11.0 DISCUSSION

11.1 Respirable Particulate Sources

11.1.1 Biomass combustion

The combustion of biomass by the two BFBs is predicted to be the most dominant source for the increase 24-hour PM_{10} and $PM_{2.5}$ GLCs occurring at House #5 due to the CDP. This house is closer to the energy plant and food producer than other receptors.

This assessment has conservatively assumed a combined energy input (for both energy plants) of 70 MW and medium height discharge stacks (20 m for the food producer and 30 m for the energy plant). Using higher stacks can further reduce the increase in ground level concentrations at this receptor.

The combustion of wood at the rate of 70 MW may also be much higher than what might occur in practice. It is noted that the particulate emissions associated with the BFBs have low uncertainty given they are based on combustion exhaust stoichiometry and well-established bag-house filter performance. Therefore, the predicted energy plant ambient particulate impacts are expected to represent a realistic worse case and it is clearly practical to reduce these values.

11.1.2 Diesel powered mobile plant

The DPM from diesel powered mobile plant is predicted to be the main source of increased 24-hour PM_{10} and $PM_{2.5}$ GLCs at House #1. The train and truck related emissions account for a small fraction (10 %) of the total DPM, while the log/container loaders contribute approximately 90 % of the total PM_{10} and $PM_{2.5}$ which is associated with DPM.

The emission estimation of diesel-powered mobile plant has used the US EPA emission factors. In regard to train related particulate emissions, the EU emission factors assumed, were compared to those measured for locomotives in New Zealand in 2021 (when operating at low power outputs) and these sets were consistent.

The assumed power outputs and time frames for locomotive idling or travelling through Marton are based on the assumptions of trains leaving under full power and arriving at the rail siding at 10 % of full power (i.e., when wagons are breaking). The number of arrivals per day of trains with 30 fully loaded wagons (i.e., six per day) is likely to overstate what will occur in practice. Likewise, the assumption of 155 truck arrivals/departures per day is also likely to exceed the actual level of truck activity.

Therefore, it is considered the DMP estimated emissions from the CDP and resultant impact assessment would represent a realistic worst-case scenario.

11.1.3 Log debarker

The log debarker contributes the highest PM_{10} source at the horse training facility, while it is the second highest PM_{10} source at the nearest houses. This is dominated by crustal material (dominated by coarse PM_{10}). As such, the contribution of $PM_{2.5}$ emissions from the log debarking to off-site concentrations is much lower than the more dominant combustion sources.

The assessment has assumed no emission controls for the log debarker. It is considered that mitigation measures such as water suppression is likely to reduce crustal derived PM_{10} impacts within the order of 80 % and likewise the potential exposures off site.

11.1.4 Wheel generated crustal dust

The PM_{10} and $PM_{2.5}$ effects due to the crustal dust from truck and loader movements are generally lower than those from DPM. As with DPM emissions, the conservative assumption of 155 truck arrivals/departures per day is likely to have created conservative wheel movement related crustal dust emission estimates. Furthermore, the assumption of all the loaders (four in total) moving non-stop at 10 km/hr for 10 hours per day is also likely to have resulted in conservative emission estimates from this activity.

11.2 Daily and Annual Exposures – Respirable Particulate

11.2.1 Incremental exposure due to the CDP

The incremental rise in 24-hour PM_{10} and $PM_{2.5}$ concentrations due to a realistic worst-case level of activity at the CDP is approximately 10 %, or less of human health-based criteria at the nearest houses. Whereas for the horse training facility this increment is approximately 2 % of the health-based criteria.

The incremental rise in annual PM_{10} and $PM_{2.5}$ concentrations due to a realistic worst-case level of activity at the CDP is approximately 3 %, or less of health-based criteria at the nearest houses. Whereas for the horse training facility this increment is approximately 0.4 %, or less of the health-based criteria.

The above assessments of incremental concentrations should represent upper estimates to what would occur in practice. This is because main industrial activities will need to undertake air discharge consenting processes, which are likely to impose the Best Practicable Option for minimising emissions. Furthermore, the rates of activity which this assessment has assumed for truck, train and loader movements and rates of wood combustion for energy production are conservatively high.

11.2.2 Cumulative exposure

The 24-hour and annual cumulative PM_{10} and $PM_{2.5}$ concentrations at the assessed locations are mainly driven by the existing background concentrations. Due to the low incremental effects of the CDP and existing background levels, the 24-hour and annual PM_{10} and $PM_{2.5}$ levels are likely to occur at all sensitive receptor locations (especially the horse training facility) and are likely to be 50 % or less (for nearby houses) of the relevant human health-based guideline criteria.

For the horse training facility, the cumulative PM_{10} and $PM_{2.5}$ concentrations are likely to remain within 40 %, or less than the human health-based criteria and would only have a very small contribution from the CDP operation. Furthermore, the relocation of the existing petfood manufacturing plant from its current nearby location to the west of the horse training facility, may well result in no change to existing PM_{10} and $PM_{2.5}$ exposure levels, or even a reduced exposure, as this plant would be located at a greater distance from the facility. The residual ambient impact from the existing plant at the horse training facility was outside the scope of this assessment. However, it is clear that moving this site to the proposed CDP location (which is much further away from the horse training facility), will reduce the current level of air quality impact from this existing plant.

The WHO (2005)[8] state that "*The long-term mean $PM_{2.5}$ guideline concentration of 10 µg/m^3 is based on the lower end of the range at which significant effects on survival were observed in the American Cancer Society's (ACS) study, including cardiopulmonary and lung cancer mortality…*".

It is understood that WHO guidelines for ambient PM_{10} and $PM_{2.5}$ are designed to reduce human health risk from exposure to an acceptably low level.

Given the above guidance from WHO and assessed daily and long term cumulative PM_{10} and $PM_{2.5}$ concentrations, this indicates a low potential for human health effects from cumulative particulate exposures at the residential dwelling.

The very small change to existing cumulative PM_{10} and $PM_{2.5}$ concentrations at the horse training facility indicates that the scenario of industrial developments proposed at the CDP site poses a very low incremental health risk to horses at the training facility. Likewise, the cumulative concentrations are likely to remain well within human-health based criteria for daily and long-term annual exposure.

11.3 Construction Dust

The scale of construction during each stage is sufficient to require proactive dust mitigation measures such as those listed in Section **Error! Reference source not found.** – especially for residential dwellings 2, 3 and 5 as shown in Figure 1. The need for a wheel wash or not, will become clear if trucks leaving the start to track mud onto Makirikiri Road.

For both erosion related dust impacts and those due truck movements and other activities onsite, residential dwellings 2 and 3 have a moderate risk of adverse effects if no dust mitigation measures were routinely applied. However, given the buffer distance to these houses and others further away, it is considered that application of standard measures such (as listed in 0) and possibly including the wheel wash measures as described in 9.3.2, should readily ensure only minor levels nuisance effects, and less than minor, or negligible potential for any adverse health effects.

For locations which would have large (i.e., receptors 6 and 8), or a very large separation/buffer distance (Horse training facility) from the CDP's construction stages, the analysis indicates that people at these locations are likely to experience negligible levels of construction dust, even if there are limited dust mitigation procedures employed. Nuisance effects for these two distant receptors (which have large separation distances from the CDP area) should be readily controlled, so that they are less than minor.

11.4 Odour Effects

The scale of the proposed food production plant is such that it is likely to require best practice odour mitigation measures applied to product drying exhaust air streams to ensure only minor odour effects (i.e., odour which

[8] World Health Organisation (WHO) 2005. *Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulphur dioxide*. Global update 2005, Summary of risk assessment. Available at: http://www.euro.who.int/__data/assets/pdf_file/0005/78638/E90038.pdf

is not objectionable or offensive) at surrounding residential dwellings. Whether or not an ozone (or other chemical) based scrubbing system, or a biofilter system is the best option for removing odour from process streams can be determined once specific parameters such as flow, temperature and humidity are established. However, it is clear that both options, when meeting good-design practice, is likely to achieve a minor level of odour impact and therefore a minor potential to cause nuisance/objectionable effects.

Given the scale of the proposed food production plant and proximity of the nearest residential dwellings to this development (shown in Figure 2), then achieving *less than minor* potential for nuisance odour effects may not be as practical to achieve for the nearest residential dwellings.

For the bioplastics manufacturing plant, it is likely that odour effects can be controlled using standard odour abatement technology, such that these only cause a *less than minor* potential for nuisance effects.

12.0 CONCLUSIONS

12.1 Respirable Particulates

Given the assessment assumptions and findings, then the following conclusions are made with respect to potential respirable particulate effects due to the proposed activities within the established CDP area:

- The discharge of respirable particulate (both crustal and combustion derived) would be the primary air contaminant for causing any adverse air quality effects associated with the proposed scenario of industrial activities at the CDP site.
- The proposed industrial hub could cause a low increase (≤10 % of health-based criteria) to the existing ambient respirable particulate levels occurring at nearby houses, and a very low increase (≤2 % of health-based criteria) to existing ambient levels occurring at the Marton horse training facility.
- The cumulative particulate exposures at the most impacted residential dwellings, following the establishment of the proposed scenario industrial activities at the CDP site, are likely to remain well within health guideline criteria, and can be further reduced via the application of standard particulate emission mitigation measures, which could be imposed via normal air resource consenting processes.
- The cumulative particulate exposures at the Marton horse training facility, following the establishment of the proposed scenario industrial activities at the CDP site, are likely to change very little, and also remain well within health guideline criteria. These potential exposures could also be further reduced via the application of standard particulate emission mitigation measures, which could be imposed via normal air resource consenting processes.

12.2 Construction Dust Effects

Given the assessment assumptions and findings, then it is concluded that during construction of the CDP area and infrastructure, that construction dust emissions could be reliably controlled (using good practice dust mitigation methods), such that there is only a minor, or less potential to cause nuisance dust effects at the nearest sensitive receptor locations. For sensitive receptors over 500 m from the CDP area (including the Marton Horse training facility), these potential effects are likely to be less than minor, or lower, given good practice dust mitigation methods are employed.

It is also concluded the potential for any adverse health effects associated with construction of the CDP area could be reliably controlled to a *less than minor*, and probably a *negligible* level for all sensitive receptor locations.

12.3 Odour Effects

It is concluded that the most significant source of odour impact from the CDP area is likely to be discharges from the food production plant. Given its proposed location, it is concluded that implementation of accepted good practice odour abatement technology for treating discharged process air streams, is likely to ensure a minor, or less potential for nuisance odour (i.e., odour that is objectionable or offensive to an extent that it causes an adverse effect) to occur at the nearest off-site sensitive receptors (i.e., a minor potential for nuisance odour to occur). Furthermore, the level of odour impact is likely to be practically reduced, such that the potential for nuisance odour effects is *less than minor*, if not negligible for sensitive receptors over 500 m from the CDP area (including the Marton Horse training facility).

Signature Page

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RSC/NG/mt

https://golderassociates.sharepoint.com/sites/144965/project files/6 deliverables/004 r_air quality report/21464670-004-r-rev1_air modelling report_combined_with_bos.docx

APPENDIX A

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APPENDIX B

CALPUFF Modelling

1.0 INTRODUCTION

CALPUFF version 7.2.1 was run from 1 January 2016 to 31 December 2017. Most standard options were used, including the 'pdf' formulation for dispersion under convective conditions (Scire, Strimaitis & Yamartino 1999; TRC 2011). Contaminant concentrations were calculated at a number of discrete receptors, and on nested grids with 50 m and 200 m spacing.

The 24-hour and annual average ground level concentrations of PM_{10} and $PM_{2.5}$ were modelled. The generic model parameters, emission rates and building information are presented in Section 2.0 to 4.0. A total of nine sub-runs containing different emission sources were set up to reduce the model computational time. The results of each sub run were then summed by using CALSUM.

2.0 GENERIC CALPUFF PARAMETERS

A fuller list of parameters used in the CALPUFF runs is given in the following tables. Parameters not mentioned below should be assumed to take default values, or they relate to a particular feature of the model that is not used.

Table 1: CALPUFF start and end times.

Parameter		Value	
Start date/time		00:00	1 January 2016
End date/time		23:00	31 December 2017
Base time zone	XBTZ	-12 (NZST)	
Time step	NSECDT	3600 s	
Number of runs		9	

Table 2: Pollutant specifications.

Parameter		Value	
Number of chemical species	NSPEC	2	
Number of emitted species	NSE	2	
Species; modelled; emitted; deposited?		PM_{10} $PM_{2.5}$	Yes; Yes; No Yes; Yes; No
Chemical mechanism	MCHEM	0	(No chemistry)
Dry deposition	MDRY	1	(Modelled dry deposition)
Wet deposition	MWET	0	(No wet deposition)

Table 3: Technical options.

Parameter		Value	
Dispersion coefficient calculation	MDISP	2	use micrometeorological variables
PDF for dispersion under convective conditions	MPDF	1	(On)
Building downwash	MBDW	2	Prime
Check parameters for regulatory settings		No	(they are USEPA-specific)
Minimum σ_v over land (default 0.5 m/s)		0.5 m/s	

Table 4: Map projection (parameters should match CALMET).

Parameter	Value
Map projection	Universal Transverse Mercator (UTM)
Datum region	WGS-84
UTM Zone	60 S

Table 5: Grid control.

Parameter		Value
SW corner of grid cell (1,1)		(351.815, 5545) km (UTM)
Grid dimensions	NX x NY; DGRIDKM	100 x 100 grid cells at spacing 250 m
Vertical grid, number of layers		11
Cell-face heights for vertical grid (m)		0, 20, 50, 100, 200, 300, 450, 650, 950, 1400, 2000, 3000
Use of sampling grid (gridded receptors)?		No
Nested grid receptors SW corner		362.958, 5559.149 km UTM
Nested grid receptors box size (width by height)		2.2 km by 3 km
Nested grid receptors spacing		50 m
Nested grid receptors distance from bounding box		1800 m
Nested grid receptors receptor spacing		200 m

Table 6: Discrete receptors.

Number	UTM Easting (m)	TUM Northing (m)	Ground Elev. (m)*
1	364802.43	5559830.97	126.03
2	365010.01	5559607.42	120.17
3	364919.44	5560004.33	127.41
4	365115.48	5559233.85	118.8
5	363513.11	5559556.17	126.35
6	363148.81	5559598.87	125.98
7	364712.42	5560396.35	135.01
8	364449.06	5558695.76	118.09
9	363618.2	5561221.74	139.65

Note: * Above mean sea level – height shown is that of the CALMET grid cell containing the receptor point.

3.0 SOURCE PARAMETERS

The modelled point sources, volume sources and line volume sources are summarised in Table 7, Table 8, Table 9.

Table 7: Point source parameters and emission rates for PM_{10} and $PM_{2.5}$ (no diurnal scaling factor applied).

