ALLIANCE

FARMERS' PRODUCE

SINCE 1948

ALLIANCE GROUP LIMITED

MATAURA PROCESSING PLANT

DISCHARGES TO AIR

Resource Consent Applications and
Assessment of Environmental Effects

9 September 2020

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PART A

Resource Consent Application

FORM 9

APPLICATION FOR RESOURCE CONSENT

Sections 88 and 145, Resource Management Act 1991

To **Environment Southland**

1. Alliance Group Limited apply for the following type of resource consent:

Discharge Permit to discharge contaminants and odour to air associated with the operation of a meat works.

2. The activity to which the application relates (the proposed activity) is as follows:

Alliance Group Limited (**Alliance**) owns and operates the Mataura Meat Processing Plant (**the Plant**) on the true right bank of the Mataura River in the Mataura township.

Alliance is seeking a replacement resource consent to discharge contaminants and odour to air from the Plant such that it can continue to operate and contribute in a major way to the social and economic wellbeing of the surrounding community. Of note, Alliance propose a substantial upgrade to the Plant's Main Boiler, and implementation of additional odour management measures within three years of the commencement of the new consent term.

A 35-year term is sought for the new discharge permit.

3. The site at which the proposed activity is to occur is as follows:

The Plant and infrastructure are located on the true right bank of the Mataura River, within the Mataura township.

Map reference:	NZMS 260 F46: 911 384
Legal description:	Sec 1-3 Blk VII Twn Mataura
	PtS 4 Blk VII Twn Mataura
	Lot 3 DP 5255
	Lot 1 DP 5255
	Lot 4-7 DP 5255, PtS 6 Blk VII Twn Mataura
	Lot 1 DP 8137, PtS 7 Blk VII Twn Mataura

Lot 2 DP 9633

Lot 1 DP 9633

PtL 2 DP 1157, Lot 1 DP 7659

Lot 1-2 DP 12431, Lot 1 DP 12500

PtS 28 Blk XIII Twn Mataura

Sec 10 Blk VII Twn Mataura

4. The full name and address of each owner or occupier (other than the applicant) of the site to which the application relates are as follows:

Alliance Group Limited is the owner and occupier of the land associated with the Plant.

5. The value of the investment of the existing consent holder is considerable. The latest estimate (December 2018) for the Plant's insured value is $225 million and much of this value is sunk – i.e. it could not be recovered if the Plant were forced to downsize, close or be relocated.

6. There are no other activities that are part of the proposal to which this application relates.

7. The following additional resource consents are needed for the proposal to which this application relates and have not been applied for:

Land use consent to demolish a boiler and erect a new Biomass Fired Boiler (in the event this upgrade option is preferred).

8. I attach an assessment of the proposed activity's effect on the environment that—

(a) includes the information required by clause 6 of Schedule 4 of the Resource Management Act 1991; and

(b) addresses the matters specified in clause 7 of Schedule 4 of the Resource Management Act 1991; and

(c) includes such detail as corresponds with the scale and significance of the effects that the activity may have on the environment.

9. I attach an assessment of the proposed activity against the matters set out in Part 2 of the Resource Management Act 1991.

10. I attach an assessment of the proposed activity against any relevant provisions of a document referred to in section 104(1)(b) of the Resource Management Act 1991, including the information required by clause 2(2) of Schedule 4 of that Act.

Signed:

Doyle Richardson
Group Environmental Manager
Dated September 9, 2020

Electronic Address for Service: Doyle.Richardson@alliance.co.nz
Telephone: +62 27 537 815

B

PART B

Assessment of Environmental Effects

1. INTRODUCTION

1.1 OVERVIEW OF THE ACTIVITY

Alliance Group Limited (**Alliance**) owns and operates the Mataura Meat Processing Plant (**the Plant**) on the true right bank of the Mataura River in the Mataura township.

Alliance is a farmer owned cooperative and the Plant is a vital component of Southland's agricultural sector processing stock from the region. It is also a vital component of the local and regional economy, employing approximately 500 people in the peak of the season and contributing approximately $164 million per year to the economy (mostly in livestock payments) and approximately $30 million in wages and salaries for the 2018 / 2019 season.

Figure 1: The Alliance Mataura Meat Processing Plant (foreground).

The Plant currently operates under 10 resource consents issued by Southland Regional Council ('**Environment Southland'**). The consents which authorise the discharge of contaminants to air from the Plant expire on 15 December 2020.

Alliance is seeking a replacement resource consent to discharge contaminants and odour to air from the Plant as a **discretionary activity** pursuant to Rule 5.5.2 of the Southland Regional Air Plan.

This Assessment of Environmental Effects ('**AEE'**) is in support of applications for this replacement resource consent. Alliance has conducted a substantial review of its emissions and emissions control technology as part of this reconsenting process.

The output of that work programme is a proposal to, within three years of the commencement of the new consent term:

- Substantially reduce the discharge of fine particulate matter from the Plant ('**the Thermal Plant Upgrade'**) by either installing a new baghouse filter on the Plant's Main Boiler (Option 1), or decommissioning that boiler and replacing it with a new 8 MW Biomass Fired Boiler ('**BFB'**) (Option 2); and
- Implement a variety of additional measures to reduce the odour generated by the Plant.

Both Thermal Plant Upgrade options would require significant capital investment (approximately $5 million for Option 1 and $8.8 million for Option 2), and when combined with the capital investment Alliance has committed to spending on the Plant's wastewater system in the next 10 – 15 years, Alliance's total spend on improving the environmental performance of the Plant will be approximately $18.9 million to $22.7 million.

The significant investment in technology proposed by Alliance needs to be justified and secured over an appropriate timeframe. In turn, Alliance is seeking a 35-year consent term for the replacement discharge to air consent being sought. A long consent term also suitably reflects the significant social and economic benefits this Plant provides in the local area and gives greater certainty those benefits will endure.

The Plant is specifically provided for in the Gore District Plan and industrial activities are permitted on the site. Should Option 2 be preferred for upgrading the Plant's Main Boiler, land use consent may be required to demolish the existing boiler and erect the new one. This would be sought later once a decision is made on which upgrade option will be pursued.

1.2 REPORT STRUCTURE

Part A of this document sets out the resource consent application (Form 9) to Environment Southland.

Part B of this document is this AEE, which has been prepared to accompany the resource consent application. It addresses all of the matters Alliance is required to address in these consent applications by Schedule 4 of the Resource Management Act ('**RMA**' or '**the Act'**). The AEE is structured as follows:

Section 1 Is this introduction.

Section 2 Provides background information on Alliance and its environmental management systems.

Section 3 Describes the existing environment for the proposed activities

Section 4 Provides a description of the activities for which consent is sought.

Section 5	Assesses the social and economic effects of granting the consents sought and enabling the Plant to continue to operate.
Section 6	Assesses the actual and potential effects of discharging the products of combustion on the environment.
Section 7	Assesses the actual and potential effects of the discharge of odour on the environment.
Section 8	Provides an overview of how alternative means of undertaking the proposed discharge activities have been considered and why the proposed discharge activities are the best practicable option.
Section 9	Describes the consultation undertaken in respect of these resource consent applications.
Section 10	Is an assessment of the key directives in the relevant planning documents, and how the proposed activities sit in relation to them.
Section 11	Sets out the RMA statutory framework which applies to resource consent applications and assesses the proposal against those provisions.
Section 12	Is a concluding comment.

Various technical assessments have been commissioned by Alliance to support this AEE. They are appended to this AEE and are referenced throughout this document, as necessary.

2. ALLIANCE GROUP LIMITED

2.1 OVERVIEW

Alliance is a large meat processing and exporting company operating five meat processing and export plants throughout the South Island and two plants in the North Island. These plants are located at:

- Stoke, Nelson
- Smithfield, Timaru
- Pukeuri, North Otago
- Mataura, Southland
- Lorneville, Southland
- Levin, Horowhenua
- Dannevirke, Hawkes Bay

The company was established in 1948 and is now a wholly farmer-owned cooperative company. On an annual basis, Alliance processes approximately 6 million lambs, 1 million sheep, over 200,000 cattle, 115,000 deer and 270,000 calves.

This equates to approximately 30% of New Zealand's sheep meat production, 10% of beef and 30% of venison.

The company exports products to over 65 different countries. Approximately 80% of its activities are related to sheep and lamb processing, the remainder being beef, and deer processing. Processing is vertically integrated with about 80% of the meat production being further processed by boning, cutting and consumer packaging. A proportion of the production is exported in a chilled state to Europe and North America. Co-products such as wool, skins and other carcass material are also processed for export by the company, usually at the same location as the meat processing facility.

As a wholly farmer-owned co-operative company, all profits are returned to the company's farmer shareholders with a portion retained for growth and to fund capital projects such as the Thermal Plant Upgrade proposed in this application. Alliance employs approximately 4,650 people (permanent and seasonal staff) and services about 4,340 farmer shareholders who supply livestock, with 36% of these based in Southland.

Alliance's annual turnover for the 2018 / 2019 season was $1.7 billion and operating profit was $20.7 million.

2.2 ALLIANCE'S ENVIRONMENTAL POLICY AND ENVIRONMENTAL MANAGEMENT SYSTEMS

Alliance is committed to the sustainable management of the natural and physical resources that it depends on. Alliance therefore adheres to the following environmental policy:

> *Alliance Group Ltd is committed to the sustainable management of the natural and physical resources which it depends on. In meeting this commitment, Alliance* Group will align itself with applicable New Zealand and international standards and will take all practicable steps to:
>
> - *meet or exceed internal and key stakeholder expectations and relevant regulatory requirements;*
> - *continually improve environmental performance by identifying and measuring impacts, developing clear objectives and meaningful targets, and measuring progress with effective monitoring;*
> - *optimise the use of all resources including energy, water, packaging and chemicals, to minimise the wastes produced and the overall impact of our operations;*
> - *annually review the adequacy of the environmental management programme and progress towards achieving environmental objectives and targets;*
> - *communicate regularly on environmental matters with stakeholders including shareholders, employees, customers, suppliers, communities and regulatory bodies;*
> - *allocate appropriate resources to enable effective environmental management.*

Alliance holds ISO 14001:2015 environmental management systems certifications, as well as numerous quality certifications including ISO 9001:2015. ISO 14001 is an internationally recognised environmental management standard. As part of this system, all environmental aspects and impacts of Alliance's plants are identified and prioritised for action, and processes are put in place to control these aspects. Targets and objectives are established and monitored to enable demonstration of continuous performance and improvements are driven by internal audits and management reviews.

Alliance employs a Group Environmental Manager who has authority and responsibility to co-ordinate and implement the on-site environmental management systems in conjunction with Site Environmental Managers or Environmental Representatives. The Group Environmental Manager is also responsible for ensuring that all the necessary regulatory consents and approvals are held and are current, and that compliance with all conditions of the consents held is being achieved. The board of directors of Alliance receive and review a monthly report on environmental performance matters.

3. EXISTING ENVIRONMENT

3.1 ENVIRONMENTAL SETTING

Mataura is situated on State Highway 1 and the Main South Line railway, on the eastern fringe of the Southland Plain 13 km south west of Gore and 53 km north east of Invercargill. It contains 747 dwellings and a population of 1,629 people as per 2018 census data.

Mataura is bisected by the Mataura River and surrounded by rural land. A large industrial area is located on western side of the Mataura River in the township. The meat processing part of the Plant (‘**Processing Plant’**) is located at the southern end of this industrial area. The hide salting part of the Plant (‘**Hide Plant’**) is located at its northern end. A large industrially zoned area which is owned by a third party is located on the eastern side of the Mataura River opposite the Plant.

Residentially zoned land is located to the south, east and west of the Processing Plant. The closest residential dwellings are located 110 m to the west, 200 m to the south and 300 m north east of the Plant’s main Coal Fired Boiler. Dwellings are also located on elevated land 210 m to the east. Mataura School is located approximately 750 m southwest of the Processing Plant. The land surrounding the Hide Plant is in the Rural Zone. The residential dwelling closest to that site is located approximately 250 m to the west on the western side of Stage Highway 1.

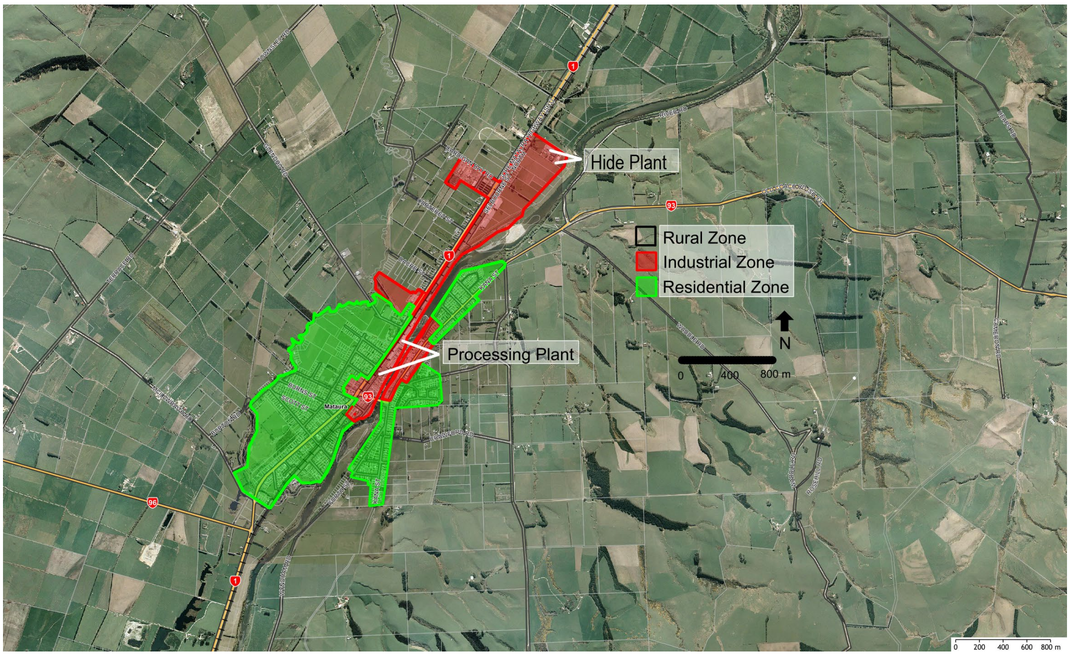

Figure 2: Zoning of land around the Plant.

3.2 CULTURAL VALUES

Tangata whenua have a strong and long-standing relationship with the Mataura River catchment. The entire Mataura River is recorded in the Ngāi Tahu Claims Settlement Act 1998 (NTCSA) as a Statutory Acknowledgement Area (Schedule 42), establishing the cultural, spiritual, historic, and traditional associations of Ngāi Tahu with this river, from the mountains to the sea, ki uta ki tai.

In the immediate vicinity of Mataura itself, where the Plant is located and its impacts on air quality are experienced, is Te Au-Nui-Pihapiha-Kanakana/Mataura Falls. Ngāi Tahu history of the site at Te Au-Nui-Pihapiha-Kanakana/Mataura Falls tells of Ngāti Māmoe rangatira Parapara Te Whenua establishing association between the falls and kanakana harvest. It is both a recorded archaeological site, and a site of consistent mahinga kai practice from the time of Parapara Te Whenua to the present day.

This stretch of the Mataura River is also within the Mataura River Mātaitai Reserve, which has Te Au-Nui-Pihapiha-Kanakana at its core and ends north of Tuturau. This was the first freshwater mātaitai established in New Zealand in 2006, through the leadership of kaumātua Rewi Anglem, which is an indication of how greatly this area is valued within Hokonui Rūnanga and tribally. Regulation making powers established in the wake of the Treaty Fisheries Settlement (Fisheries Act 1996) have enabled this reserve to be established for the primary purpose of supporting customary fisheries management.

3.3 METEOROLOGY

Wind patterns in Mataura are significantly influenced by the raised terrain running along the eastern side of the Mataura River. As such, southerly and northerly wind conditions tend to align with a north northeast to south southwest bearing and cold air drainage flows can be expected to move along this same bearing and towards the south southwest towards town as shown in Figure 3.

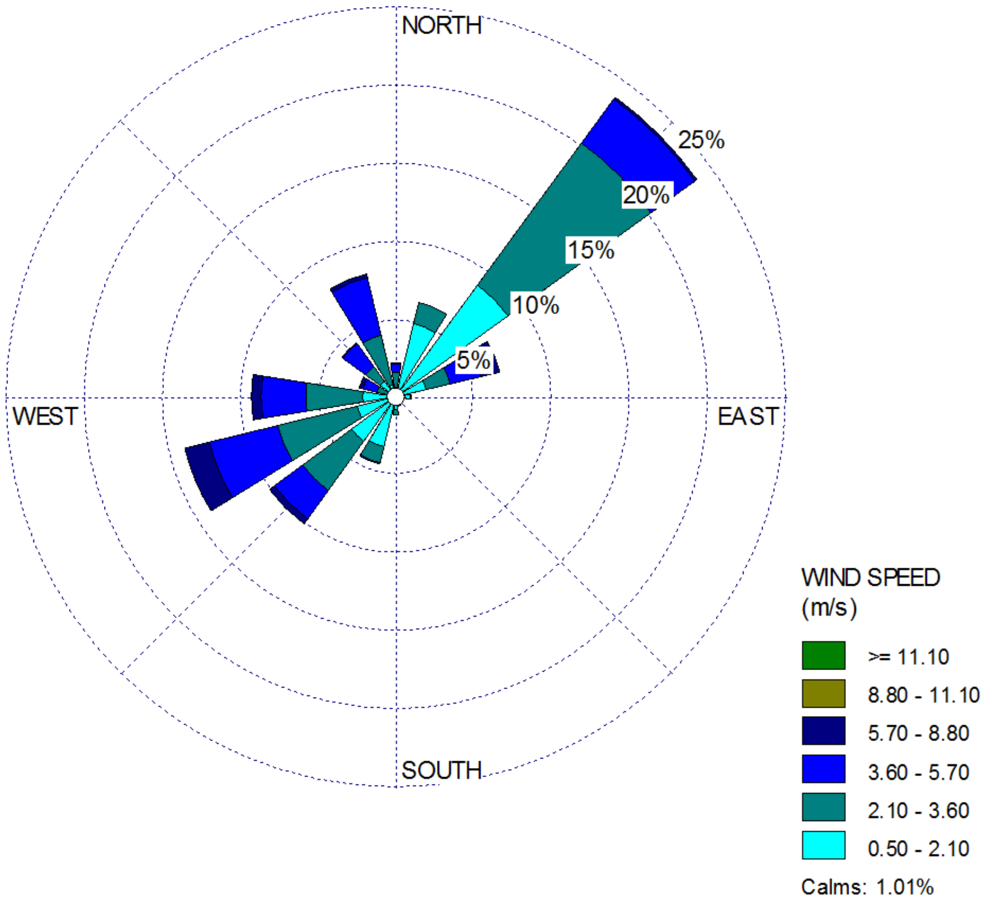

Figure 3: Mataura wind rose (April – July 2018).

3.4 AMBIENT AIR QUALITY

3.4.1 Fine Particulate Matter

Historical ambient PM_{10} monitoring programmes by Environment Southland and Alliance have previously indicated the Mataura airshed is in compliance with the Ministry for the Environments National Environmental Standards (**NES**) for particulate matter smaller than 10 microns (**PM_{10}**)

To inform these consent applications and the long-term plan for the Plant's boilers, Golder Associates ('**Golder**') conducted additional monitoring of ambient PM_{10} and $PM_{2.5}$ between March and early July in 2018 (see **Appendix A**). The results of that monitoring are shown in Figure 4 and Figure 5 below. The Golder monitoring data indicates that ambient concentrations of PM_{10} and $PM_{2.5}$ are significantly elevated in the Township, and that on occasion they breach the World Health Organisation guideline for $PM_{2.5}$.