Source ID	Desc	Coordinates (UTM, m)	Base elevation (m)	Height (m)	Diameter (m)	Velocity (m/s)	Efflux temp(K)	PM_{10} (m/s)	$PM_{2.5}$ (m/s)
SRC_1	Energy plant BFB	363869, 5559577	126.92	30	1.7	15.7	423	0.65	0.59
SRC_2	Food Producer BFB	363970, 5559994	131.35	20	1.2	15.75	423	0.33	0.29

Table 8: Volume sources parameters and emission rates for PM_{10} and $PM_{2.5}$.

Source ID	Desc	Height (m)	Base elevation (m)	Sigma Y (m)	Sigma Z (m)	PM_{10} (g/s)	$PM_{2.5}$ (g/s)	Diurnal pattern scaling factor
SRC_3	Debarker	1	127	0.5	0.5	0.2	0.001	0,0,0,0,0,0,0,1,1,1,1,1,1,1,1,1,1,1, 0,0,0,0,0,0
SRC_4	Log Loaders	3.6	127.58	5	0.9	0.075	0.063	
SRC_5	Container loaders	5	125.01	6.1	1.25	0.063	0.053	
SRC_6	Locomotive - idling D'	4.5	127.47	4.6	1.13	0.006	0.006	0,0,0,0,0,0,1,0,1,0,1,0,1,0,1,0,1,0, 0,0,0,0,0,0,
SRC_7	Locomotive - idling D	4.5	123.95	4.6	1.13	0.006	0.006	0,0,0,0,0,0,0,1,0,1, 0,1,0,1,0,1,0,1, 0,0,0,0,0,0,

Table 9: Line volume sources parameters and emission rates for PM_{10} and $PM_{2.5}$.

Source ID	Desc	Length of side (m)	Total line length (m)	Sigma Z (m)	Release height (m)	PM_{10} (g/s)	$PM_{2.5}$ (g/s)	Diurnal pattern scaling factor
SCR_8	Trucks	30	2182.2	3.56	1.78	0.022	0.0061	0,0,0,0,0,0,0,1,1,1,1,1,1,1,1,1,1,1, 1,0,0,0,0,0,0
SCR_9	Trains A-B	80	2627.3	4.5	2.25	0.020	0.020	0,0,0,0,0,0,0,0.05, 0,1,0,0.05,0,1,0, 0.05,0,1, 0,0,0,0,0,0,0
SCR_10	Trains B-C	80	3362.7	4.5	2.25	0.050	0.050	
SCR_11	Trains C-D	80	1392	4.5	2.25	0.002	0.002	0,0,0,0,0,0,1,0,0,0,1,0,0,0,1,0,0, 0,0,0,0,0,0,0
SCR_12	Trains E-D	80	1288.7	4.5	2.25	0.027	0.027	0,0,0,0,0,0,0,0,1,0,0,0,1,0,0,0,1, 0,0,0,0,0,0,0
SCR_13	Trains E-F	80	1052.3	4.5	2.25	0.015	0.015	0,0,0,0,0,0,0,0,0.05,0,1,0,0.05,0, 0.05,0,1, 0,0,0,0,0,0,0
SCR_14	Trains F-G	80	1279.8	4.5	2.25	0.010	0.010	
SCR_15	Trains C-D'	80	856.6	4.5	2.25	0.027	0.027	0,0,0,0,0,0,0,0,1,0,0,0,1,0,0,0,1, 0,0,0,0,0,0,0
SCR_16	Trains E-D'	80	801.6	4.5	2.25	0.024	0.024	0,0,0,0,0,0,0,0,0,0,1,0,0,0,1,0,0, 0,1,0,0,0,0,0
SCR_17	Trains a-b	80	2618.7	4.5	2.25	0.010	0.010	1 x 24
SCR_18	Trains b-c	80	3329.3	4.5	2.25	0.033	0.033	
SCR_19	Trains c-d	80	2988.2	4.5	2.25	0.012	0.012	

4.0 BUILDING INFORMATION

```
'P'
'METERS'  1.00000000
'UTMY'  0.0000
2
'BLD_1'  1       126.96
   4        15.00
         363861.59     5559589.34
         363881.29     5559585.87
         363876.95     5559561.25
         363857.25     5559564.72
'BLD_2'  1       131.27
   4        10.00
         363958.05     5559989.12
         363961.42     5560003.73
         363980.91     5559999.23
         363977.54     5559984.62
```

5.0 REFERENCES

Scire JS, Strimaitis DG, Yamartino RJ 1999. A user's guide for the CALPUFF dispersion model (version 5.0). Earth Tech, Inc., Boston.

TRC 2011. Generic Guidance and Optimum Model Settings for the CALPUFF Modeling System for Inclusion into the 'Approved Methods for the Modeling and Assessments of Air Pollutants in NSW, Australia'. Prepared for NSW Office of Environment and Heritage, Sydney, Australia, March 2011.

APPENDIX C

CALMET Modelling

1.0 INTRODUCTION

This Appendix describes the development of a meteorological data set which will be used for this dispersion modelling. The end point of this development is a CALMET hourly, three-dimensional, gridded model of the meteorological parameters (wind, temperature, humidity, cloud, etc.). CALMET can be based on local surface and upper-air measurements, or on a prognostic, 'forecasting' model. In this case, CALMET's meteorological fields were based on the outputs of the prognostic model TAPM.

The following sections detail the development of the TAPM and CALMET meteorological model, including review of data, configuration of TAPM and CALMET models.

2.0 MODEL YEAR SELECTION

A two-year period meteorological modelling was carried out to capture some inter-annual variability and model a wider range of conditions than those that might occur in a single year.

The most recent eleven-year meteorological data (January 2010 to December 2020, inclusive) obtained from Ohakea Aero Weather Station have been used to aid decisions on the years modelled. The Ohakea Aero is operated by Met Service (Network number: E05231).

Golder has examined the wind patterns for these periods from the above site (see Figure 1). There is little variation between years, with prevailing northerlies and westerlies.

Temperature data from this site were also examined. Figure 2 shows the monthly averaged temperatures for periods from 2010 to 2020 are very similar. Wind data availability has been also taken into consideration. It shows 2016 and 2017 have more than 99.8 % data capture rate, comparing to less than 99 % in 2018, 2019 and 2020.

Based on the above, the 2016 and 2017 were selected, considering the availability of meteorological data.

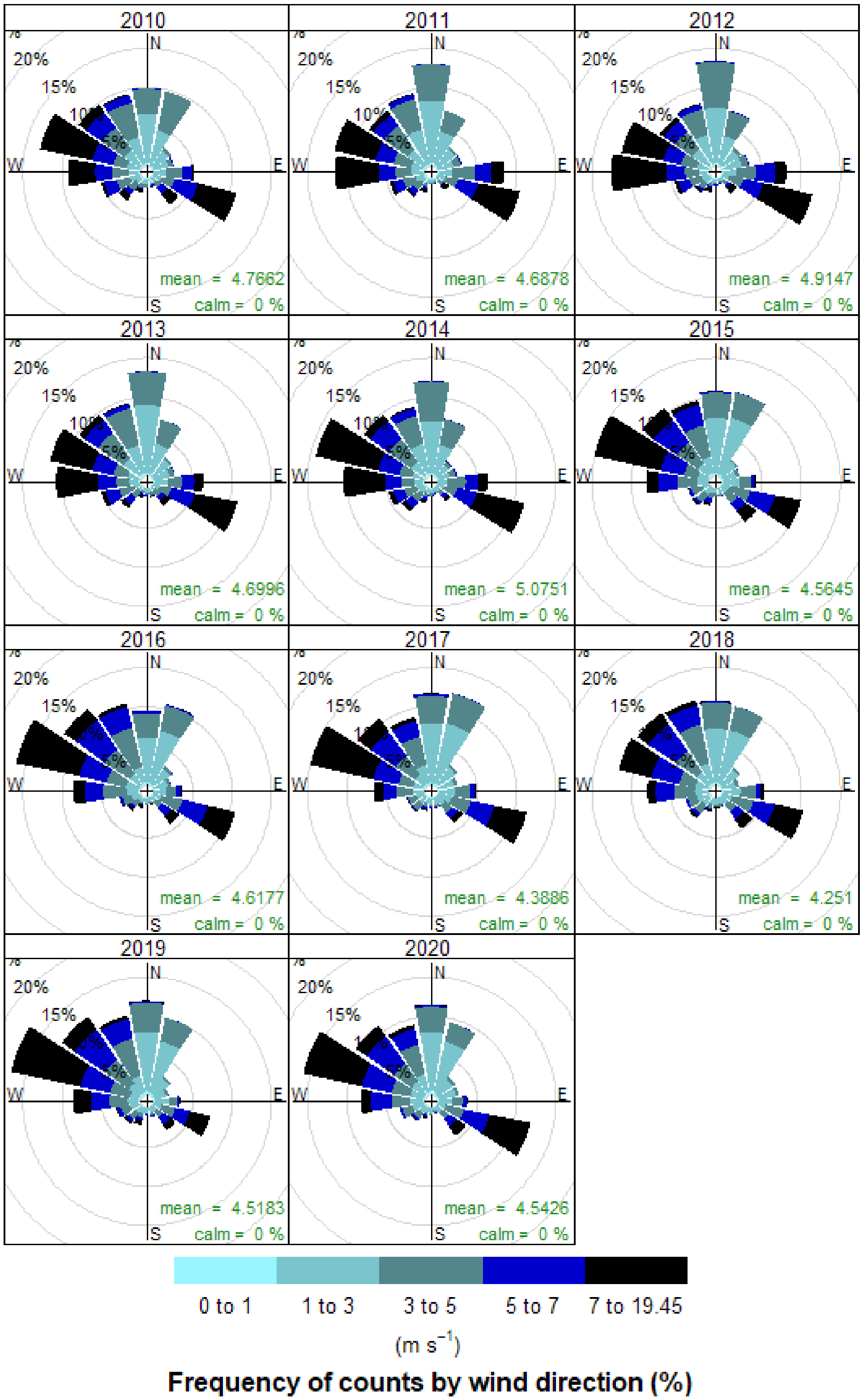

Figure 1: Ohakea Aero windroses (2010 to 2020).

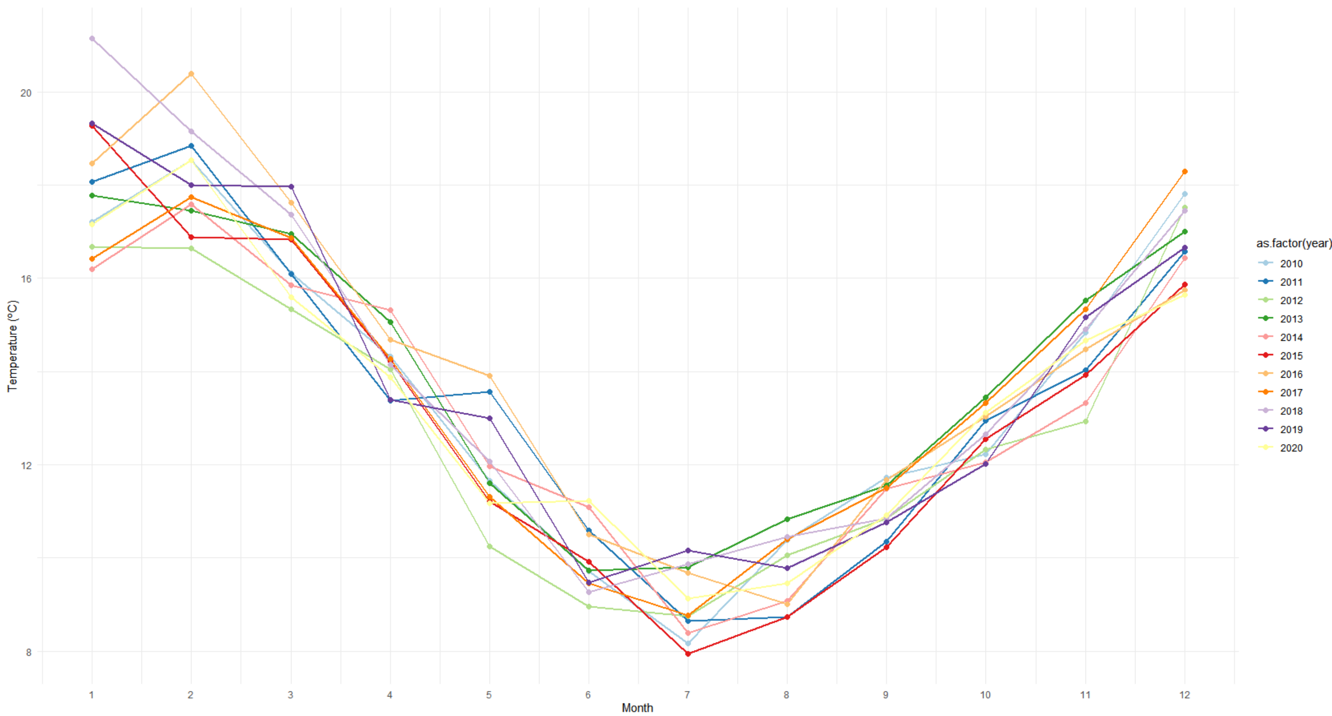

Figure 2: Ohakea Aero monthly average temperature (2010 to 2020).

3.0 TAPM MODELLING

3.1 Model Configuration

TAPM was developed by CSIRO in the late 1990s as a tool to carry out air quality assessments (Hurley et al. 2005). It includes a prognostic meteorological model and several modules to simulate dispersion of air contaminants. It was developed to model dispersion from industrial and urban sources (Luhar & Hurley 2003). This assessment uses version 4.0.5 (Hurley 2008) to provide meteorological outputs for CALMET.

TAPM accesses a number of databases including the following (from Hurley 2008):

- Terrain-height data at a 30-second grid spacing (approximately one kilometre) from the US Geological Survey.
- Australian terrain height data at 9-second (approximately 300 metres) grid spacing based on data from Geoscience Australia.
- Global land cover at a 30-second grid spacing from the US Geological Survey.
- Global soil texture types at 2-degree grid spacing (approximately four kilometres) based on FAO/UNESCO soil classes data set.
- Global 5-year monthly mean leaf-area index (LAI) at 2-degree spacing based on Boston University LAI data sets.

- Global 10-year monthly mean sea surface temperatures at 1-degree grid spacing (approximately two kilometres), from the US National Center for Atmospheric Research.
- Synoptic-scale meteorological re-analyses from the US National Centers for Environmental Prediction to initialise the meteorological component of TAPM and provide conditions at its boundaries.