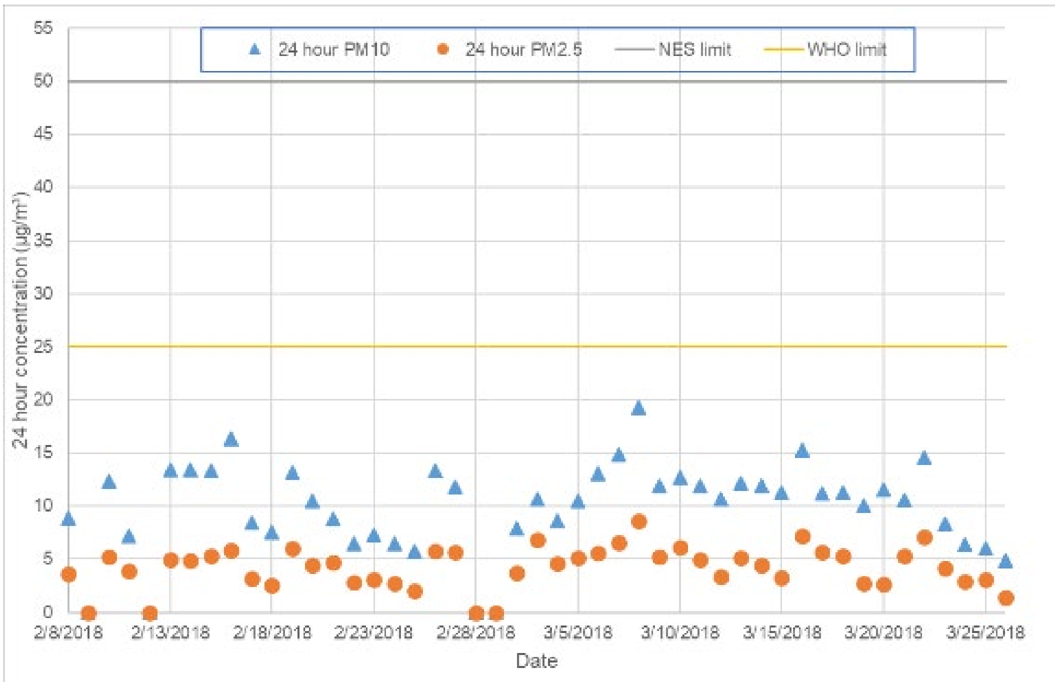

Figure 4: 24-hour average PM10 and PM2.5 concentrations recorded at Hillview Crescent (representative of surrounding hilltop areas).

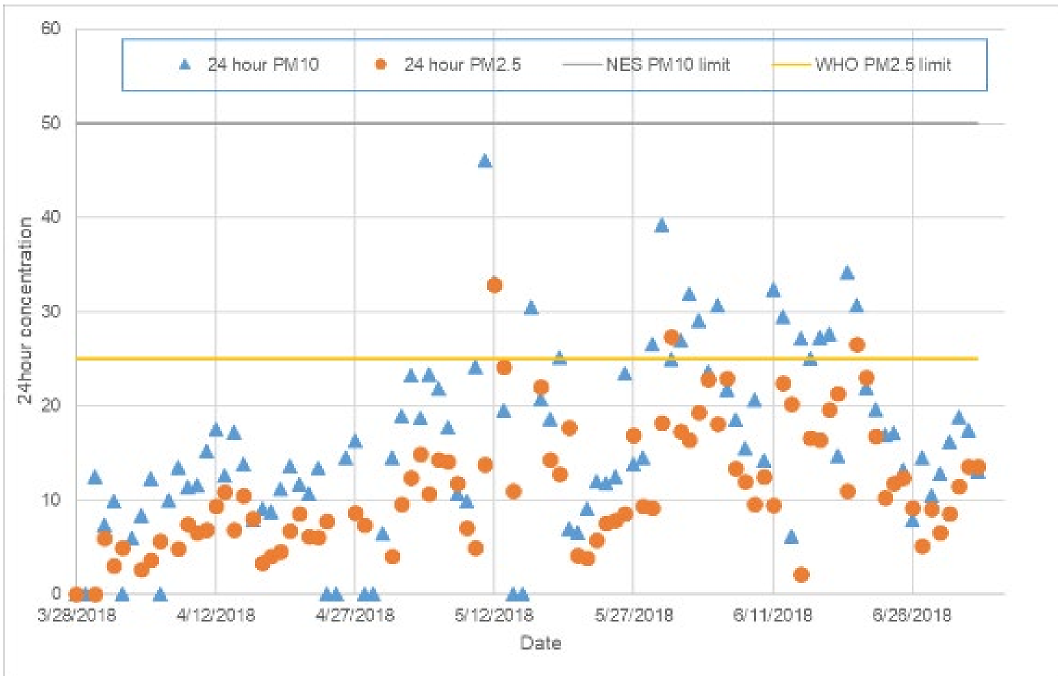

Figure 5: 24 hour average PM10 and PM2.5 concentrations recorded at the Plant's southern boundary (representative of concentrations in the township area).

3.4.2 Other Parameters

Other than fine particulate there are no other air quality parameters of concern in Mataura.

While there is no readily available data on the ambient sulphur dioxide (**SO_2**) or nitrogen dioxide (**NO_2**) concentrations in Mataura, based on the data from other South Island towns, Golder has estimated background SO_2 concentrations in Mataura to be 120 µg/m^3, 30 µg/m^3 and 5 µg/m^3 for 1-hour, 24-hour and annual average, respectively. These concentrations are well below the relevant standards and guidelines.

Likewise, in accordance with the Ministry for the Environment guidelines Golder has conservatively estimated ambient NO_2 concentrations in Mataura of 58 µg/m^3, 38 µg/m^3 and 13 µg/m^3 for NO_2 (1-hour, 24-hour and annual average, respectively). These concentrations are also well below the relevant standards and guidelines.

4. THE PROPOSED ACTIVITY

4.1 THE MATAURA PLANT

The Plant is located on the right bank of the Mataura River at the northern end of Mataura Township as shown in Figure 2). A site plan is provided in Figure 6 below.

The Plant historically processed up to 10,000 sheep per day and 560 beef animals per day (with additional by-products processed including casings and rendering). However, in 2012 the processing of sheep and rendering ceased and beef production increased to up to 1,120 beef animals per day. For the foreseeable future, it is expected that the Plant will continue to operate solely as a beef processing plant.

The Plant generally operates five days per week, over almost 24 hours during peak processing. During the peak of the processing season the Plant will also operate on one weekend day in order to keep up with demand.

The following sections provide more detail on the Plant's:

- Cattle yards;
- Processing facilities;
- Renderable material;
- Skin processing;
- Wastewater system;
- Odour control measures; and
- Thermal emissions.

4.1.1 Cattle Yards

Stock are held in yards prior to slaughter. Cattle yards are located at the north end of the site (see Figure 6). Cleaning of the yards occurs regularly.

4.1.2 Processing Facilities

Slaughtering and further processing facilities (i.e. a cutting room and edible offal processing) are located at the Processing Plant site. Processed carcasses, meat cuts and edible offal are refrigerated and stored in on-site chillers and freezers and transported off-site by road or rail.