TAPM will optionally assimilate user-prepared surface-level wind observations using a ‘nudging’ technique which attracts the model solution towards the observed wind speed and direction within a user-defined radius of influence. TAPM runs on a set of grids starting with the larger scales (ranges of around 1000 km), then telescopes to smaller domains at higher resolution. The finest grid contains 1 km cells. TAPM’s fine grid was centred between Marton and Ohakea Aero, covering Marton, Ohakea, Feilding and their immediate surrounds (an area 39 km by 39 km). Coarser girds ‘telescope’ outwards from this central area, covering the North Island and much of the South Island at 27 km horizontal resolution. Figure 2 shows the TAPM grid extents and Table 1 show the TAPM configuration parameters.

Wind data from Ohakea station was assimilated into TAPM. This has the effect of bringing the model solution near to those locations more in line with the observations.

Table 1: TAPM configuration parameters.

Parameter	Values
Start and end dates	1 January 2016 to 31 December 2017
Grid centre (latitude, longitude)	40° 8’ 30” S; 175° 26’ 30” E
Grid centre (UTM)	367254 m Eastings; 5555355 m Northings
No. of grids; no. of grid cells in each horizontal direction	4; 39 x 39
Horizontal grid-cell spacing of each grid	27 km, 9 km,3 km, 1 km
Grid size east to west (equals north to south) for each grid	1053 km, 351 km, 117 km, 39 km
Heights of levels in the vertical (m above ground level)	10, 25, 50, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 600, 750, 1000, 1250, 1500, 1750, 2000, 2250, 2500, 3000, 3500, 4000, 4500, 5000, 6000, 7000, 8000

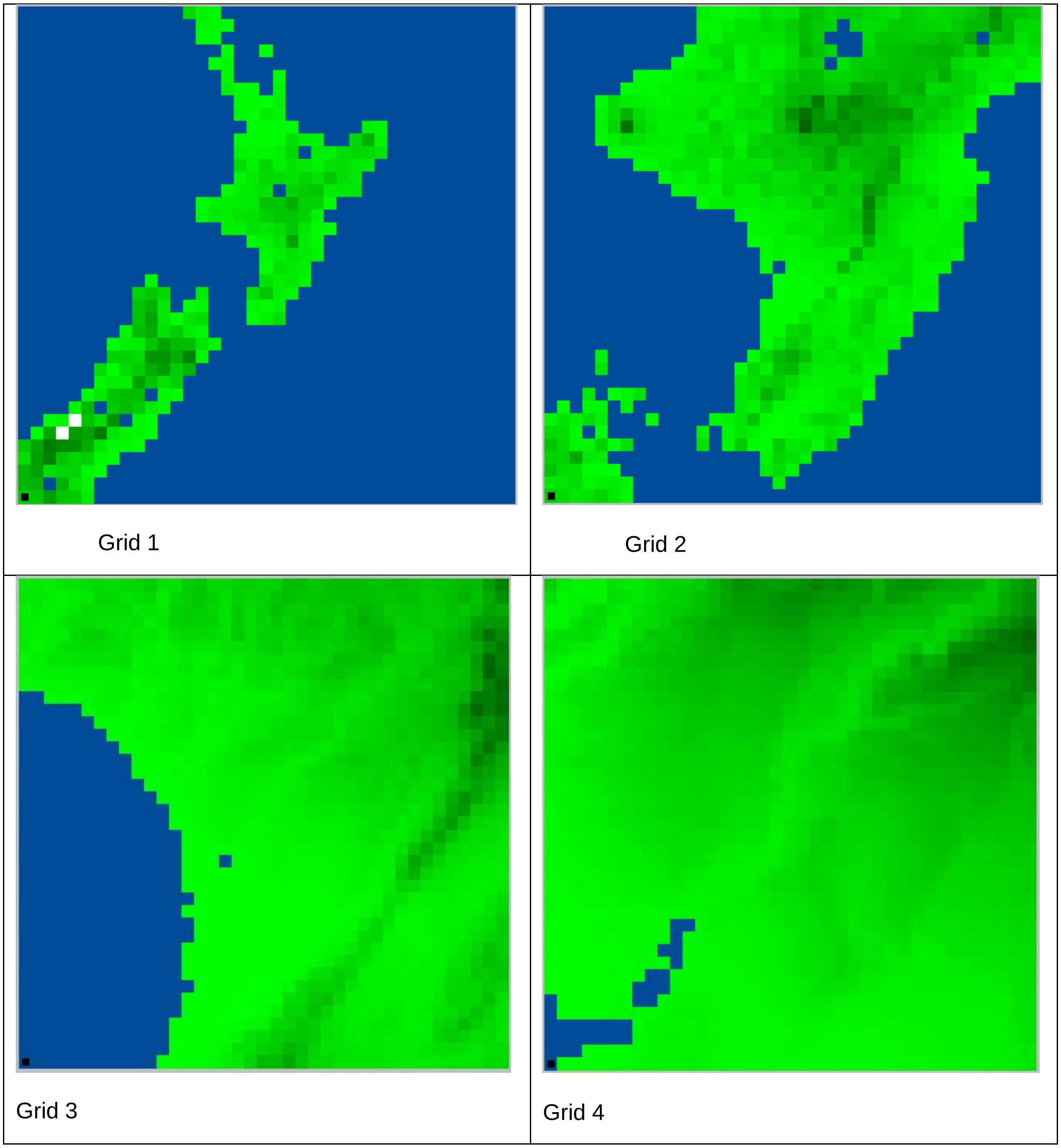

Figure 3: TAPM grid extents. Grid lines are shown in black; terrain heights are shaded green; water is shaded blue.

3.2 Evaluation of TAPM

TAPM has been evaluated with respect to observations at the Ohakea Aero, using common statistical measures of model performance. Parameters compared were wind speed, eastwards and northwards wind components, temperature and humidity. TAPM was run both with and without wind data assimilation, and therefore results for wind components are better for the data-assimilation case. Measures for temperature and humidity are largely unchanged, as the assimilation process has no effect on these parameters.

Some statistical measures of model performance are shown in Table 2. The wind results are good, with low bias and low RMS errors. The index of agreement (IOA) varies between 0 for no agreement and 1 for perfect agreement between modelled and observed parameters. The agreement between modelled and observed wind is good, with IOAs at least 0.83. Results for temperature and relative humidity are still reasonable, noting that the results for these parameters are produced by the model without assimilation of observations. The model produces temperatures on average slightly warmer than observed (mean bias +0.34 K), and slightly wetter in terms of relative humidity.

In summary, TAPM produces good results, which can be used as inputs to the CALMET model.

Table 2: TAPM performance at monitoring sites. U and V are the eastwards and northwards components of the wind velocity, respectively.

Parameter	Mean Bias	RMS Error	Index of agreement
Wind speed	-0.69 m/s	0.93 m/s	0.83
U	-0.13 m/s	0.78 m/s	0.92
V	0.15 m/s	0.55 m/s	0.90
Temperature	0.34 k	1.75 k	0.82
Relative humidity	0.94 %	11.42 %	0.57

4.0 INCORPORATION OF TAPM OUTPUTS INTO CALMET

TAPM outputs for the years 2016 and 2017 were converted into a CALMET-compatible form using the CALTAPM routine, supplied by CALPUFF's developers. CALMET takes this information at 3 km resolution and superposes terrain and land-use effects such as land/sea breezes and valley/drainage flows at 100 m resolution. It also incorporates weather observations, having a specified range of influence around the monitoring sites.

5.0 CALMET MODELLING

5.1 Introduction

CALMET version 6.5.0 has been used to provide hourly, three-dimensional meteorological fields for input to the CALPUFF dispersion model. The CALMET run was done on a 25 km by 25 km domain, which is centred close to the proposed industrial hub and includes the Ohakea Aero. A grid spacing of 250 m was chosen to allow the region to be modelled using currently available computational resources.

5.2 Graphical Information for CALMET

CALMET requires terrain and land-use data on a regular grid of points. This information enables the model to produce terrain-driven effects such as blocking and slope and valley flows, and to produce the variations in boundary-layer structure associated with changes in land use (particularly the contrast between land and sea).

Gridded terrain information for the surrounding area has been derived using Golder's in-house GIS procedures. Land-use data were extracted from Golder's in house database and converted to the CALMET input format.

The meteorological model domain has dimensions 25 km x 25 km, consisting of 100 x 100 grid cells of size 250 m x 250 m. Maps of the terrain and land use data used in the CALMET run for airshed modelling are shown in Figure 4 and Figure 5, respectively. The colour-coding for land use categories is shown in Table 3.

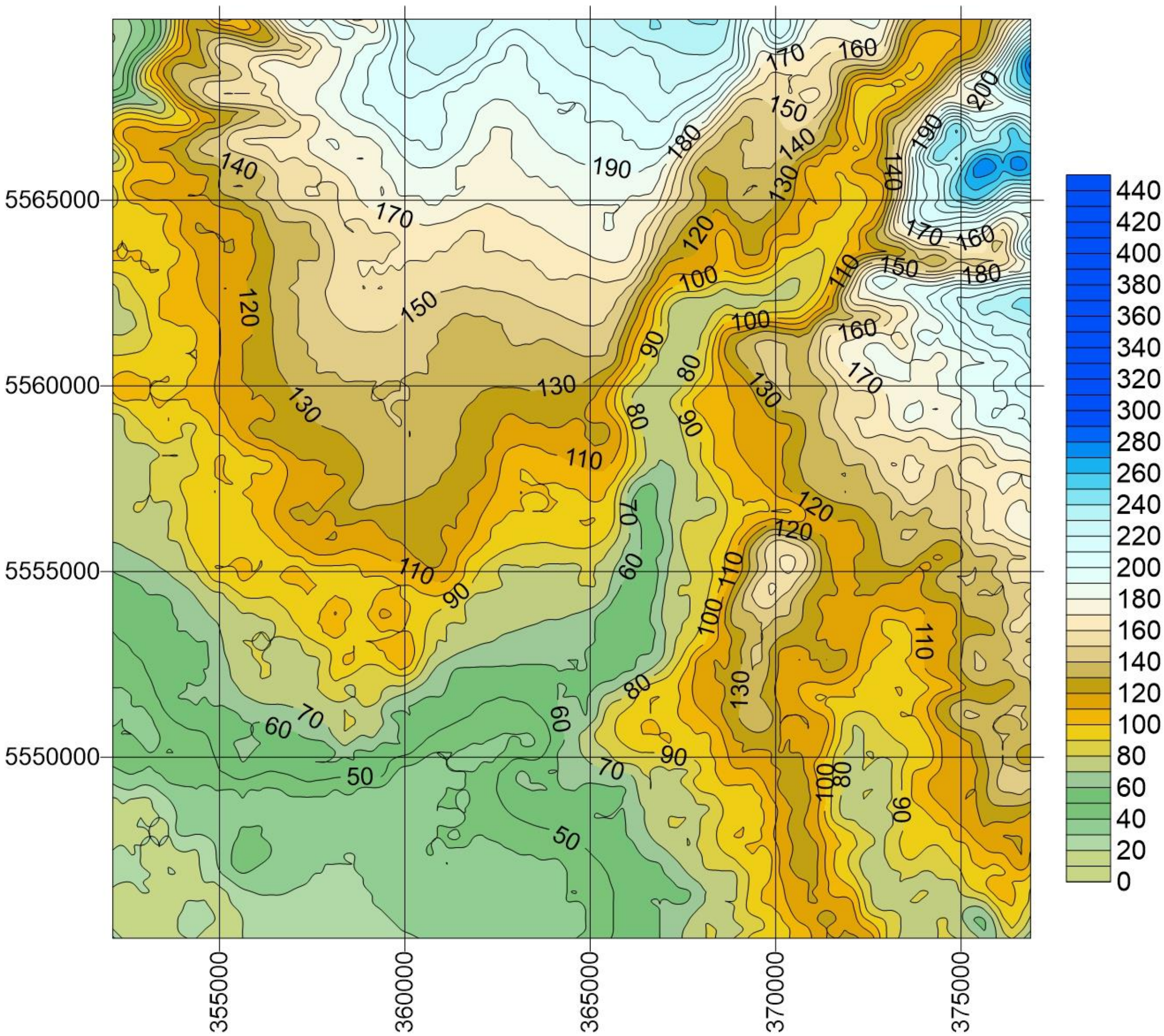

Figure 4: Contours of terrain height used for the CALMET modelling domain (coordinates in UTM metre).

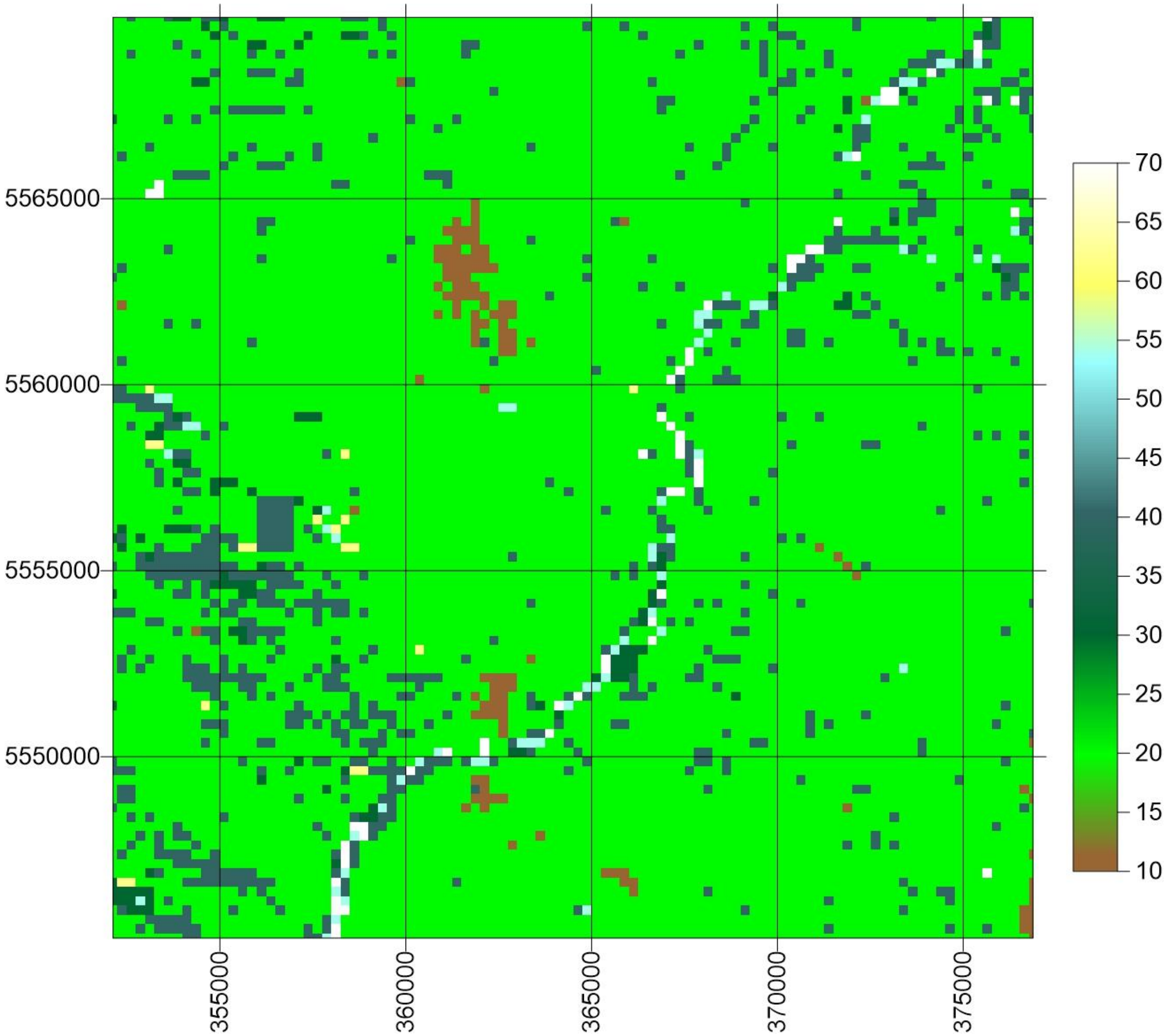

Figure 5: Land use type for the CALMET modelling domain (coordinates in UTM metre).

Table 3: Land use categories used by CALMET.

Colour coding on Figure 5	**Land use category**
Brown	Urban or built-up land
Light green	Agricultural Land – unirrigated/ open space
Green	Rangeland
Dark green	Forest land
Blue	Water
White	Sand or gravel

5.3 Meteorological Station Data

CALMET requires meteorological data from local weather stations. Local data are used to ensure that the modelled fields are consistent with observations. There is one meteorological monitoring site (Ohakea Aero) close to Marton by Metservice. Data from this site have been used in the CALMET modelling, as described in Section 2.0 of this appendix. This site measures surface wind, temperature, relative humidity, and station pressure, and cloud cover. A summary of the data availability from the meteorological station is shown in Table 4. CALMET has been run with a time step of one hour.

Table 4: Summary of surface meteorological station data used by CALMET. For National Climate Database (CliDB) stations the ID is the agent number.

Station name	Station ID	Location (km, UTM)	Parameters
Ohakea Aero	3206	361.521, 5548.830	Wind speed, wind direction, air temperature, relative humidity, pressure, cloud cover

5.4 Other CALMET Configuration Parameters

The following information provides details of the user input parameters for generating the CALMET generating the CALMET three-dimensional meteorological data set. The start and end times for the CALMET run are shown in Table 5. Other key parameters are shown in Table 6 to Table 9.

Table 5: Run control parameters.

Parameter	Value
Starting date/time	1/1/2016 00:00:00
Finish date/time	1/1/2018 00:00:00
UTC time zone	UTC+1200 (which is NZST)
Time step	3600 s
Number of runs	12

Table 6: CALMET map projection.

Parameter	Value
Map projection	UTM
Datum region	WGS-84
UTM zone	60

Parameter	Value
Hemisphere	S

Table 7: Grid control parameters.

Parameter	Value
SW corner of grid cell (1,1)	352, 5545 (km, UTM)
Grid dimensions	100 x 100 grid cells of size 250 m x 250 m
Vertical grid, number of layers	11
Cell-face heights for vertical grid (m)	0, 20, 50, 100, 200, 300, 450, 650, 950, 1400, 2000, 3000

Table 8: Prognostic model options.

Parameter	Value
Use of TAPM for surface or upper-air information	NOOBS =1; Use surface and overwater stations (no upper air observations); Use 3D for upper air data
Use of TAPM for wind information	IPROG = 14; Use winds from 3D.DAT file as initial guess field
Use of TAPM for temperature information	ITPROG = 2; No surface or upper air observations; Use 3D for surface and upper air data
Use of TAPM for relative humidity information	IRHPROG = 0; use RH from surf.dat file
Use of TAPM for cloud information	MCLOUD = 1; Clouds data generated from surface observations
Use of TAPM for precipitation information	NPSTA = 0; precipitation included in the surface file

Table 9: CALMET wind field options and parameters.

Parameter	Value
Extrapolation of surface wind observations	IEXTRP = -1; no extrapolation is done, except layer 1 data at upper air stations are ignored
Layer-dependent biases	-1, 10x1
Maximum radius of influence of meteorological data	RMAX1 = RMAX2 =2 km; RMAX3 = 0 km

Parameter	Value
Relative weighting of first-guess field and observations (that is, distance from site at which they are equally weighted)	R1 = R2 = 1.0 km
Radius of influence of terrain features	TERRAD = 1 km
Minimum radius of influence used in the wind field interpolation	RMIN= 0.1 km

6.0 EVALUATION OF CALMET

A statistical evaluation of CALMET's performance at the monitoring sites is not appropriate. The site data are used directly by CALMET and its output matches its input at the monitoring sites, by definition. An evaluation of CALMET involves inspection of the evolution of the wind field over several days, to ensure that the results appear qualitatively reasonable. Attention is usually paid to the following:

- Inspection of winter night times to ensure wind field is consistent with terrain – with channelling effects and downslope flows. This checks whether parameter TERRAD is large enough.
- Inspection of day-time wind fields in flat terrain, to ensure that they are uniform. This checks that TERRAD is not too large.
- Occurrence of sharp-discontinuities ('bull's eyes') around climate site location. This assesses the site radius of influence parameters (R1, R2, RMAX1 and RMAX2).

An evaluation of this type has been carried out for the current CALMET runs, and the parameter choices are reasonable.

7.0 REFERENCES

Hurley P 2008. TAPM V4. Part 1: Technical description. CSIRO Marine and Atmospheric Research Paper No. 25, October 2008. p. 59 pages.

Luhar AK & Hurley PJ 2003. Evaluation of TAPM, a prognostic meteorological and air pollution model, using urban and rural point-source data. Atmospheric Environment. 37 (20): 2795–2810.

APPENDIX D

Emission Calculations

1.0 INTRODUCTION

This Appendix discusses the assumptions and emission calculations in detail for each of the sources presented in Section 5 of the main report.

2.0 PARTICULATE EMISSION RATES

2.1 Wheel Generated Crustal Dust

It is assumed that the internal heavy vehicle access road for the proposed CDP, the log yard and the container yard surface are all paved. The US EPA Compilation of Air Pollutant Emission Factors (AP 42) documents (USEPA 2011)[1] has been used to calculate the emission rate for these sources. The assumptions that have been made for calculating these emission rates are discussed in the following sections. The calculated emission rates are presented in Table 1 and Table 2. Note that the NOx emission for some of the above sources are also included in the calculation, however, the assessment of the effects from NO_2 emissions is beyond the scope of this report.

2.1.1 Trucks movements on the internal access road

Assumptions

The frequency of trucks movements, working hours, travel distance and information related to the trucks are established from the following assumptions:

- A total of 155 trucks/day carrying the logs and other goods travel along the internal road from 6 am to 6 pm.
- 42 % of the trucks travel to the log yard, 19 % to the container yard, 26 % to the PLA and PHA plants and 13 % to the food producer.
- The trucks travel 1 km to the log yard, 0.5 km to the container yard and PLA and PHA plants, and 0.6 km to the food producer.
- The average vehicle kilometre travelled (VKT) per day (travelled round trip) is approximately 224.
- Vacuum sweeping is to be applied to the paved internal road during dry conditions, which provides an 80 % dust reduction.
- The truck tare weight is assumed to be 20 tonnes (t), and the fully loaded weight is 50 t (with 30 t logs). Assuming 100 % trucks arrive with full load, and 50 % leave empty, the average truck weight is 42.5 t.
- A road surface silt loading rate of 0.6 g/m² is assumed for the internal road. This is consistent with a baseline silt loading default value for an annual daily traffic (ADT) less than 500 vehicles (as shown in Table 13.2.1-2 of US EPA AP 42).

Emission calculations

The calculations of PM emissions from the paved internal road are described in detail in Table 1, and are based on USEPA's AP-42 equations for paved roads. These calculations utilise the transport related information of average VKTs per day, the average weight of the vehicles (tonnes) and road surface silt loading

[1] United States Environmental Protection Agency, 'AP-42, Compilation of Air Pollutant Emission Factors, Chapter 13.2.1 Miscellaneous Sources for Paved Roads. January 2011.

rate, as summarised above. A summary of the estimated PM_{10} and $PM_{2.5}$ emission rates for the internal access road system as detailed in Figure 2 (in the main report) are as follows:

- PM_{10}: 0.02 g/s
- $PM_{2.5}$: 0.005 g/s

2.1.2 Log loaders movement at log yard

Assumptions

- Two log loaders (L260H) operate at the log yard for 10 hours per day (7 am to 5 pm) with an average speed of 10 km/hr.
- The average vehicle kilometre travelled (VKT) per day is 200.
- The loader tare weight is assumed to be 24 t, and the fully loaded weight is 39 t. The average loader weight is 31.5 t.
- Water flushing is to be applied to the paved log yard during dry conditions – this provides an 80 % dust reduction.
- A road surface silt loading rate of 0.6 g/m² is assumed for the internal road. This is consistent with a baseline silt loading default value for an annual daily traffic (ADT) less than 500 vehicles (as shown in Table 13.2.1-2 of US EPA AP 42).

Emission calculations

The calculations of PM emissions from the paved log yard surface are described in detail in Table 2 and are based on USEPA's AP-42 equations for paved roads. These calculations utilise the average VKTs per day, the average weight of the vehicles (tonnes) and road surface silt loading rate, as summarised above. A summary of the estimated PM_{10} and $PM_{2.5}$ emission rates are as follows:

- PM_{10}: 0.016 g/s
- $PM_{2.5}$: 0.004 g/s

2.1.3 Container stackers movement at container yard

Assumptions

- Two container stackers operate at the container yard for 10 hours per day (7 am to 5 pm) with an average speed of 10 km/hr.
- The average vehicle kilometre travelled (VKT) per day is 200.
- The stacker tare weight is assumed to be 11 t, and the fully loaded weight is 41 t. The average stacker weight is 26 t.
- Water flushing is to be applied to the paved container yard during dry conditions – this provides an 80 % dust reduction.
- A road surface silt loading rate of 0.6 g/m² is assumed for the internal road. This is consistent with a baseline silt loading default value for an annual daily traffic (ADT) less than 500 vehicles (as shown in Table 13.2.1-2 of US EPA AP 42).

Emission calculations

The calculations of PM emissions from the paved container yard are described in detail in Table 2, and are based on USEPA's AP-42 equations for paved roads. These calculations utilise the average VKTs per day, the average weight of the vehicles (tonnes) and road surface silt loading rate, as summarised above. A summary of the estimated PM_{10} and $PM_{2.5}$ emission rates are as follows:

- PM_{10}: 0.013 g/s
- $PM_{2.5}$: 0.003 g/s

2.2 Exhaust from Diesel Powered Vehicle and Onsite Machinery

2.2.1 Truck exhaust

The truck exhaust emission rates are derived from the New Zealand Transport Agent (NZTA) Vehicle Emission Prediction Model (VEPM) 6.1 emission factors for 2020 fleet (Figure 2.2 of NZTA 2020[2]). The emission factors for diesel articulated heavy vehicle (34 – 40 t) are used. The assumption of average VKT per day is same as that listed in this Section 2.1.1 . The detailed calculations and results of emission rates are presented in Table 3**Error! Reference source not found.**. Note that the PM_{10} emission includes PM_{10} brake and tyre emissions, and $PM_{2.5}$ exhaust emissions. A summary of the estimated PM_{10} and $PM_{2.5}$ emission rates are as follows:

- PM_{10}: 0.0017 g/s
- $PM_{2.5}$: 0.0012 g/s

2.2.2 Loaders and container stacker exhaust

Two log loaders and two container stackers are assumed to operate within the log yard and container yard respectively. The assumption of their rated power and operational hours is listed as follows:

- 2 x 421 horsepower (hp) L260H loaders operating 10 hr/day.
- 2 x 355 hp DCG 400/410 GS container stackers operating 10 hr/day.

The above ratings were obtained from the diesel engine manufacturer brochures. It is also assumed that these diesel engines comply with US EPA Tier 3 emission standard.

The US EPA exhaust and crankcase emission factors for nonroad engine modelling – compression ignition (US EPA 2002)[3] are used to estimate the exhaust from onsite machinery (i.e., loaders and container stackers). These emission factors were applied to the horsepower rating of the diesel engines to estimate the emission rates in g/s. The detailed calculations and results of emission rates are presented in Table 4. Note that all PM emissions are assumed to be PM_{10} and $PM_{2.5}$. A summary of the estimated PM_{10} and $PM_{2.5}$ emission rates are as follows:

- Log loader: PM_{10}: 0.06 g/s, $PM_{2.5}$: 0.06 g/s
- Container stackers: PM_{10}: 0.05 g/s, $PM_{2.5}$: 0.05 g/s

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[2] NZTA 2020. Vehicle Emissions Prediction Model (VEPM 6.1) User Guide, Version 4.0 September 2020.

[3] US EPA 2002. Exhaust and Crankcase Emission Factors for Nonroad Engine Modelling – Compression Ignition – Report No. NR-009D. November 2002.

2.3 Crustal Dust from Log Debarker

One Nicholson A8 debarker is planned to operate at the log yard for 10 hr/day (7 am to 5 pm) with a throughput of 1300 t logs per day. No control measures have been assumed for the log debarking operation.

The PM_{10} emission factor (in lb/tons) from US EPA WebFire database for log barking[4] is applied to the assumed throughput to estimate the emission rates in g/s. The $PM_{2.5}$ emission factor is based on the information from the National Council for Air and Stream Improvement's (NCASI) memo for $PM_{2.5}$ emission from drum debarking (NCASI 2014)[5]. The detailed calculations and results of emission rates are presented in Table 5. A summary of the estimated PM_{10} and $PM_{2.5}$ emission rates are as follows:

- PM_{10}: 0.2 g/s
- $PM_{2.5}$: 0.001 g/s

2.4 Exhaust from Diesel Powered Trains

The arrival and departure of twin-engine locomotives with thirty wagons will increase respirable particulate emissions into the local environment from the combustion of diesel and braking. The particulate emissions related to the locomotive output power and the operational speed. To quantify a realistic upper limit to these emissions, realistic operational assumptions of trains are defined in the following sections.

Assumptions – locomotive power output

It is assumed three trains will arrive at the new rail hub from the south and north respectively. Each train is expected to be equipped with two DL Class locomotive engines. Each locomotive engine has a maximum power output rate of 2,700 kW. It assumes that for trains departing the rail hub, it operates at 100 % rated power, while at 5 % of the rated power when it arrives.

It is understood that Kiwirail currently operates 32 trains per day through Marton. Assume these trains are operated at 50 % of the rated power on average.