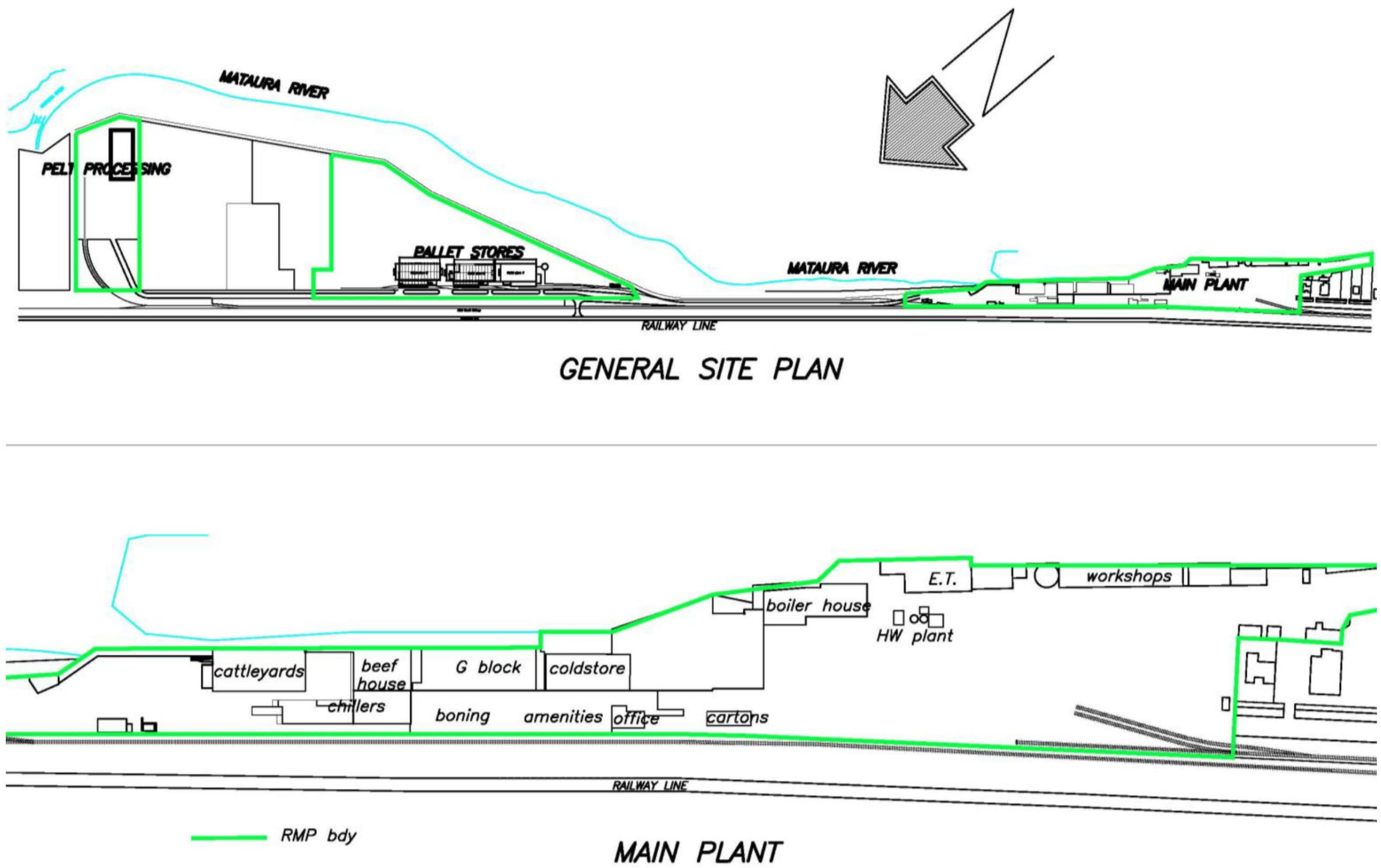

Figure 6: **Site Plan.**

4.1.3 Renderable Material

All inedible offal and other by-products generated from the slaughter and processing of stock is transferred to the Alliance Lorneville site for rendering. Renderable materials are pumped or blown from the Plant and discharged into a large 50 m^3 material storage bin with a discharge conveyor for loading out to trucks.

Bones are also transferred to Lorneville for making soup stock. Soup stock bones are stored in closed bins and removed by truck daily when the site is operating.

Blood is generally processed as soon as possible after collection and within 48 hours of being produced. It is collected from the slaughtering areas and pumped to a holding tank and is then screened to remove unwanted solids before it is coagulated (via injection with steam) and then decanted. The centrate (or liquid) from the decanting of coagulated blood solids is directed to the wastewater treatment plant. Drying of decanted blood solids is undertaken using a conventional in-direct steam heated rotary disc dryer. Dried blood solids are bagged, palletised and then stored or sent off-site for sale.

Exhaust vapours from the blood dryer are cooled via a water-cooled condenser and the resulting non-condensed gases (NCGs) are extracted and utilised as combustion air for the boiler. The condensate generated from the pre-cooling of the dryer exhaust air is treated at the wastewater treatment plant.

Blood was not processed onsite during the 2019 / 2020 season.

4.1.4 Skin Processing

Cattle hides are treated at the Hide Plant (2 km north of the Plant). This is a salting operation for preservative purposes and further processing is done elsewhere.

4.2 WASTEWATER SYSTEM

4.2.1 Wastewater Streams

The main wastewater streams at the Plant are:

- **The Cattle Yards** - Washing of the yards is undertaken to remove animal waste. This is carried out by regular use of high-pressure water hoses, with the resulting flow collected within a sump from where it is screened through a screw press (to remove solids) with remaining wastewater pumped over a contra-shear screen to remove any additional solids before being pumped to the site’s wastewater treatment plant.
- **The Truck Wash** - Alliance operates a truck wash on-site for trucks that deliver stock and a stock truck effluent collection facility. Wastewater from these is also treated in the plant wastewater treatment system.

- **The Process Plant** - Wastewater streams are produced from the slaughter and further processing chains from a range of activities including sterilisation, room cleaning, product chutes and hides cooling. This includes a liquid waste stream from blood drying (see Section 4.1.3), and liquid drainings from the raw material storage bin (see Section 4.1.3). Process wastewater streams primarily comprises of fat, protein, and semi-digested gut contents.

4.2.2 Wastewater Treatment Plant

The wastewater treatment system at Mataura is designed to remove suspended solids, including associated organic matter, oil and grease, phosphorus and some nitrogen from the wastewater prior to its discharge as shown in Figure 7 below. It comprises preliminary treatment (screening), primary treatment (settling) and physio-chemical treatment via a Dissolved Air Floatation (‘**DAF’**) system of the wastewater prior to it being discharged to the Mataura River.

The green waste stream receives an additional alkali DAF stage (i.e. pH is lifted through the addition of lime) to remove phosphorus due to its comparatively high phosphorus load (outlined in Figure 7). The non-green waste does not contain high concentrations of phosphorus.

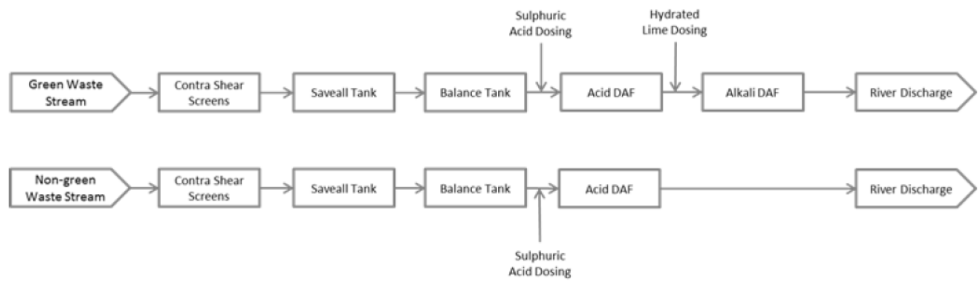

Figure 7: Existing wastewater treatment process at the Plant.

In the initial process step the wastewater passes through a contra-shear screen and a "Save-All" which remove solids by physical separation and settling, respectively. These solids (hereafter referred to as “**compost solids”**) are collected in a bin and are periodically taken off-site for composting.

The preliminarily treated wastewater is then transferred to balance tanks which supply a steady flow to the physio/chemical wastewater treatment plant.

The wastewater from the balance tanks is then sent into the DAF treatment stage and is dosed with sulphuric acid and a flocculating agent as it is directed through one of six DAF tanks. Separation of further solids from the wastewater is achieved using DAF technology that injects dissolved air into the DAF tanks which assists in floating the coagulated solids to the surface of the tanks, creating a floating high-protein layer of solids on its surface (hereafter referred to as "**DAF solids**").

Figure 8: Final dried DAF solids ready to be taken off-site for composting.

These DAF solids (approx. 7.0 to 8.0 wt.% solids) are removed by scraping and are pumped to a holding tank. The DAF solids are then pumped out via a steam coagulator and into a decanter (installed in August 2017) which dewaters the DAF solids to 50 wt.% solids, such that they can be conveyed to a parked truck trailer, and trucked offsite daily for composting.[1] However, there is contingency for discharge to land, the Lorneville treatment plant, or landfill in the event the material is not suitable for composting.

A DAF tank cleaning procedure is carried out on a regular basis to remove heavy solid material accumulating in the base of each tank, these solids are processed through the decanter along with the DAF solids.

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1 Historically the Mataura Plant disposed of the wastewater treatment solids produced by the wastewater treatment process by spreading it onto local consented farmland. However, with operational changes to the Mataura Plant, including the increase in the number of cattle processed by the site and the removal of sheep and lamb processing, the peak processing time for the Plant shifted from the summer months (Jan-Mar) to the Autumn months (Mar-Jun). This shift caused difficulties in finding suitable land to spread the solids onto during periods of wet weather. To address this a decanter was installed and commissioned in August 2017 to dewater the wastewater treatment solids. This allows them to be transported offsite for composting at an independent composting operation instead.

In the future, dewatered DAF solids may be conveyed to a new biomass boiler for use as a biofuel.

4.3 ODOUR MANAGEMENT

The Plant is operated in accordance with an Air Discharge Management and Contingency Plan (**Management Plan**), which includes a comprehensive section on odour management measures. A copy of the Management Plan is included in the Golder report included in **Appendix C** of this AEE.

A summary of the odour management measures contained in the Management Plan and which are currently implemented at the Plant are set out in Table 1 below.

Table 1: Summary of the odour management measures currently implemented at the Plant.

Activity	Odour Management Measures Implemented by Alliance
Wastewater Treatment Plant	› Sumps, pumps, screens, general operation, and the discharge are checked at least every 2 hours and issues recorded in a diary for action by relevant personnel. › Regular checks of the sand and grit plant are carried out. › The grit plant is cleaned approximately weekly. › DAF tanks are routinely emptied and cleaned to minimise the build-up of solids in the bottom of the tanks. Approximately 3 tanks (of 12) are cleaned each week and this occurs during the night shift period to minimise any potential effect on neighbours. › The balance tanks are cleaned when necessary noting that this is an infrequent occurrence due to the installation of a sand and grit removal system. If required, accumulated solids are removed by suction tanker, or dug out with a small tractor unit. The solids are transported off-site for composting. The solids are largely inorganic sand and grit and as such are not very odorous. › Unexpected malfunctions are corrected promptly by the on-site maintenance team. › During the shutdown period, all sumps, save-alls, balance tanks and DAF tanks are drained and cleaned for inspection. › Routine maintenance of the treatment plant including pipe work, tanks, pumping and dosing systems occurs during scheduled plant shut-down periods.
Wastewater Solids Loadout	› Transport of the collected sand and grit (compost solids) to an off-site location (in conjunction with the beef paunch content material) during processing to minimise the risk of it becoming odorous

Activity	Odour Management Measures Implemented by Alliance
	› The dewatered solids are discharged into a parked trailer, which when full, is transported offsite to an external composting operation. › The trailer is cleaned via hosing with water between loads. › If the DAF sludge is not able to be dewatered, the material is removed for discharge every production day and on no occasion is it allowed to accumulate for more than 24 hours prior to discharge. › The DAF solids tank and associated pump and pipe work is cleaned out every off-season. › Periodic inspections and maintenance as required. › If disposal to land becomes unavailable another contingency is in place that involves transport of DAF solids to the Alliance Lorneville plant for disposal to its wastewater treatment plant.
Rendering Raw Material Load Out	› The product is loaded out approximately four times every 24 hours, depending on Plant production. It is never held for more than 24 hours. › When there is a risk of odours (generally warm weather associated with off-peak kills) the material is stabilised by spraying the rendering product with an antioxidant. The stabilising agent used is a blend of organic acids, with a specialised surfactant. The material is dosed at the rate recommended by the supplier who periodically checks the application. › The raw material bin is cleaned daily. › The transporting truck is cleaned at a minimum daily, usually after every load. › Sump and pump are cleaned regularly. › Loadout auger is maintained free of blockages to ensure no material is dropped on the ground. › Sump pump is serviced during scheduled shutdowns. › If the Alliance Lorneville plant is unable to receive raw material for rendering a contingency is in place that would see an external renderer receive the material or it will be landfilled.
Blood Processing	› Routinely blood is processed the same day as it is collected from slaughter and no blood over 48 hours old is processed unless it has been stabilised with 0.3% sodium metabisulphate or another suitable stabilising agent. › The non-condensable gases ex the drier are directed into the boiler and discharged to atmosphere via the 30-metre stack.