For a train in idling cycle at the rail hub, it is understood that the train would be running at a very low power cycle. The power output for idling is assumed to be 0.2 % of the maximum rated power, i.e., 5.4 kW. This assumption is based on locomotive emission testing carried out by the New South Wales (NSW) Environment Protection Authority (EPA) (NSW EPA 2016)[6].

The assumptions of the locomotives power output rate are summarised in Table D1.

Assumptions – locomotive speed and arrival/departure time

The train operational speed is another key input for calculating the particulate emissions. This assessment focuses on the emissions from the rail siding and the main trunk for approximately 5.9 km long (north of the rail siding) and 2.3 km long (south of the rail siding). The assessed main trunk sections are shown in Figure D1, Figure D2 and Figure D3. The average train speeds for each section marked on these figures are assumed as follows:

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[4] SCC code 3-07-0089-01

[5] NCASI 2014. $PM_{2.5}$ Emissions from Drum Debarking. July 2014.

[6] NSW EPA 2016. Diesel Locomotive Fuel Efficiency & Emission Testing. November 2016.

- Rail siding: an average of 10 km/h at sections C-D, E-D, C-D' and E-D'.
- Main trunk: an average of 20 km/h at sections B-C and E-F, and an average of 40 km/hr at sections A-B and F-G.
- Main trunk for trains passing through the rail hub (baseline trains): an average of 50 km/h at sections a-b and c-d and average of 20 km/h at section b-c.

Assume six trains arriving at or departing the rail hub from 6 am to 6 pm, while the existing trains passing through the CDP operate 24 hours a day. The length of each section, assumed train speed, calculated travel time and assumed train arrival and departure time are presented in Table D2.

Assumptions – idling

It is conservatively assumed each train will idle for two hours (1 hour on each end of the siding). Assume idling occurs at location D and D' (two ends of the rail sidling). The assumed idling hours are presented in Table D3.

Emission calculations

Based on the engine manufacturer's specification, the emission discharged from the DL class locomotives is compliant with the Stage IIIA European Emission Standards for the Rail Traction Engines. The PM emission standard is 0.2 g/kWh[7] for engines with net power greater than 560 kW. This emission factor is used to estimate the PM emissions from locomotives.

For trains that idle at the rail hub, the PM emission factor is conservatively assumed to be 10 times higher than the EU emission factors for trains on duty cycle. This assumption is based on locomotive emission testing carried out by the NSW EPA (NSW EPA 2016)[6].

Golder is aware of two studies associated with train emissions. WSP has carried out a ventilation assessment for KiwiRail, which includes emission testing for DL series locomotives (WSP 2021)[8]. Canterbury Regional Council (CRC) prepared an emission inventory that covers emission estimation from railway locomotives (CRC 2009)[9]. This study utilised railway emissions from an old Minister of Transport (MoT) assessment in 1999. Both the emission testing result and the MoT emission factors are consistent with the EU emission factors used in this assessment.

The PM emission factor for the duty cycle is applied to the assumed power output and travelling time to estimate the emission rate (g/hr) for each section. The detailed calculations and results of emission rates are presented in Table 6. The estimated PM emission rates are summarised in Table D2 and Table D3. A 24-hour emission profile is shown in Figure D4. Note that all PM emissions are assumed to be PM_{10} and $PM_{2.5}$, as the particulate emission from the combustion of diesel fuel is primarily associated with particles that are less than 10 microns in diameter.

[7] Table 8 Stage III A/B Emission Standards for Rail Traction Engines.

[8] WSP 2021. KiwiRail NIMT Tawa Tunnel1 – Ventilation Assessment. Project Number: 6-ME942.00. 3 June 2021.

[9] CRC 2009. Inventory of Emissions to Air in Christchurch. Canterbury Regional Council. January 2011. Report No. R11/17.

Table D1: Locomotive assumptions.

Locomotives	DL Class (2 locomotives per train)			
	Duty cycle – departing rail hub	Duty cycle – arriving at rail hub	Duty cycle – passing through (baseline)	Idling
Power (kW)	2700┼	135#	1350#	5.4#
Emission factors - PM (g/kWh)	0.2	0.2	0.2	2.0
Source	Table 8 of EU Stage IIIA standard for P>560 kW Stage III A/B emission standards for rail traction engines			Assume 10 times higher than duty cycle*

Note: ┼ maximum rated power output. # power output assumptions: (1) 5 % of the maximum rated power for trains arriving at the rail hub. (2) 50 % of the maximum rated power for trains passing through the rail hub (baseline) (3) 0.2 % of the maximum rated power for idling trains. * This assumption is based on the NSW locomotive emission testing.

Table D2: Locomotive speed assumptions and calculated PM emission rate for each section.

Sections#	Length (km)	Average speed (km/h)	Average travelling time (hr)	Number of trains	Assumed departure/ arrival time	PM emission rate (g/train)	PM emission rate (g/hr)*
a. Trains arriving at the rail hub from the north							
A – B	2.6	40	0.065	3	6 am 10 am 1 pm	4	4
B – C	3.3	20	0.165	3		9	9
C – D	1.4	10	0.14	3		8	8
b. Trains departing the rail hub to the north							
D' – C	0.9	10	0.09	3	8 am 12 pm 3 pm	98	98
C – B	3.3	20	0.165	3		178	178
B – A	2.6	40	0.065	3		71	71
c. Trains arriving at the rail hub from the south							
G – F	1.3	40	0.0325	3	8 am 12 pm 3 pm	2	2
F – E	1	20	0.05	3		3	3
E – D	1.3	10	0.13	3		7	7
d. Trains departing the rail hub to the south							
D' – E	0.8	10	0.08	3	10 am 2 pm 6 pm	86	86
E – F	1	20	0.05	3		54	54
F – G	1.3	40	0.0325	3		35	35
e. Trains passing through the rail hub (baseline)							

Sections#	Length (km)	Average speed (km/h)	Average travelling time (hr)	Number of trains	Assumed departure/ arrival time	PM emission rate (g/train)	PM emission rate (g/hr)*
a – b	2.6	50	0.052	32	24 hours continuously	28	37
b – c	3.3	20	0.165	32		89	119
c – d	3	50	0.06	32		32	43

Note: # as shown in Figure D1 to Figure D3. * For trains arriving at or departing the rail hub, the PM emission rate per train is averaged to 1 hour. For trains passing through the rail hub, the PM emission rate for 32 trains is averaged to 24 hours.

Table D3: Assumptions and PM emission rate for idling cycle.

Locations	Idling time per train (hr)	Assumed idling hours	PM emission rate (g/hr)
Location D	1	6 to 7 am, 8 to 9 am 10 to 11 am, 12 pm to 1 pm, 2 pm to 3 pm, 4 pm to 5 pm	540
Location D'	1	7 to 8 am, 9 to 10 am, 11 am to 12 pm, 1 pm to 2 pm, 3 pm to 4 pm, 5 pm to 6 pm	540

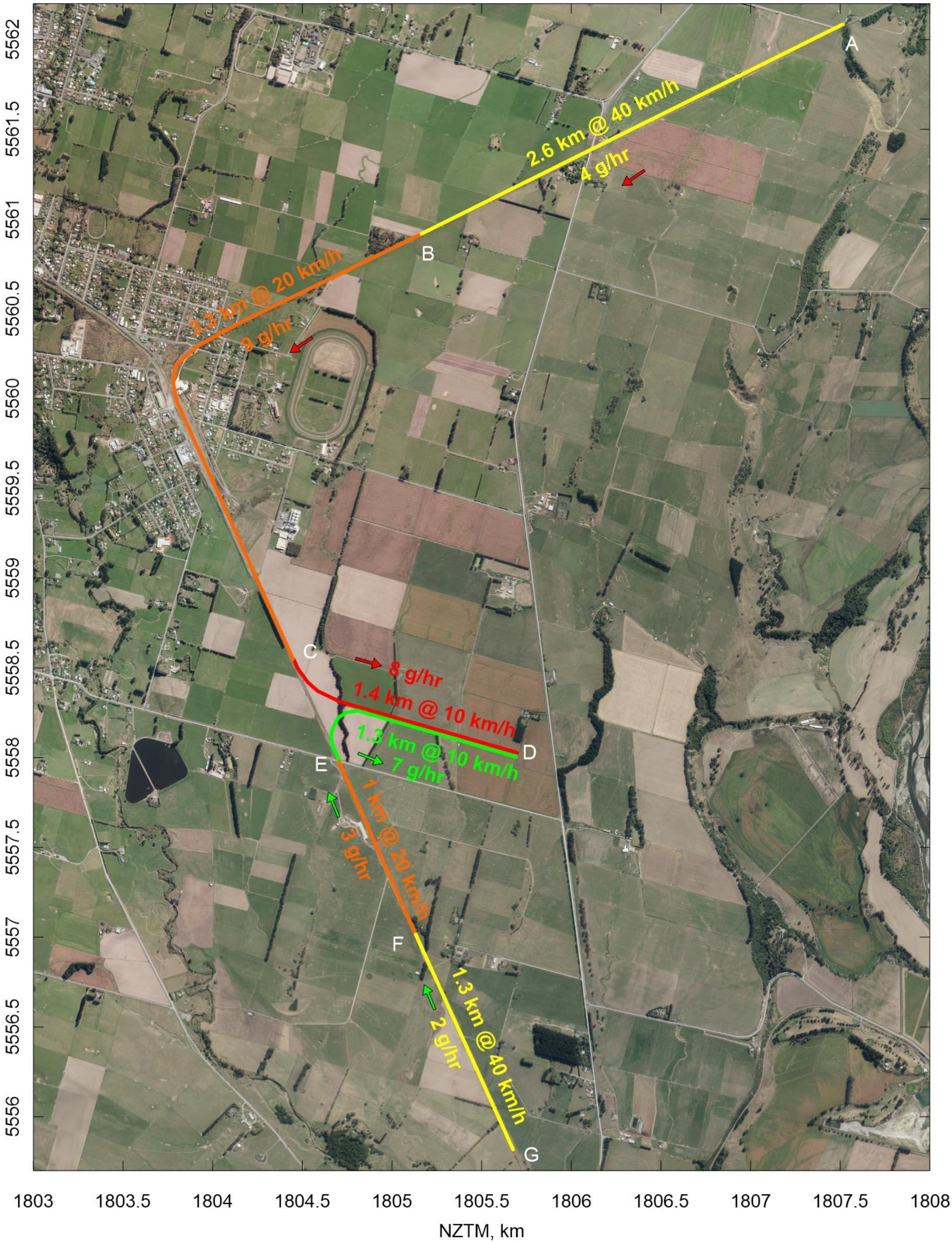

Figure D1: Train speed assumptions and calculated emission rates for trains arriving at the railway siding.

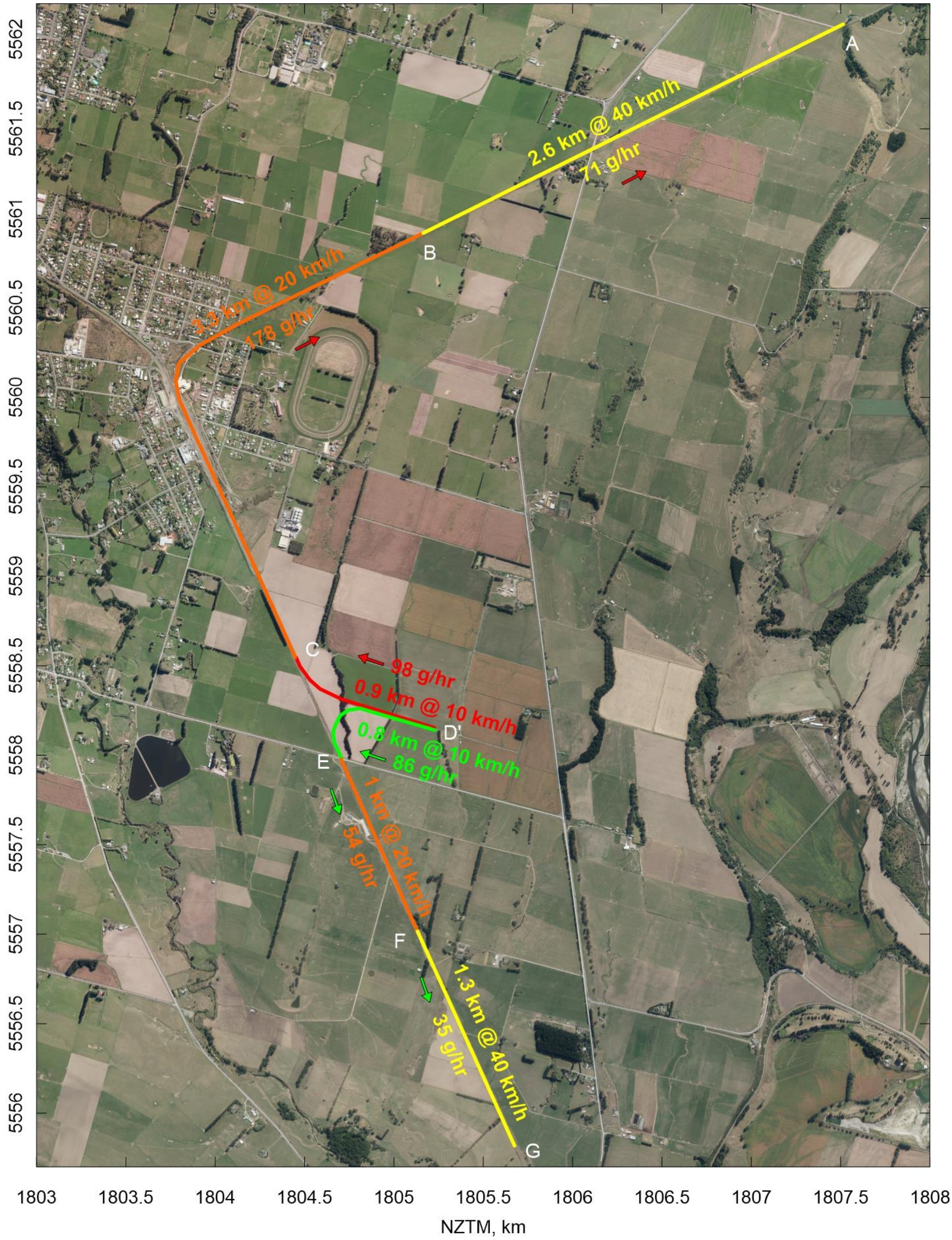

Figure D2: Train speed assumptions and calculated emission rates for trains departing the railway siding.