Activity	Odour Management Measures Implemented by Alliance
	- A full Clean in Place (CIP) clean occurs at the end of each processing day. - Unexpected malfunctions are corrected promptly by the on-site maintenance team. - Routine maintenance of the blood plant including pipe work and tanks occurs during scheduled plant shut-down periods. - If there is a significant malfunction raw blood can be transferred to the Alliance Lorneville plant for processing.
Stock Holding Yards	- The yards are hosed down daily, and the waste stream screened. - The solid wastes from the yards are transported off site daily while processing to a composting operation.

4.4 THERMAL EMISSIONS

4.4.1 Current Operations

Alliance currently operates two coal fired boilers onsite:

- A 9,400 kilowatt (kW) Babcock and Wilcox spreader stoker boiler at the Plant (‘**the Main Boiler’**); and
- A 923 kW Boag spreader stoker boiler at the Hide Plant (‘**the Hide Plant Boiler’**).

The location of these two boilers is shown in Figure 9.

The emissions from each boiler are controlled using a multi-clone system.

There is also a backup spreader stoker boiler (3,800 kW) to the Main Boiler (‘**the Backup Boiler’**), and a small 160 kw lignite-fired boiler for office heating (‘**the Office Boiler’**). The Backup Boiler operates very infrequently and generally for a very short duration. The last time it was used was in 2013. The Office Boiler is also operated infrequently. The last time being in 2016.

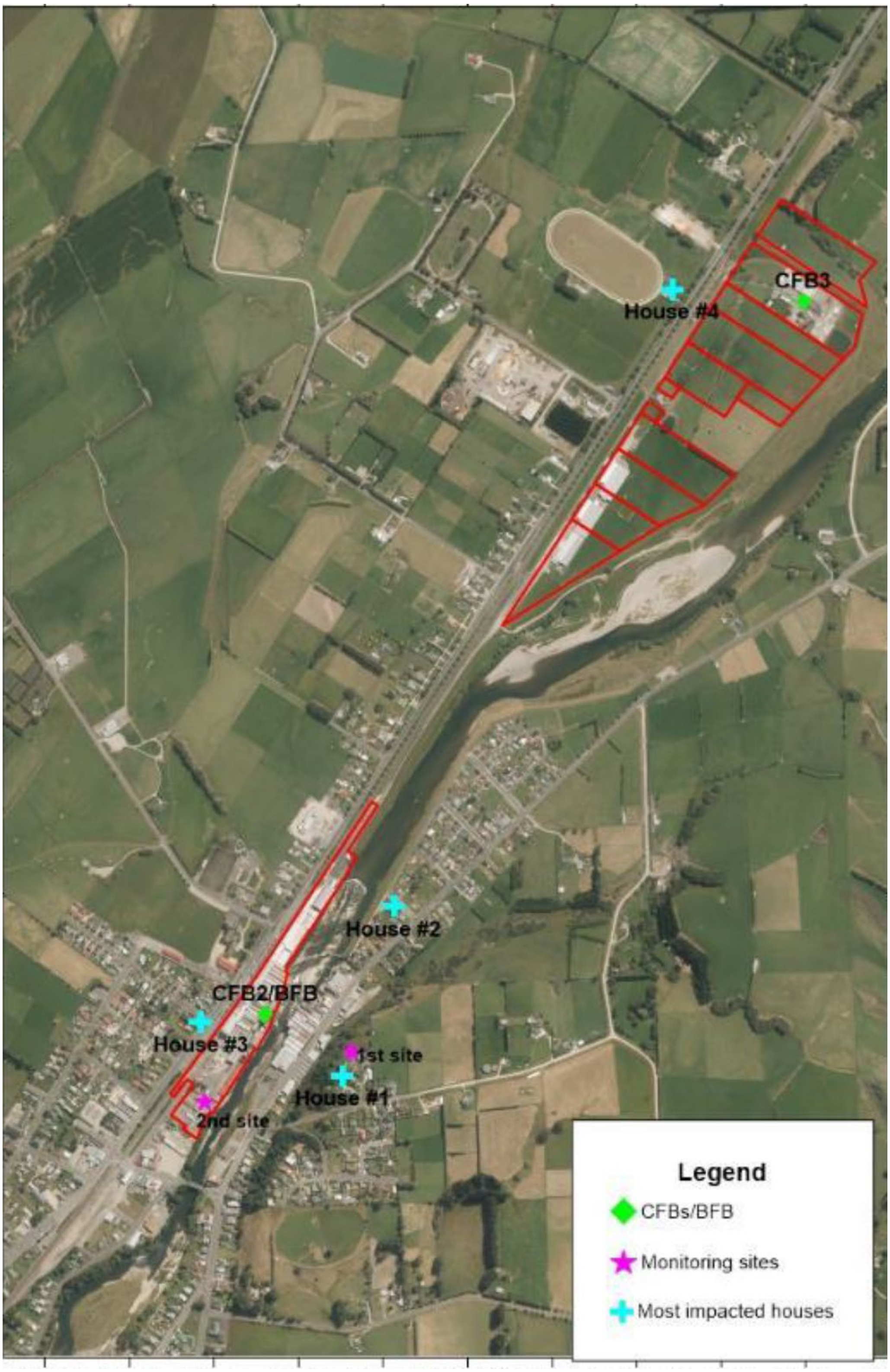

Figure 9: Location of the existing and proposed thermal plant.

The Main Boiler:

- Operates up to 24 hours a day, seven days per week in peak season, and 14 hours per day and five days per week during shoulder seasons;[2]
- Has a 30 m high stack with an efflux diameter of 2 m; and
- Typically operates up to 50 % of its maximum continuous capacity rating (MCR) (more detail on the MCR of the boiler is provided in the Golder Report in **Appendix B**).

The Hide Plant Boiler:

- Operates approximately 35 hours per week over three days in peak season;
- Has a 20 m high stack with a discharge diameter of 0.6 m; and
- Typically operates up to 40 % of its MCR.

Both boilers are fired on a lignite coal that is supplied from the Newvale Coal Mine. An analysis of the coal properties is provided in the Golder Report in **Appendix A** to this AEE.

Both the Main Boiler and the Hide Plant Boiler produce hot exhaust air streams containing combustion products and particulates. The latter arise due to a wide range of processes including fly ash carry over, un-combusted carbon (soot) and from the condensation of un-combusted organic volatiles.

The main portion of the exhaust consists of nitrogen (**N_2**) and residual oxygen (**O_2**) from the combustion air. The primary products of combustion include carbon dioxide (**CO_2**), SO_2, NO_2 and water vapour. There is also a range of products of incomplete combustion (**PICs**) that mainly include volatile organic compounds (**VOCs**), carbon monoxide (**CO**), nitrogen oxide (**NO**) and nitrous oxide (**N_2O**). Contaminant emission rates for each boiler are provided in the Golder Report in **Appendix A** to this AEE.

The condensation of VOCs within the boiler stack and un-burnt carbon particulates (soot) are a key source of fine particulate matter less than 2.5 micrometres in diameter (**$PM_{2.5}$**), whereas fine particulate matter less than 10 micrometres in diameter **(PM_{10}**) and larger suspended particulates are derived from these sources as well as larger fractions of fine fly ash and coal fines. VOCs also include trace levels of poly aromatic hydrocarbons and dioxin like compounds.

4.4.2 The Thermal Plant Upgrade

Alliance proposes to reduce the discharge of PM_{10} and $PM_{2.5}$ from the Main Boiler within three years of the commencement of the new consent by either:

- Option 1 - Installing a new baghouse filter on the Main Boiler; or

[2] Peak season is November – July, shoulder season is August – October.

- Option 2 - Decommissioning the Main Boiler and replacing it with a new 8 MW BFB.

The Hide Plant Boiler would continue to operate as it does currently.

The new BFB would have a stack height of 29 m, and would achieve a nominal efflux velocity of 15 m/s. An efflux diameter of 0.76 m was established via stoichiometric calculations.

The products of combustion emitted from both upgrade options are described in the Golder Report contained in **Appendix B.** They are generally as set out above for the existing operation of the Main Boiler except:

- For both upgrade options the particulate emission rate will be approximately 85% lower than the existing Main Boiler[3]; and
- For the BFB option, the extent of metals, PaHs and dioxin/furan compounds within the exhaust air is relatively low compared to the trace levels that are contained within CFB exhaust air. Furthermore, BFBs produce minimal SO_2 emissions.

4.5 OTHER EMISSIONS

There are various other miscellaneous emissions from the site including building ventilation, minor refrigerant losses and water vapour. The effects of any odour contained in these discharges are addressed in Section 7 of this AEE. Any other adverse effects will be de minimis.

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3 Assuming it is operating at 50% MCR.

5. SOCIAL AND ECONOMIC EFFECTS OF ALLOWING THE ACTIVITIES

When considering these applications, the RMA requires the consent authority to have regard to the actual and potential effects of allowing the activity, including positive effects.

A detailed assessment of the economic benefits of the Plant continuing to operate was completed by Brown, Copeland & Co Ltd in May 2019 (**the economic assessment**). A copy of the economic assessment is provided in **Appendix D** of this AEE.

The economic assessment has confirmed there are significant economic benefits accruing from the Plant, and that it is an asset for the Gore District and Southland region. Obtaining resource consents which allow the Plant to continue to operate would allow these benefits to continue.

The Plant employs 500 full time salaried staff and seasonal workers during peak seasons. This equates to 340 full time equivalent staff (FTEs). The Plant pays out $22 million in wages and salaries per annum ($30 million for the 2018/2019 season) and spends an estimated additional $12.3 million per annum in the Southland region on goods and services. These are quantified as direct economic impacts for the region's economy arising from the Plant's operation.

In addition, the economic assessment has identified a number of indirect impacts arising from:

- The effects on suppliers of goods and services provided to the Plant from within the region (i.e. the "forward and backward linkage" effects); and
- The supply of goods and services from within the region to employees at the Plant and to those engaged in supplying goods and services to the Plant (i.e. the "induced" effects). For example, there are additional jobs and incomes for employees of supermarkets, restaurants and bars as a consequence of the additional expenditure by employees directly employed at the Plant.

When these indirect effects are accounted for, the total contribution of the Plant's operation is assessed to be 595 FTE jobs for Southland residents, and $38.5 million per annum in wages and salaries for local Southland residents.

Figure 10: Beef boners at the Mataura Plant.

The economic assessment notes that the Plant gives the Gore District greater critical mass and, as a consequence, the residents and businesses within the Gore District benefit from economies of scale, greater competition, increased resource utilisation and better central government provided services. This is also true for the Southland region, although to a lesser extent given the economic activity generated by the Plant is proportionately less for the region as compared to the Gore District.

Continuation of the Plant at its current site, on a longer consent term (i.e. 35 years) also generates a number of economic efficiency benefits. The economic assessment identifies these as including:

- The continued use of existing plant and equipment with an insured value of $225 million (much of this value is sunk i.e. it could not be recovered if the plant was forced to downsize, close or be relocated);
- The minimisation of transport costs (and carbon footprint) due to the proximity of the Plant to producers of livestock and finished product dispatch;
- The availability of a trained and experienced workforce and businesses with appropriate expertise and experience within close proximity of the Plant; and
- Greater certainty for investment and management of the Plant.

If the Plant were to cease operation and Southland farmers had to truck cattle out of the region for processing, it would add to farmers' costs, reduce their disposable incomes and reduce spending in the Gore District and elsewhere within the region.

Alliance also contributes directly to the economic and social wellbeing of the community via its rates payments and other community contributions.

6. EFFECTS OF THERMAL EMISSIONS

6.1 INTRODUCTION

Alliance commissioned Golder to assess the effects on the environment of thermal plant emissions from:

- The existing Main Boiler and Hide Plant Boiler (see **Appendix A** of this AEE); and
- Those boilers following the Thermal Plant Upgrade (see **Appendix B** of this AEE).

A summary of the key findings from the Golder reports is provided below.

6.2 KEY CONTAMINANTS OF CONCERN

As set out in Section 4.7 of this AEE Golder identified the key contaminants of concern in the thermal plants' emissions as PM_{10}, $PM_{2.5}$, SO_2 and NO_2. The effects of the thermal plants' discharge of these contaminants is addressed in detail below.

6.3 ASSESSMENT CRITERIA

Relevant assessment criteria when assessing the effects of the thermal plants' emissions on ambient air quality are:

- The Resource Management (National Environmental Standards for Air Quality) Regulations 2004 (**NESAQ**);
- The Ambient Air Quality Guidelines produced by the Ministry for the Environment and Ministry of Health (**AAQG**); and.
- The World Health Organisation Guidelines (**WHO**).

In April 2020 central government released a document setting out proposed amendments to the NESAQ for public consultation (**NESAQ Consultation Document**). It included a proposal to put more focus on $PM_{2.5}$ for managing fine particulate levels in New Zealand's ambient air. The relevant criteria set out in the NESAQ Consultation Document are included in Table 1 below, and are discussed in the appended Golder reports, however it is important to note those provisions are not currently in force and may change when future changes to the NESAQ are ultimately made.

Table 2: **Summary of ambient air quality 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	NESAQ
	20	Annual	0	AAQG
$PM_{2.5}$	25	24 hour	0	WHO
			3	NESAQ Consultation Document
	10	Annual	0	WHO NESAQ Consultation Document
SO_2	350	1 hour	9	NESAQ
	570	1 hour	0	NESAQ
	120	24 hour	0	MfE AAQG
	30	Annual	0	MfE AAQG
NO_2	200	1 hour	9	NESAQ
	100	24 hour	0	MfE AAQG

6.4 EFFECTS OF THE MAIN PLANT BOILER AND HIDE PLANT BOILER ON FINE PARTICULATE MATTER (PM_{10} & $PM_{2.5}$)

Golder have assessed the effects of the fine particulate matter discharged from the boilers pre and post the Thermal Plant Upgrade.

A summary of the key findings from the Golder assessment is set out below.

6.4.1 Effects of the Existing Boilers

The Golder report identifies ambient particulate levels in Mataura are elevated. With the existing boilers operating in their current configuration Golder assess they approach, but likely comply with, the NESAQ for 24-hour PM_{10}, and relevant guideline values for annual average PM_{10} and $PM_{2.5}$. However, they are unlikely to comply with the WHO Guideline for

24-hour $PM_{2.5}$, and potentially would not comply with the corresponding standard in the NESAQ Consultation Document.

After analysing ambient monitoring data and atmospheric dispersion modelling results, Golder identified that for the most part elevated PM_{10} and $PM_{2.5}$ concentrations in Mataura occur on cold still days, and that domestic fires are the dominant cause of those elevated concentrations. The Plant's boilers make a relatively small contribution at these times. Good context to this is provided in the results of the ambient air quality modelling conducted by Golder which show in these cold still conditions:

- Ambient PM_{10} (Plant + background) at the residential dwelling in Mataura most impacted by the Plant's boilers would be elevated, and 82% of the 24 hour NESAQ, but that the contribution of the thermal plants to those ambient PM_{10} concentrations would only be in the order of 5.5% (or less) of the NESAQ; and
- Ambient $PM_{2.5}$ (Plant + background) at that dwelling would be 120% of the relevant WHO 24 hour standard, but that the contribution of the thermal plants to those ambient $PM_{2.5}$ concentrations would only be in the order of 8% (or less) of the WHO standard.

However, both the ambient air quality monitoring and atmospheric dispersion modelling results show that in other meteorological conditions the Plant's Main Boiler can, on occasion, significantly increase ambient PM_{10} and $PM_{2.5}$ concentrations in Mataura, thereby increasing the total number of days in the year when ambient levels of fine particulate in Mataura are high, and air quality is degraded, and therefore increasing the potential for non-compliance with the 24 hour $PM_{2.5}$ standard contained in the WHO guidelines and NESAQ Consultation Document. Of relevance here the Golder report identifies the Main Boiler as the likely cause of one of the exceedances of the 24-hour $PM_{2.5}$ WHO guideline recorded in 2018 on the Plant's southern boundary (see Figure 5). The Golder modelling also shows the Main Boiler can cause elevated $PM_{2.5}$ concentrations in an area to the east of the Plant, which may, on occasion, approach, or exceed the WHO guideline.

With respect to the operation of the small Hide Plant Boiler, modelling predicts it will cause maximum increases of 24-hour off-site PM_{10} and $PM_{2.5}$ concentrations which are less than 50 % of their respective 24-hour ambient standard/guideline, and that these impacts occur on nearby uninhabited pastural areas. Beyond this area of uninhabited land, the impact concentrations decrease rapidly.

6.4.2 Effects Following the Thermal Plant Upgrade

As outlined in Section 4.4 of this AEE, within three years of the commencement of the new consent, Alliance will upgrade the Plant's Main Boiler to reduce its particulate emissions. The upgrade will comprise either:

- Installing a new baghouse filter on the Main boiler (Option 1); or

- Decommissioning the Main Boiler and replacing it with a new 8 MW BFB (Option 2).

Both options contain best practice emissions control technology for fine particulate matter and would reduce the particulate emission rate from the Plant's Main Boiler by approximately 85%.

Golder has modelled the effects of the Main Boiler / BFB and Hide Plant Boiler operating together following the Thermal Plant Upgrade.

It shows in cold still conditions, when background quality is poorest, ambient air quality would remain degraded in Mataura due to the impact of domestic fires, but that the contribution of the Main Boiler in those conditions would be reduced and minimal. For example, in these conditions the modelling predicts:

- Ambient PM_{10} (Plant + background) at the residential dwelling in Mataura most impacted by the Plant's boilers would be 77% of the 24 hour NESAQ for both the baghouse and BFB upgrade option and remain elevated, but the contribution of the Main Boiler to those ambient PM_{10} concentrations would only be in the order of 0.5% (or less) of the NESAQ; and
- Ambient $PM_{2.5}$ (Plant + background) at the dwelling would be 113% of the relevant WHO standard for both the baghouse and BFB upgrade option, but the contribution of the Main Boiler to those ambient $PM_{2.5}$ concentrations would only be in the order of 1% (or less) of the WHO standard.