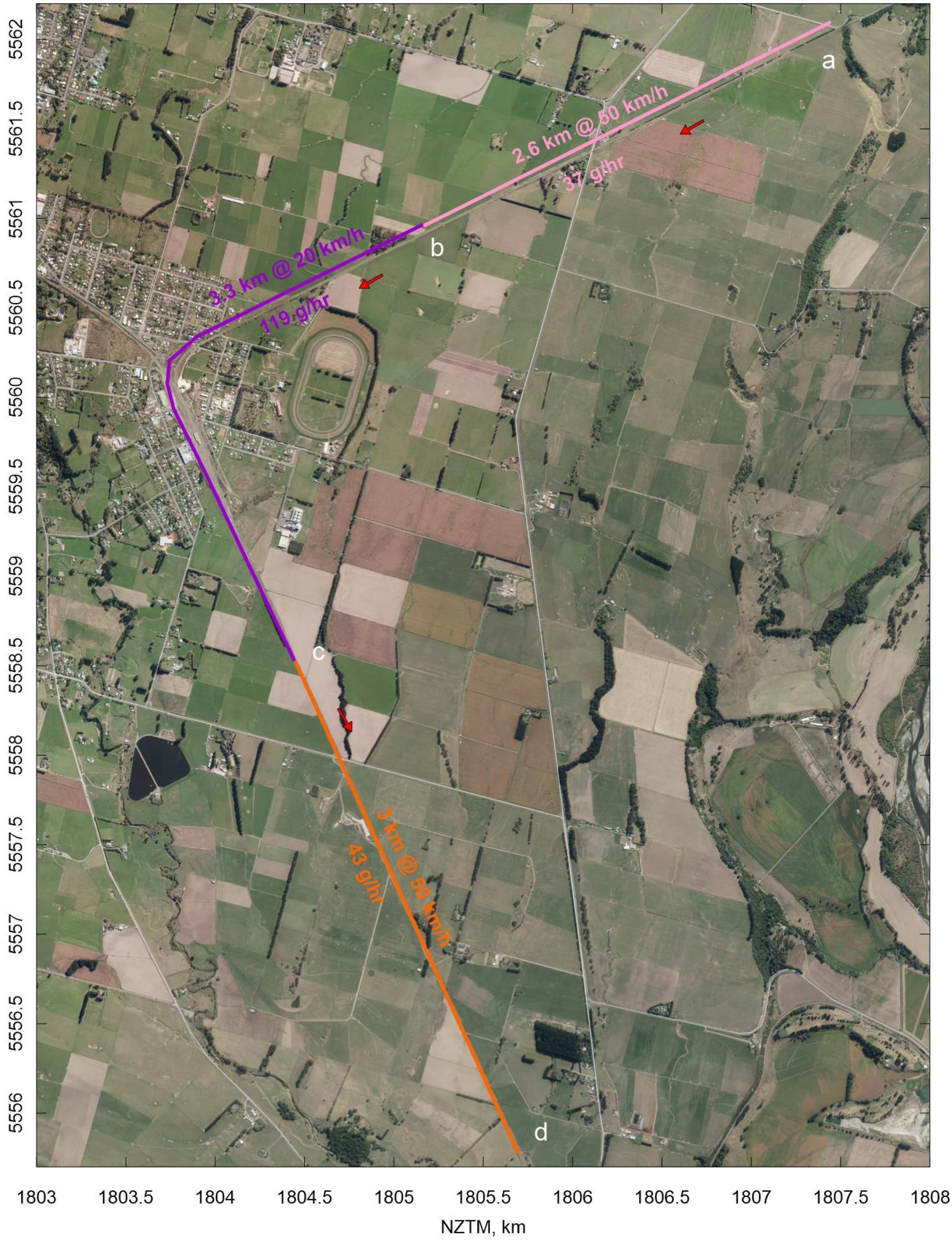

Figure D3: Train speed assumptions and calculated emission rates for trains passing through the new rail siding (baseline scenario).

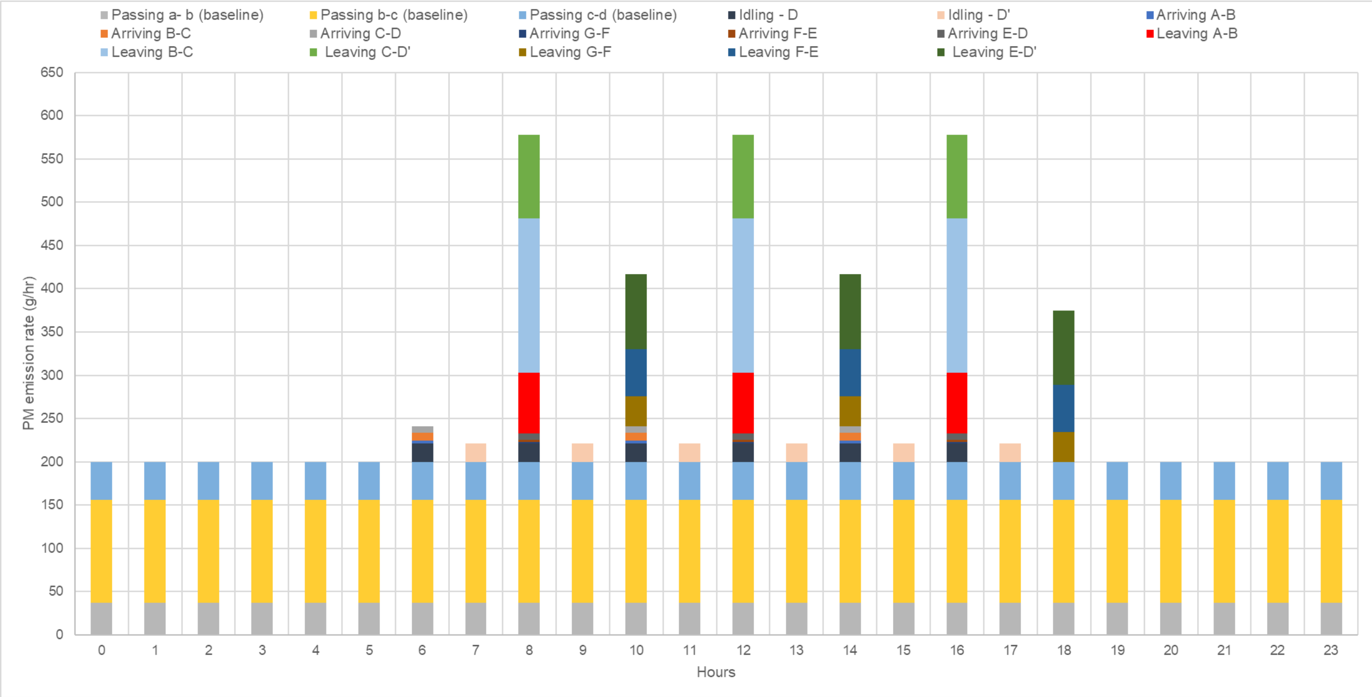

Figure D4: 24 hours profile for PM emissions from trains (g/hr).

2.5 Combustion Emission from Energy Production and Food Producer

2.5.1 Boilers and fuel assumptions

An energy plant will be established to provide electricity to operate the food plant, PHA and PLA plants. It is assumed that the energy plant will operate a biomass fired boiler (BFB) with a maximum energy input of 50 MW. The proposed fuel is made up of waste biomass (mainly wood) sourced from the PHA and PLA plant, waste bark from the log yard, and dairy waste from the Fonterra sites. The fuel composition is provided in Table D4, which shows that the fuel is dominated by the waste biomass. Assumption of the fuel property is shown in Table D5. The boiler will operate continuously 24 hours a day and 7 days a week.

Table D4: Fuel composition and moisture content.

Fuel composition	Daily consumption (t/day)	Moisture content (%)	Sources
Waste biomass	180	30	PHA and PLA plant
Waste bark	90	30	Log yard
Dairy-waste	20	80	Fonterra

The food producer is assumed to have a BFB with a maximum energy input of 20 MW. It is also assumed this BFB will be fired on wood with 30 % moisture content and operate continuously 24 hours a day and 7 days a week. The fuel property is assumed to be same as the energy plant BFB fuel, as shown in Table D5.

Table D5: Assumed fuel property.

Property	Value
Moisture	30 % wt
Ash	0.56 % wt
Carbon (dry ash free basis)	50.3 % wt
Hydrogen (dry ash free basis)	6.24 % wt
Oxygen (dry ash free basis)	43.26 % wt
Nitrogen (dry ash free basis)	0.2 % wt
Sulphur (dry ash free basis)	0 % wt
Net calorific value (as received basis)	12500 kJ/kg

2.5.2 Exhaust flow and stack discharge assumption

The BFBs combustion exhaust flow rates were calculated using stoichiometric equations with fuel property assumptions in Table D5 and a nominal value of exhaust oxygen content of 7 vol. % dry. A summary of the stoichiometry calculations is presented in Appendix E. The calculated exhaust flow rates were then used to estimate stack diameters that allows the efflux velocity to be approximately 15 m/s. The estimated and assumed stack parameters for both BFBs are provided in Table D6.

Table D6: Stack parameters for the energy plant and food producer BFBs.

Parameter	Energy plant BFB	Food producer BFB
Maximum steam output (MW)	50	20
Assumed stack height (m)	30	20
Stack diameter (m)	1.7	1.2
Efflux velocity (m/s)	15.7	15.7
Stack oxygen (vol. % dry)	7	7
Assumed efflux temperature (ºC)	150	150
Assumed fuel consumption	4 kg/s (as received basis)	2 kg/s (as received basis)

2.5.3 Emission Calculations

The PM_{10} emission rate was calculated based on an assumed in-stack PM_{10} concentration of 30 mg/Nm³ (corrected to 12 vol. % CO_2 dry basis) with the use of baghouse filter. Accordingly, a PM_{10} mass emission rate of 0.65 g/s was calculated for the 50 MW BFB and 0.33 g/s for the 20 MW BFB. It is also reasonable to assume that 90 % PM_{10} will be within the $PM_{2.5}$ size fraction. Therefore, the $PM_{2.5}$ mass emission rates are 0.59 g/s and 0.29 g/s for these BFBs respectively. The detailed calculations and results of emission rates are presented in Appendix E.

TABLE 1 - ESTIMATION OF PM EMISSION RATES FROM TRUCK WHEELS ON PAVED INTERNAL ROAD

Assumptions

Paved road, emission control method	Vacuum sweeping	
Emission control removal efficiency, %	80	
Truck travelling hours	6 am to 6 pm	
Truck travelling hours per day, hr/day	12	
Average Vehicle Speed, kph	50	
Truck tare weight, t	20	
Truck loaded weight, t	50	30 t logs
Average truck weight, t	42.5	Assume 100% arrive full @ 50 t 50% leave empty
Number of trucks per day, trucks/day	155	
Percentage of trucks to log yard	42%	
Percentage of trucks to container	19%	
Percentage of trucks to PLA and PHA	26%	
Percentage of trucks to food	13%	
Distance to log yard, km	1	
Distance to container km	0.5	
Distance to PLA and PHA, km	0.5	
Distance to food, km	0.6	
Days of precipitation greater than or equal to 0.254 mm -based on rainfall data from Tutututara	155	
Average Vehicle Kilometer Travelled, VKT (daily) -no. vehicles x km travelled round trip	224	

Estimated Emission Factors (EF)

Particulate matters from wheels	US EPA 13.2.1-4	
Emission factor (EF) equations		
Uncontrolled EF (UEF) Equation - short term	k (sL)^0.91 x w^1.02	
Uncontrolled EF (UEF) Equation - long term	k (sL)^0.91 x w^1.02 x [1 - p/(4 x 365)]	
Controlled EF (CEF) Equation	UEF x (1 - Removal efficiency (%))	
E	Particulate emision factor	
k	Particle size multiplier for paricle size range and units of intereset	
sL	Road surface silt loading g/m²	
W	Aeverage weight of the vehicles traveling the road (tons)	
p	Number of days of precipitation greater than or equal to 0.254 mm	
k for PM, PM10 and PM2.5		
PM, g/VKT	3.23	
PM_{10}, g/VKT	0.62	
PM2.5, g/VKT	0.15	
sL for the internal road, g/m²	0.6	ADT <500 ubiquitous baselin
W - average weight, tons	46.85	
	1.10231 factor to convert to US tons	
PM EF - uncontrolled, g/vkt	102.67	Short term
	91.77	Long term
PM EF - controlled, g/vkt	20.53	Short term
	18.35	Long term
PM10 EF - uncontrolled, g/vkt	19.71	Short term
	17.61	Long term
PM10 EF - controlled, g/vkt	3.94	Short term
	3.52	Long term
PM2.5 EF - uncontrolled, g/vkt	4.77	Short term
	4.26	Long term
PM2.5 EF - controlled, g/vkt	0.95	Short term
	0.85	Long term

Calculated Emission Rates (ER)

PM emission rate -controlled, kg/day	4.60	Short term
PM emission rate -controlled, g/s	0.11	Short term

PM10 emission rate - controlled, kg/day	0.88	Short term
PM10 emission rate - controlled, g/s	0.02	Short term
PM2.5 emission rate - controlled, kg/day	0.21	Short term
PM2.5 emission rate - controlled, g/s	0.00	Short term

TABLE 2 -ESTIMATION OF PM EMISSION RATES FROM LOADER/STACKERS WHEELS

Assumptions

Paved surface at container yard		
Unpaved surface at log yard		
Operational hours	7am - 5pm	
Loader/stackers average speed, km/hr	10	
Truck onsite travel distance, km/per truck	1	
Operational hours, hr/day	10	
Number of loaders	2	
Number of stackers	2	
Average Vehicle Kilometer Travelled, VKT (daily) -log yard	200	
Average Vehicle Kilometer Travelled, VKT (daily) -container yard	200	
Loader tare weight, t	24	Static tipping load at full turn
Loader loaded weight, t	39	Max. weight based on manufacturers specs
Average Loader weight, t	31.5	
Stacker tare weight, t	11	
Stacker loaded weight, t	41	
Average stacker weight, t	26	
Days of precipitation greater than or equal to 0.254 mm	155	
-based on rainfall data from Tutututara		
Control measures at log yard	Water flushing	
Emission control removal efficiency, %	80	
Control measures at container yard	Water flushing	
Emission control removal efficiency, %	80	

Estimated Emission Factors (EF)

Particulate matters from container stacker wheels (Paved Area)	US EPA 13.2.1-4	
Emission factor (EF) equations		
Uncontrolled EF (UEF) Equation - short term, g/VKT	= k (sL)^0.91 x w^1.02	
Uncontrolled EF (UEF) Equation - long term, g/VKT	= k (sL)^0.91 x w^1.02 x [1 - p/(4 x 365)]	
Controlled EF (CEF) Equation, g/VKT	= UEF x (1 - Removal efficiency (%))	
k	Particle size multiplier for paricle size range and units of intereset	
sL, %	Road surface silt loading g/m²	
W, tons	Aeverage weight of the vehicles traveling the road (tons)	
p	Number of days of precipitation greater than or equal to 0.254 mm	
k for PM, PM10 and PM2.5		
PM, g/VKT	3.23	
PM_{10}, g/VKT	0.62	
PM2.5, g/VKT	0.15	
sL for container yard, g/m²	0.6	ADT <500 ubiquitous baselin
W - average weight, tons	28.66	
	1.10231 factor to convert to US tons	
Emission factor (EF)		
PM EF - uncontrolled, g/vkt	62.19	Short term
	55.59	Long term
PM EF - controlled, g/vkt	12.44	Short term
	11.12	Long term
PM10 EF - uncontrolled, g/vkt	11.94	Short term
	10.67	Long term
PM10 EF - controlled, g/vkt	2.39	Short term
	2.13	Long term
PM2.5 EF - uncontrolled, g/vkt	2.89	Short term
	2.58	Long term
PM2.5 EF - controlled, g/vkt	0.58	Short term
	0.52	Long term