In other meteorological conditions the modelling also shows the Main Boiler would no longer cause elevated particulate levels in Mataura. For example, in the meteorological conditions the Main Boiler is predicted to cause its highest level of impact:

- Ambient PM_{10} (Plant + background) at the residential dwelling in Mataura most impacted by the Plant's Main boiler would be 33% of the NESAQ for both the baghouse and BFB upgrade option and comply with that standard, with the Main Boiler only contributing PM_{10} concentrations in the order of 5% (or less) of the NESAQ in these conditions; and
- Ambient $PM_{2.5}$ (Plant + background) at the dwelling would be 42% of the relevant WHO standard for both the baghouse and BFB upgrade option, with the Main Boiler only contributing $PM_{2.5}$ concentrations in the order of 10% (or less) of the WHO standard in these conditions.

The effects of operating the Hide Plant Boiler in its current configuration would be the same as outlined in the previous section and of no concern.

As a result, the Golder reports assess that following the Thermal Plant Upgrade:

- The emissions control technology on the Main Boiler would represent best practice;

- The PM_{10} and $PM_{2.5}$ discharges from the thermal plants would only have a minor effect on existing background air quality within Mataura, and there would be a significant reduction in air quality effects compared to those currently caused by the existing energy plant;
- Due to the impact of emissions from domestic fires particulate levels in Mataura would remain elevated during cold still days but would likely comply with the NESAQ for 24-hour PM_{10}, and annual average PM_{10} and $PM_{2.5}$; and
- While there may be residual issues with the Mataura airshed complying with the 24-hour standard for $PM_{2.5}$ contained in the WHO guidelines and NESAQ Consultation Document, those issues would be due to domestic fires, and not the Plant.

6.5 EFFECTS OF THE MAIN PLANT BOILER AND HIDE PLANT BOILER ON SULPHUR DIOXIDE AND NITROGEN DIOXIDE

The Golder reports includes a cumulative assessment of SO_2 and NO_2 impacts due to the emissions from the thermal plants and background levels pre and post the Thermal Plant Upgrade. For both these air contaminants, the predicted worst-case cumulative impacts are well within their respective NESAQ and MfE AAQG criteria for all relevant averaging periods.

Given the extent of predicted compliance with relevant health-based criteria, Golder considers the cumulative effects of these contaminants are likely to have a less than minor potential to cause adverse effects on people, flora or fauna.

6.6 EFFECTS OF THE BACKUP BOILER AND OFFICE BOILER

The backup boiler will only operate when the Main Boiler is offline. This is very infrequent (it hasn't happened since 2013) and will only be for a very short-term period. When this happens, it will displace the emissions from the Main Boiler. The effects of the short-term operation on ambient air quality will be less than minor.

The office boiler is very small (160 kw) and discharges via a 180 mm diameter 6.5 m high stack. The effects of the discharge from this comparatively small boiler on ambient air quality, including particulate levels, will be localised, and minor.

6.7 CONCLUSION

PM_{10} and $PM_{2.5}$ concentrations are elevated in Mataura. While ambient air quality complies with the NESAQ for 24-hour $PM_{10,}$ it does not appear to comply with the WHO guideline for 24-hour $PM_{2.5}$ which central government has flagged for inclusion in the NESAQ in the near future. For the most part this occurs on cold still days when domestic fires are the dominant cause of elevated concentrations. However, in other meteorological conditions, the Main Boiler, can, on occasion be the dominant source.

Within three years of the commencement of the new consent term Alliance will upgrade the Plant's Main Boiler with either a baghouse or new BFB. This will reduce the amount of fine particulate discharged by the Main Boiler by 85% and bring its emissions control technology in line with best practice. It will also mean the Plants Main Boiler is no longer a contributor of consequence to ambient PM_{10} and $PM_{2.5}$ concentrations in Mataura.

While there may be residual issues with elevated PM_{10} and $PM_{2.5}$ concentrations in the Mataura airshed, those issues would be due to domestic fires, and not the Plant.

All other contaminants discharged from the thermal plants readily comply with the relevant health-based standards and guidelines.

7. EFFECTS OF ODOUR EMISSIONS

7.1 INTRODUCTION

To inform these consent applications Alliance commissioned Golder to conduct a thorough review of the odour generated by the Plant and the mechanisms in place to reduce that odour, and to identify opportunities to further reduce the levels of odour generated.

A copy of the Golder odour report is provided in **Appendix C** of this AEE. A summary of the key findings from the Golder odour report is provided below.

7.2 METHODOLOGY

The Golder assessment was undertaken in accordance with The Ministry for the Environment's '*Good Practice Guide for Assessing and Managing Odour in New Zealand*' (MfE, 2016). It included:

- Identification of the potential odour sources at the Plant;
- Analysis of the Plant's complaints record;
- A comprehensive 3-month odour diary programme (completed between 15 November 2019 and 22 February 2020 which involved community members who had previously complained about odour from the Plant);
- A follow up site visit and review of emission control systems by Golder personnel; and
- Application of expert knowledge of odour generating processes for sites of this kind.

7.3 POTENTIAL ODOUR SOURCES

Golder confirmed the main potential sources of recognisable off-site odour from the Plant as the following activities, which, as is outlined in Section 4.7 of this AEE, are already subject to a wide range of odour management practices:

- The cattle yards;
- The operation of the wastewater treatment system's DAF tanks and their periodic draining and pumping of sludge to the DAF solids decanter;
- The operation of the DAF solids decanter, and the storage and loadout of DAF solids;
- The storage and loadout of compost solids and by-products for offsite rendering; and
- Blood storage and processing.

7.4 THE PLANT'S COMPLAINTS RECORD

Odour complaint records have been analysed from 1 October 2015 to 10 August 2020. Figure 10 below shows a summary of the number of complaints per month.

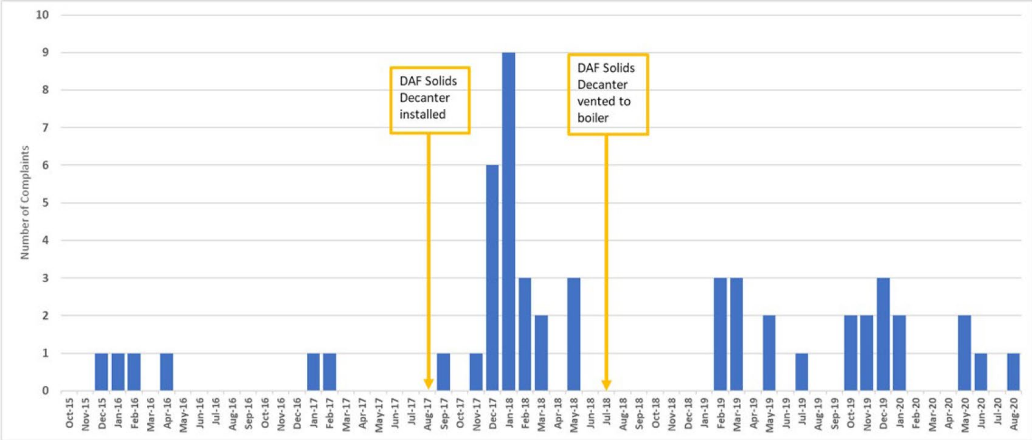

Figure 11: Number of odour complaints per month (Oct 2015 - Aug 2020).

As shown in Figure 10 the number of complaints increased significantly following installation of the new DAF solids decanter in August 2017. In early 2018 Alliance asked Golder to review the complaints and the Plant's odour sources to identify the source of the odour issue. Golder confirmed a roofline vent above the DAF solids decanter as likely being the main cause of the odour issue. To address this issue, in July 2018, Alliance connected an air extraction duct to the DAF solids decanter and liquid phase discharge chute and directed the extracted air to the site's main Coal Fired Boiler for use as combustion air. While a significant reduction in odour complaints occurred following this upgrade, Alliance has continued to receive a small number of complaints about Plant odour (up to 2 – 3 per month).

Golder analysed these occasional complaints (including the odour described by the complainant and meteorological conditions present at the time) and concluded that they were likely associated with the same odour sources as odour observations recorded during the odour diary programme conducted between November 2019 and February 2020.

7.5 ODOUR DIARY PROGRAMME

The odour diary programme was undertaken between 15 November 2019 and 22 February 2020. It involved three offsite residential odour diaries and one onsite diary by a security staff member at the Plant. During the diary programme, Alliance recorded the intermittent site activities (such as those discussed in Section 7.3 above) that have the potential to cause odour beyond the site boundary. This included DAF tank operational activities as well as periods when renderable by-product material was being loaded out. There are other more regular site activities including the DAF sludge decanter operation which also have the potential to cause offsite odour. Wind speed and direction data was available from the nearby Daiken Manufacturing Site.

The offsite odour recorded during the diary programme indicates odour exposure for one diarist occurs 1.7 % of time. While around 40% of these diary records occurred when the diarist was not clearly downwind of the Plant, Golder consider this exposure is still at a level where additional mitigation, where practicable, would be justified.

While intermittent site activities appear to be associated with some offsite odour records, the Golder analysis did not identify any of those intermittent activities as a clearly dominant source of offsite odour observations.

In turn, Golder concluded that other more routine discharges of odour, such as the DAF solids decanter operation, are a more likely source of offsite odour observations.

7.6 SITE VISIT FINDINGS AND RECOMMENDED MITIGATION

Golder staff visited the site on 15 July 2020 to review site activities (including those listed in Section 7.3 of this AEE) and assess odour onsite and offsite.

Following the site visit and considering the results of the odour diary programme, and the site's complaint history, it is Golder's assessment that:

- Remaining odour associated with the DAF solids decanting activity is likely to be the key source of existing odour effects beyond the site boundary; and
- Two other sources of odour at the site associated with the storage and loadout of compost solids and rendering by-products also likely contribute to the existing level of odour effects beyond the site boundary.