Particulate matters from log loader (Paved Area) | US EPA 13.2.1-4

Emission factor (EF) equations

Uncontrolled EF (UEF) Equation - short term, g/VKT	= k (sL)^0.91 x w^1.02	
Uncontrolled EF (UEF) Equation - long term, g/VKT	= k (sL)^0.91 x w^1.02 x [1 - p/(4 x 365)]	
Controlled EF (CEF) Equation, g/VKT	= UEF x (1 - Removal efficiency (%))	
k	Particle size multiplier for paricle size range and units of intereset	
sL, %	Road surface silt loading g/m²	
W, tons	Aeverage weight of the vehicles traveling the road (tons)	
p	Number of days of precipitation greater than or equal to 0.254 mm	
k for PM, PM10 and PM2.5		
PM, g/VKT	3.23	
PM_{10}, g/VKT	0.62	
PM2.5, g/VKT	0.15	
sL for container yard, g/m²	0.6	ADT <500 ubiquitous baselin
W - average weight, tons	34.72	
	1.10231 factor to convert to US tons	
Emission factor (EF)		
PM EF - uncontrolled, g/vkt	75.64	Short term
	75.02	Long term
PM EF - controlled, g/vkt	15.13	Short term
	15.00	Long term
PM10 EF - uncontrolled, g/vkt	14.52	Short term
	14.40	Long term
PM10 EF - controlled, g/vkt	2.90	Short term
	2.88	Long term
PM2.5 EF - uncontrolled, g/vkt	3.51	Short term
	3.48	Long term
PM2.5 EF - controlled, g/vkt	0.70	Short term
	0.70	Long term

Calculated Emission Rates (ER)

ER at container yard

PM emission rate -controlled, kg/day	2.5	Short term
PM emission rate -controlled, g/s	0.07	Short term
PM10 emission rate - controlled, kg/day	0.48	Short term
PM10 emission rate - controlled, g/s	0.013	Short term
PM2.5 emission rate - controlled, kg/day	0.12	Short term
PM2.5 emission rate - controlled, g/s	0.003	Short term

ER at log yard (paved)

PM10 emission rate - controlled, kg/day	0.58	Short term
PM10 emission rate - controlled, g/s	0.016	Short term
PM2.5 emission rate - controlled, kg/day	0.14	Short term
PM2.5 emission rate - controlled, g/s	0.004	Short term
PM emission rate -controlled, kg/day	3.03	Short term
PM emission rate -controlled, g/s	0.084	Short term

TABLE 3 -ESTIMATION OF EXHAUST PM NOx EMISSION RATES FROM TRUCK

Assumptions

Diesel Articulated	34 - 40	Gross vehicle mass, from NZTA VEPM 6.1
Vehicle load, %	50	From NZTA VEPM 6.1
At internal road		
Average Vehicle Kilometer Travelled, VKT (daily)	224	
Truck travelling hours	6 am to 6 pm	
Truck travelling hours per day, hr/day	12	
Average speed, km/h	50	

Estimated Exhaust Emission Factors (EF) - NZTA VEPM 6.1 Fleet 2020

PM10, g/km - brake & tyre	0.1059	Figure 2.2 of VEHICLE EMISSIONS PREDICTION MODEL (VEPM 6.1) USER GUIDE, Version 4.0 September 2020
PM2.5, g/km - exhaust	0.2239	
NOx, g/km	5.682	

Calculated Emission Rates (ER)

At Internal Road

PM10, kg/day	0.07	Assume PM10 emission includes exhaust PM2.5
PM10,g/s	0.0017	
PM2.5, kg/day	0.05	
PM2.5,g/s	0.0012	
NOx, kg/day	1.27	
NOx, g/s	0.03	

TABLE 4 -ESTIMATION OF EXHAUST EMISSION FOR CONTAINER/LOG HANDLING DIESEL ENGINES

	Assumptions			Emission Factors (EF)																Calculated Emission Rates (ER)					
		Assumed Engine		Unadjusted Emission Factors (UAF) [a]				Transient Adjustment Factors (TAF) [b]				Deterioration Factors (DF) [c]			S Adjustment[d]	Adjusted Emission Factors (UAFxTAFxDF) [e]				Hourly Emission Rates (Daily Average)[g]					
	Number of	HP Rating	Work hour	HC	NO_X	PM_{10}	BSFC	HC	NO_X	PM_{10}	BSFC	HC	NO_X	PM_{10}	$S_{PM\ adj}$	HC	NO_X	PM_{10}	SO_2	NO_X		PM_{10}		SO_2	
Vehicle Description	Vehicles	(HP)	(hr/day)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(lb/hp-hr)								(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(kg/day)	(g/s)	(kg/day)	(g/s)	(kg/day)	(g/s)
L260H loader at log yard	2	421	10	0.1669	2.50	0.1500	0.367	1.05	1.04	1.47	1.01	1.027	1.008	1.473	0.074	0.180	2.621	0.251	0.1642	11.034	0.613	1.056	0.059	0.691	0.038
Stackers&/or wheeled toplift hoiststo load/unload trucks	2	355	10	0.1669	2.50	0.1500	0.367	1.05	1.04	1.47	1.01	1.027	1.008	1.473	0.074	0.180	2.621	0.251	0.1642	9.304	0.517	0.890	0.049	0.583	0.032

Source: Exhaust and Crankcase Emission Factors for Nonroad Engine Modelling – Compression Ignition – Report No. NR-009D.

[a] Zero-Hour, steady-state emission factors for nonroad CI engines (Tier 3), Table A-4.

[b] Transient Adjustment Factors by Equipment Type for Nonroad CI Equipment (Tier 3), Table A5.

[c] Deterioration Factors for Nonroad Diesel Engines (Tier 3), Table A6.

[d] Adjustment to PM emission factor to account for variations in fuel sulfur content is made using the following equation -

soxcnv = 0.02247 (grams PM sulfur/grams fuel sulfur consumed)
soxbas = 0.33 (default certification fuel sulfur weight percent for diesel engines)
soxdsl = 0.05 (user specified fuel sulfur weight percent, 500 ppm used)

[e] For all pollutants except PM, adjusted Emission Factor = UAF x TAF x DF.
For PM, adjusted Emission Factor = UAF x TAF x DF - $S_{PM\ adj}$.

[f] Emission Factor for CO_2 = (BSFC x 453.6 - HC) x 0.87 x (44/12).
Emission Factor for SO_2 = [BSFC x 453.6 x (1 - soxcnv) - HC] x 0.01 x soxdsl x (64/32).

g Emission rate = Engine HP-rating x Emission Factor (g/hp-hr) x No. of Vehicles /3600

TABLE 5 -ESTIMATION OF PM EMISSION RATES FROM DEBARKER

Assumptions

Operating hours, hr/day	10	
Throughput, t/day	1300	Year1 throughput. Year 2 add 1200 t/day
Throughput, t/hr	130	From activities summary provided by WSP
Throughout, t/day	1260	Year1 throughout. Year 2 add 1160 t/day
Number of debarker	1	
- Nicholson A8 Debarker		

Estimated Emission Factors (EF)a

PM EF - uncontrolled, lb/tons	0.02
PM EF - uncontrolled, kg/t	0.01
PM10 EF - uncontrolled, lb/tons	0.011
PM10 EF - uncontrolled, kg/t	0.005
PM2.5 EF - uncontrolled, lb/tons	4.50E-05
PM2.5 EF - uncontrolled, kg/t	0.00002

Calculated Emission Rates (ER)

PM uncontrolled, kg/day	13.0
PM uncontrolled, g/s	0.36
PM10 uncontrolled, kg/day	7.1
PM10 uncontrolled, g/s	0.20
PM2.5 uncontrolled, kg/day	0.03
PM2.5 uncontrolled, g/s	0.001

a. PM and PM10 EFs are based on US EPA WebFire database, SCC code 3-07-008-01, log barking
PM2.5 EF based on information from NCASI July 2014 memo for PM2.5 emission from drum debarking.

TABLE 6 -ESTIMATION OF EXHAUST PM, NOx EMISSION RATES FROM LOCOMOTIVES

<u>Assumptions</u>

Train travelling hours	6 am to 7 pm	
Train travelling hours, hr/day	13	
Max. number of locomotives per train	2	
Maximum power output per line-haul locomotive, kW	2700	Assume DL class, US EPA tier 3
Power output for trains arriving at the yard,kW	135	assume 5% of the maximum rated power used for empty trains
Power output for trains leaving the yard,kW	2700	assume 100 % of the maximum rated power used for loaded trains
Power output for idle, kW	5.4	Based on assumption of 0.2% of rated power
		Based on NSW locomotive emission testing
Number of trains arriving at the site from the south /day	3	at 5 % of rated power output
- G-F section length, km	1.3	
- G-F section average speed, km/h	40	
- G-F section travelling time, hr/train	**0.0325**	
- E-F section length, km	1	
- E-F section average speed, km/h	20	
- E-F section travelling time, hr/train	**0.05**	
- E-D section length, km	1.3	
- E-D section average speed, km/h	10	
- E-D section travelling time, hr	**0.13**	
- Total travelling time, hr/train	0.2125	
Number of trains departing the site to the south /day	3	at 100 % of rated power output
- E-D' section length, km	0.8	
- E-D' section average speed, km/h	10	
- E-D' section travelling time, hr/train	**0.08**	
- E-F section length, km	1	
- E-F section average speed, km/h	20	
- E-F section travelling time, hr/train	**0.05**	
- F-G section length, km	1.3	
- F-G section average speed, km/h	40	
- F-G section travelling time, hr/train	**0.0325**	
- Total travelling time, hr/train	0.1625	
Number of trains arriving at the site from the north /day	3	at 5 % of rated power output
- A-B section length, km	2.6	
- A-B section average speed, km/h	40	
- A-B section travelling time, hr//train	**0.065**	
- B-C section length, km	3.3	
- B-C section average speed, km/h	20	
- B-C section travelling time, hr/train	**0.165**	
- C-D section length, km	1.4	
- C-D section average speed, km/h	10	
- C-D section travelling time, hr/train	**0.14**	
- Total travelling time, hr/train	0.37	
Number of trains departing the site to the north /day	3	at 100 % of rated power output
- C-D' section length, km	0.9	
- C-D' section average speed, km/h	10	
- C-D' section travelling time, hr/train	**0.09**	
- B-C section length, km	3.3	
- B-C section average speed, km/h	20	
- B-C section travelling time, hr/train	**0.165**	
- A-B section length, km	2.6	
- A-B section average speed, km/h	40	
- A-B section travelling time, hr/train	**0.065**	
- Total travelling time, hr/train	0.32	
D Train idling time per arrival, hr	1	
D'Train idling time per departure, hr	1	
Number of trains passing (baseline) /day	32	at 50 % rated power
- a-b section length, km	2.6	
- a-b section averag speed, km/h	50	
- a-b section travelling time, hr//train	**0.052**	
- b-c section length, km	3.3	
- b-c section averag speed, km/h	20	
- b-c section travelling time, hr//train	**0.165**	
- c-d section length, km	3	
- c-d section averag speed, km/h	50	
- c-d section travelling time, hr/train	**0.06**	
- Total travelling time, hr/train	0.277	

Estimated Exhaust Emission Factors (EF)

PM10 - duty cycle, g/kWh	0.20	EU Stage IIIA standard for P>560 kW	
NOx - duty cycle, g/kwh	7.40	for net power >2000 kW	
		Table 8 Stage III A/B emission standards for rail traction engines	
PM10 - idle , g/kWh	2.00	Assume 10 times higer than duty cycle	
NOx - idle, g/kWh	22	Assume 3 times higer than duty cycle	
		Based on NSW locomotive emission testing	

Calculated Emission Rates (ER)

PM10 - trains passing (Baseline),g/hr	540	at 50% power output	
- PM10 - trains passing (Baseline) - a-b section,g/train	28		
- PM10 - trains passing (Baseline)- a-b section,g/train/km	11		
- PM10 - trains passing (Baseline)- a-b section,g/hr	**37**	ave to 24 hr	
- PM10 - trains passing (Baseline)- a-b section,g/hr/km	14	ave to 24 hr	
- PM10 - trains passing (Baseline)- a-b section,g/s	0.010		
- PM10 - trains passing (Baseline) - b-c section,g/train	89		
- PM10 - trains passing (Baseline)- b-c section,g/train/km	27		
- PM10 - trains passing (Baseline)- b-c section,g/hr	**119**	ave to 24 hr	
- PM10 - trains passing (Baseline)- b-c section,g/hr/km	36	ave to 24 hr	
- PM10 - trains passing (Baseline)- b-c section,g/s	0.033		
- PM10 - trains passing (Baseline) - c-d section,g/train	32		
- PM10 - trains passing (Baseline)- c-d section,g/train/km	11		
- PM10 - trains passing (Baseline)- c-d section,g/hr	**43**	ave to 24 hr	
- PM10 - trains passing (Baseline)- c-d section,g/hr/km	14	ave to 24 hr	
- PM10 - trains passing (Baseline)- c-d section,g/s	0.012		
PM10 - trains arriving from the south,g/hr	54	at 5% power output	
- PM10 - G-F section, g/train	1.76		
- PM10 - G-F section, g/train/km	1.4		
- PM10 - G-F section, g/hr	**1.76**	ave. to 1 hr	1 train per hour
- PM10 - G-F section, g/min	0.029	ave. to 1 hr	
- PM10 - G-F section, g/s	0.000488	ave. to 1 hr	
- PM10 - E-F section, g/train	2.7		
- PM10 - E-F section, g/train/km	2.7		
- PM10 - E-F section, g/hr	**2.7**	ave. to 1 hr	
- PM10 - E-F section, g/min	0.045	ave. to 1 hr	
- PM10 - E-F section, g/s	0.00075	ave. to 1 hr	
- PM10 - E-D section, g/train	7		
- PM10 - E-D section, g/train/km	5.4		
- PM10 - E-D section, g/hr	**7.02**	ave. to 1 hr	
- PM10 - E-D section, g/min	0.117	ave. to 1 hr	
- PM10 - E-D section, g/s	0.00195	ave. to 1 hr	
PM10 - trains departing to the south,g/hr	1080	at 100 % power output	
- PM10 - G-F section, g/train	35		
- PM10 - G-F section, g/train/km	27.0		
- PM10 - G-F section, g/hr	**35.10**	ave. to 1 hr	
- PM10 - G-F section, g/s	0.01	ave. to 1 hr	
- PM10 - E-F section, g/train	54		
- PM10 - E-F section, g/train/km	54		
- PM10 - E-F section, g/hr	**54.00**	ave. to 1 hr	
- PM10 - E-F section, g/s	0.015	ave. to 1 hr	
- PM10 - E-D' section, g/train	86		
- PM10 - E-D' section, g/train/km	108.0		
- PM10 - E-D' section, g/hr	**86.40**	ave. to 1 hr	
- PM10 - E-D' section, g/s	0.024	ave. to 1 hr	
PM10 - trains arriving from the north,g/hr	54	at 5% power output	
- PM10 - A-B section, g/train	3.51		
- PM10 - A-B section, g/train/km	1.4		
- PM10 - A-B section, g/hr	**3.51**	ave. to 1 hr	
- PM10 - A-B section, g/s	0.001	ave. to 1 hr	
- PM10 - B-C section, g/train	8.91		
- PM10 - B-C section, g/train/km	2.7		
- PM10 - B-C section, g/hr	**8.91**	ave. to 1 hr	
- PM10 - B-C section, g/s	0.002	ave. to 1 hr	
- PM10 - C-D section, g/train	7.6		
- PM10 - C-D section, g/train/km	5.4		
- PM10 - C-D section, g/hr	**7.56**	ave. to 1 hr	
- PM10 - C-D section, g/s	0.002	ave. to 1 hr	

PM10 - trains departing to the north,g/hr	1080	at 100 % power output
- PM10 - A-B section, g/train	70	
- PM10 - A-B section, g/train/km	27	
- PM10 - A-B section, g/hr	**70.20**	ave. to 1 hr
- PM10 - A-B section, g/s	0.02	ave. to 1 hr
- PM10 - B-C section, g/train	178	
- PM10 - B-C section, g/train/km	54	
- PM10 - B-C section, g/hr	**178.20**	ave. to 1 hr
- PM10 - B-C section, g/s	0.05	ave. to 1 hr
- PM10 - C-D' section, g/train	97	
- PM10 - C-D' section, g/train/km	108	
- PM10 - C-D' section, g/hr	**97.20**	ave. to 1 hr
- PM10 - C-D' section, g/s	0.03	ave. to 1 hr
PM10 - idling, g/hr/train	22	at 0.2% power output
PM10 - idling, g/arrival	22	
PM10 - idling, g/hr/location	22	ave. to 1 hr
PM10 - idling, g/s	**0.006**	ave. to 1 hr
PM10 - idling, kg/day	0.259	

APPENDIX E

Stoichiometry Calculations

COMBUSTION CALCULATIONS

GOLDER

01 Jun 2021
21464670 - Marton Industrail Hub Energy Plant
50 MW biomass boiler - 7% O2

Parameter	Value	Unit	Comment / source of data
FUEL ULTIMATE ANALYSIS			
Carbon:	50.30	%wt (DAF basis)	
Hydrogen:	6.24	%wt (DAF basis)	
Oxygen:	43.26	%wt (DAF basis)	
Nitrogen:	0.20	%wt (DAF basis)	
Sulphur:	0.000	%wt (DAF basis)	
Fuel moisture content:	30.00	%wt (as received basis)	
Ash content:	0.56	%wt (as received basis)	
DAF portion:	0.694	kg/kg fuel (as received basis)	
AIR REQUIREMENTS			
Theoretical O_2 required:	44.14	moles/kg (DAF basis)	
Excess air:	49.85	%	
Total O_2 required:	66.14	moles/kg (DAF basis)	
Flue gas CO_2 content:	13.34	%vol dry	
Flue gas O_2 content:	7.00	%vol dry	
APPLIANCE DETAILS			
Power Output:	50000	kW	Target power output
Percentage of MCR:	100.00	%	
Effective power output:	50000	kW	
Efficiency:	100.00	%	Assumed efficiency
As rcvd fuel CV:	12500	kJ/kg	Net CV for wood at 30% moisture content
Equivalent Stack diameter:	1.70	m	Assumed to match efflux velocity of 15 m/s
Heat produced by combustion:	50000	kW	
Heat loss:	0	kW	
Maximum fuel burning rate:	4.00	kg/s (as received basis)	
	14400	kg/hr	
	4.00	kg/s	
STACK PROPERTIES			
Temperature:	423.15	K	Assumed exhaust temperature of 150 °C
WET flow rate (POC sheet):	12.83	m³/kg DAF fuel	
Actual volumetric flow rate:	35.63	m³/s	
	2137.81	m³/min	
Actual volumetric flow rate:	128,268	m³/hour	
Stack x-sectional area:	2.27	m²	
Efflux velocity:	15.70	m/s	Assumed velocity
DRY flow rate @ STP (POC sheet):	7.04	Nm³/kg DAF fuel	
	19.56	Nm³/sec	
	70,432	Nm³/hour	
WET flow rate @ STP (POC sheet):	8.28	Nm³/kg DAF fuel	
	23.00	Nm³/sec	
	82,799	Nm³/hour	

NOTES:

N =	Standard atmospheric conditions (0 °C, 1 atmosphere) and zero humidity	DAF =	Dry, ash free
STP =	Standard temperature (0 °C) and pressure (1 atmosphere)	MCR =	Maximum combustion rate

GOLDER

COMBUSTION CALCULATIONS

01 Jun 2021
21464670 - Marton Industrail Hub Energy Plant
50 MW biomass boiler - 12% CO2

Parameter	Value	Unit	Comment / source of data
FUEL ULTIMATE ANALYSIS			
Carbon:	50.30	%wt (DAF basis)	
Hydrogen:	6.24	%wt (DAF basis)	
Oxygen:	43.26	%wt (DAF basis)	
Nitrogen:	0.20	%wt (DAF basis)	
Sulphur:	0.000	%wt (DAF basis)	
Fuel moisture content:	30.00	%wt (as received basis)	
Ash content:	0.56	%wt (as received basis)	
DAF portion:	0.694	kg/kg fuel (as received basis)	
AIR REQUIREMENTS			
Theoretical O_2 required:	44.14	moles/kg (DAF basis)	
Excess air:	66.43	%	
Total O_2 required:	73.46	moles/kg (DAF basis)	
Flue gas CO_2 content:	12.00	%vol dry	
Flue gas O_2 content:	8.39	%vol dry	
APPLIANCE DETAILS			
Power Output:	50000	kW	Target power output
Percentage of MCR:	100.00	%	
Effective power output:	50000	kW	
Efficiency:	100.00	%	Assumed efficiency
As rcvd fuel CV:	12500	kJ/kg	Net CV for wood at 30% moisture content
Equivalent Stack diameter:	1.80	m	Assumed to match efflux velocity of 15.7 m/s
Heat produced by combustion:	50000	kW	
Heat loss:	0	kW	
Maximum fuel burning rate:	4.00	kg/s (as received basis)	
	14400	kg/hr	
	4.00	kg/s	
STACK PROPERTIES			
Temperature:	423.15	K	Assumed exhaust temperature of 150 ºC
WET flow rate (POC sheet):	14.04	m^3/kg DAF fuel	
Actual volumetric flow rate:	39.01	m^3/s	
	2340.38	m^3/min	
Actual volumetric flow rate:	140,423	m^3/hour	
Stack x-sectional area:	2.54	m^2	
Efflux velocity:	15.33	m/s	Modelled 15.7 m/s
DRY flow rate @ STP (POC sheet):	7.83	Nm^3/kg DAF fuel	
	21.74	Nm^3/sec	
	78,278	Nm^3/hour	
WET flow rate @ STP (POC sheet):	9.06	Nm^3/kg DAF fuel	
	25.18	Nm^3/sec	
	90,645	Nm^3/hour	
EMISSION CALCULATIONS			
NO_X emission factor:	0.22	lb/MMBTU (Gross)	USEPA emission factors
	15.625	MJ/Kg	Assumed gross CV
	2.96	lb/ton	
	1.48	kg/tonne	
NO_X emission rate:	**5.91**	**g/s**	
	21.28	kg/h	
PM_{10} emission factor:	30	mg/Nm^3, 12 % vol. CO_2	Assumed for using baghouse
PM_{10} emission rate	**0.65**	**g/s**	
	2.35	kg/h	
PM 2.5 emisison rate	2.11	kg/h	Assumed 90% of PM10 is PM2.5
	0.59	**g/s**	

NOTES:

N =	Standard atmospheric conditions (0 °C, 1 atmosphere) and zero humidity	DAF =	Dry, ash free
STP =	Standard temperature (0 °C) and pressure (1 atmosphere)	MCR =	Maximum combustion rate

COMBUSTION CALCULATIONS

GOLDER

01 Jun 2021
21464670 - Marton Industrail Hub Food Producer
20 MW biomass boiler - 7% O2

Parameter	Value	Unit	Comment / source of data
FUEL ULTIMATE ANALYSIS			
Carbon:	50.30	%wt (DAF basis)	
Hydrogen:	6.24	%wt (DAF basis)	
Oxygen:	43.26	%wt (DAF basis)	
Nitrogen:	0.20	%wt (DAF basis)	
Sulphur:	0.000	%wt (DAF basis)	
Fuel moisture content:	30.00	%wt (as received basis)	
Ash content:	0.56	%wt (as received basis)	
DAF portion:	0.694	kg/kg fuel (as received basis)	
AIR REQUIREMENTS			
Theoretical O_2 required:	44.14	moles/kg (DAF basis)	
Excess air:	49.85	%	
Total O_2 required:	66.14	moles/kg (DAF basis)	
Flue gas CO_2 content:	13.34	%vol dry	
Flue gas O_2 content:	7.00	%vol dry	
APPLIANCE DETAILS			
Power Output:	20000	kW	Target power output
Percentage of MCR:	100.00	%	
Effective power output:	20000	kW	
Efficiency:	80.00	%	Assumed efficiency
As rcvd fuel CV:	12500	kJ/kg	Net CV for wood at 30% moisture content
Equivalent Stack diameter:	1.20	m	Assumed to match efflux velocity of 15.75 m/s
Heat produced by combustion:	25000	kW	
Heat loss:	5000	kW	
Maximum fuel burning rate:	2.00	kg/s (as received basis)	
	7200	kg/hr	
	2.00	kg/s	
STACK PROPERTIES			
Temperature:	423.15	K	Assumed exhaust temperature of 150 °C
WET flow rate (POC sheet):	12.83	m³/kg DAF fuel	
Actual volumetric flow rate:	17.82	m³/s	
	1068.90	m³/min	
Actual volumetric flow rate:	64,134	m³/hour	
Stack x-sectional area:	1.13	m²	
Efflux velocity:	15.75	m/s	Assumed velocity
DRY flow rate @ STP (POC sheet):	7.04	Nm³/kg DAF fuel	
	9.78	Nm³/sec	
	35,216	Nm³/hour	
WET flow rate @ STP (POC sheet):	8.28	Nm³/kg DAF fuel	
	11.50	Nm³/sec	
	41,400	Nm³/hour	

NOTES:

N =	Standard atmospheric conditions (0 °C, 1 atmosphere) and zero humidity	DAF =	Dry, ash free
STP =	Standard temperature (0 °C) and pressure (1 atmosphere)	MCR =	Maximum combustion rate

COMBUSTION CALCULATIONS

GOLDER

01 Jun 2021
21464670 - Marton Industrail Hub Food Producer
20 MW biomass boiler - 12% CO2

Parameter	Value	Unit	Comment / source of data
FUEL ULTIMATE ANALYSIS			
Carbon:	50.30	%wt (DAF basis)	
Hydrogen:	6.24	%wt (DAF basis)	
Oxygen:	43.26	%wt (DAF basis)	
Nitrogen:	0.20	%wt (DAF basis)	
Sulphur:	0.000	%wt (DAF basis)	
Fuel moisture content:	30.00	%wt (as received basis)	
Ash content:	0.56	%wt (as received basis)	
DAF portion:	0.694	kg/kg fuel (as received basis)	
AIR REQUIREMENTS			
Theoretical O_2 required:	44.14	moles/kg (DAF basis)	
Excess air:	66.43	%	
Total O_2 required:	73.46	moles/kg (DAF basis)	
Flue gas CO_2 content:	12.00	%vol dry	
Flue gas O_2 content:	8.39	%vol dry	
APPLIANCE DETAILS			
Power Output:	20000	kW	Target power output
Percentage of MCR:	100.00	%	
Effective power output:	20000	kW	
Efficiency:	80.00	%	Assumed efficiency
As rcvd fuel CV:	12500	kJ/kg	Net CV for wood at 30% moisture content
Equivalent Stack diameter:	1.20	m	
Heat produced by combustion:	25000	kW	
Heat loss:	5000	kW	
Maximum fuel burning rate:	2.00	kg/s (as received basis)	
	7200	kg/hr	
	2.00	kg/s	
STACK PROPERTIES			
Temperature:	423.15	K	Assumed exhaust temperature of 150 ºC
WET flow rate (POC sheet):	14.04	m³/kg DAF fuel	
Actual volumetric flow rate:	19.50	m³/s	
	1170.19	m³/min	
Actual volumetric flow rate:	70,212	m³/hour	
Stack x-sectional area:	1.13	m²	
Efflux velocity:	17.24	m/s	modelled 15.75 m/s
DRY flow rate @ STP (POC sheet):	7.83	Nm³/kg DAF fuel	
	10.87	Nm³/sec	
	39,139	Nm³/hour	
WET flow rate @ STP (POC sheet):	9.06	Nm³/kg DAF fuel	
	12.59	Nm³/sec	
	45,323	Nm³/hour	
EMISSION CALCULATIONS			
NO_X emission factor:	0.22	lb/MMBTU (Gross)	USEPA emission factors
	15.625	MJ/Kg	Assumed gross CV
	2.96	lb/ton	
	1.48	kg/tonne	
NO_X emission rate:	**2.96**	**g/s**	
	10.64	kg/h	
PM_{10} emission factor:	30	mg/Nm^3, 12 % vol. CO_2	Assumed for using baghouse
PM_{10} emission rate	**0.33**	**g/s**	
	1.17	kg/h	
PM 2.5 emisison rate	1.06	kg/h	Assumed 90% of PM10 is PM2.5
	0.29	**g/s**	

NOTES:

N =	Standard atmospheric conditions (0 °C, 1 atmosphere) and zero humidity	DAF =	Dry, ash free
STP =	Standard temperature (0 °C) and pressure (1 atmosphere)	MCR =	Maximum combustion rate

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