To address these residual odour sources Golder recommended that:

- Emissions from the DAF solids decanter centrate drain be extracted and treated using a biofilter to further reduce the odour associated with the DAF decanter process;
- Modification of the screened solids (compost solids) storage system, and removal of compost solids from site on a daily rather than the current less regular basis;
- Modification of the renderables by-product storage and load out system, including additional ventilation and use of a biofilter to capture and treat odour emissions; and
- The Odour Management Plan be updated to incorporate the above matters.

With successful implementation of these additional odour mitigation measures Golder concluded that the potential for off-site exposure to any short-term unpleasant odour to be minor or less than minor.

Alliance will implement these process improvements early in the new consent term and will review their effectiveness two years after they are commissioned.

7.7 CONCLUSION

Following installation of the new DAF solids decanter in August 2017 there was a significant increase in odour complaints. Additional mitigation was installed to address this issue, and, while there was a subsequent significant reduction in the number of odour complaints received, Alliance has continued to receive a small number of complaints about the Plant's odour (up to 2 – 3 per month). From an evaluation of the complains record, and the results from the Plant odour diary programme, Golder concluded that the Plant may still be producing an excessive frequency of recognisable odour, which has more than minor potential effects.

Golder has recommended that further mitigation measures be implemented at the Plant to address the residual odour issues.

With the successful implementation of those additional measures, and maintenance of existing odour controls via good site management practices, Golder has assessed the potential for off-site exposure to any short-term unpleasant odour will be reduced to be minor or less than minor.

8. MANAGEMENT AND MONITORING OF EFFECTS

A range of mitigation, remediation, management and monitoring measures are either occurring at the Plant or are recommended for implementation during the next consent term. These are summarised in Table 3 below. Alliance expects these measures will form the basis of the consent conditions for the new discharge permit issued for the activity.

Table 3: Summary of the recommended mitigation and monitoring measures.

Actual or Potential Effect	Assessment	Mitigation	Monitoring and Reporting
Effects of the Main Boiler on ambient $PM_{2.5}$ and PM_{10} levels.	On occasion the Main Boiler is causing elevated levels of PM_{10} and $PM_{2.5}$ in sensitive areas and is a notable contributor to Mataura's degraded air quality. Following the Thermal Plant Upgrade the Main Boiler would no longer be a contributor of any consequence to ambient PM_{10} and $PM_{2.5}$ concentrations in Mataura.	Thermal Plant Upgrade described in Section 4.8.2 within three years of the commencement of the consent term. Until the Thermal Plant Upgrade is complete – continue to mitigate emissions by: › Maintaining efficient combustion; › Annual servicing of boilers; › Using and maintaining a multi-clone system; and › Discharging emissions via a 30 m high stack at specified efflux velocities.	Periodic stack testing to confirm the emission rate of fine particulate matter from the boiler stacks. Provision of annual service records.
Effects of the Hide Plant Boiler on ambient $PM_{2.5}$ and PM_{10} levels	The fine particulate matter discharged by the Hide Plant Boiler continuing to operate in its current form only has a localised and very minor impact on ambient levels on adjacent	Continue to mitigate emissions by: › Maintaining efficient combustion; › Annual servicing of boilers;	Provision of annual service records.

Actual or Potential Effect	Assessment	Mitigation	Monitoring and Reporting
	farmland, and does not contribute to the elevated concentrations of fine particulate in the sensitive urban areas of Mataura	› Using and maintaining a multi-clone system; and › Discharging emissions via a 20 m high stack at specified efflux velocities.	
Effects of the Main Boiler and Hide Plant Boiler on ambient SO_2 concentrations	All relevant health-based guideline levels will be achieved.	Continue to mitigate emissions by: › Only using coal with a sulphur content which is less than 0.6% by weight; › Maintaining efficient combustion; › Annual servicing of boilers; and › Discharging emissions via a 30 m high stack (Main Boiler) / 29m high stack (BFB / 20m high stack (Hide Plant Boiler) at specified efflux velocities.	6 monthly monitoring and reporting of coal sulphur levels.
Effects on ambient air quality from the other products of combustion	All other products of combustion will readily comply with their relevant health-based guidelines.	Continue to mitigate emissions by: › Maintaining efficient combustion; › Annual servicing of boilers; and › Discharging emissions via a 30 m high stack (Main	None.

Actual or Potential Effect	Assessment	Mitigation	Monitoring and Reporting
		Boiler) / 29m high stack (BFB / 19.5m high stack (Hide Plant Boiler) at specified efflux velocities.	
Odour	The Plant may still be producing an excessive frequency of recognisable odour, which has more than minor potential effects. These should be addressed by the additional mitigation measures proposed.	Continue to implement the various measures specified in Section 5 of the Plant's Management Plan. Implement the following additional measures (see Section 7.6) and incorporate them into the Plants Management Plan: - Emissions from the DAF solids decanter centrate drain be extracted and treated using a biofilter to further reduce the odour associated with the DAF decanter process; - Modification of the screened solids (compost solids) storage system, and removal of compost solids from site on a daily rather than the current less regular basis; - Modification of the by-products storage and load out system,	Maintain an odour complaints diary. Annual provision of odour complaints diary to Environment Southland. Review the effectiveness of the new odour mitigation measures wo years after they are commissioned.

Actual or Potential Effect	Assessment	Mitigation	Monitoring and Reporting
		including additional ventilation and use of a biofilter to capture and treat odour emissions; and › The Odour Management Plan be updated to incorporate the above matters.	

9. CONSIDERATION OF ALTERNATIVES AND THE BEST PRACTICABLE OPTION

9.1 INTRODUCTION

Under the RMA, a consideration of alternative locations and methods is relevant in certain respects:

- Schedule 4 of the RMA requires an AEE to include a description of any possible alternative locations or methods for undertaking the activity where it is likely that the activity will have a significant adverse effect on the environment;
- Where an activity includes the discharge of a contaminant, Schedule 4 also imposes an obligation on an applicant to provide a description of any possible alternative methods of discharge, including discharge into any other receiving environment;
- Similarly, Section 105 of the RMA requires decision makers to have regard to various matters including “any possible alternative methods of discharge, including discharge into any other receiving environment”; and
- Section 108 of the RMA also sets out that a condition may be imposed on a discharge permit requiring the consent holder to adopt the Best Practicable Option (‘**BPO**’) in order to prevent or minimise any actual or likely adverse effects on the environment of the discharge.

As is set out in Section 11.3 of this AEE, adoption of the BPO is also a key policy directive in the Southland Regional Policy Statement for improving air quality in the Southland Region.

As defined in section 2 of the RMA, the BPO in relation to a discharge of a contaminant means:

> *The best method for preventing or minimising the adverse effects on the environment having regard, among other things, to—*
>
> *(a) the nature of the discharge or emission and the sensitivity of the receiving environment to adverse effects; and*
>
> *(b) the financial implications, and the effects on the environment, of that option when compared with other options; and*
>
> *(c) the current state of technical knowledge and the likelihood that the option can be successfully applied.*

Determining what the BPO is in a given circumstance requires a decision maker to weigh competing considerations, including the nature of the discharge, sensitivity of the environment and practicalities of that and any other option. The use of the words "among other things" clearly signals that other factors can also be taken into consideration.

As noted in the quote below, the words 'BPO' do not mean the best option, the best technical option, the best economic option, or the best environmental option. Nor do they require adherence to what might be considered "best practice". A judgement needs to be made as to what is practicable and proportionate to the likely risks from a contaminant to be discharged. The key word is 'practicable' and this means not granting consents that require adherence to an option that would be prohibitively expensive or involve procedures that are unnecessarily onerous or impractical.

These considerations have been summarised by Dr Royden Somerville QC in his paper "How to give effect in regional plans to the National Policy Statement for Freshwater Management 2011", dated 20 January 2012:

> *"The words 'best practicable option' do not mean the best option, the best technical option, the best economic option, or the best environmental option. A judgement needs to be made as to what is practicable and proportionate to the risks likely from a contaminant. The Shorter Oxford English Dictionary defines "practicable" as "capable of being carried out in action; feasible".*
>
> *In Medical Officer of Health v CRC, it was held that "practicable" is the key word in the definition of BPO, and it would be wrong to impose conditions which afforded the holder no practical means of compliance.*
>
> *The words "among other things" in the definition do not limit the considerations a regional council may address, to those matters in paras (a), (b) and (c).*
>
> *The matters in paragraphs (a), (b) and (c) are relative. This approach reflects the "principle of proportionality" which allows for a dilution of absolute standards and is used in European community law. Some overseas jurisdictions put more emphasis on technical options for addressing pollution. This is sometimes known as a technologically forcing regulatory approach. The BPO is the optimum combination of all methods to manage the risk of an adverse environmental effect to the greatest extent practicable. It is necessary to consider the options and financial implications when determining how best to attain the BPO.*
>
> *Thus, what constitutes the BPO in any given case is a question of fact and degree. Regard is to be had primarily to all three subsections (a), (b) and (c) of the definition, although one or more may be given more weight than others in any given case. The environmental performance targets being aspired to by using the BPO should be set out in the documentation."*

As part of its preliminary resource consent investigations, Alliance has undertaken a thorough assessment into the availability and practicalities of alternative methods and technologies to minimise the effects arising from its discharges to air.

This section of the AEE summarises these investigations and determination of the BPOs available to be implemented now and in the future.

9.2 THERMAL PLANT

After considering the discharges from the thermal plants through the lens of the BPO test described in Section 9.1 above, it is assessed the following represents the BPO for those discharges:

- Upgrading the Main Boiler to reduce its discharge of particulate matter by either installing a baghouse filter on the existing boiler (Option 1), or replacing the Main Boiler with a new BFB (Option 2); and
- Continuing to maintain and operate the Hide Plant Boiler in its current form.

The proposed option is considered the BPO for the following reasons:

- The Golder assessment identifies fine particulate matter (PM_{10} and $PM_{2.5}$) as the only parameter of concern in respect of ambient air quality, and that the existing concentrations of fine particulate matter in Mataura may be having an adverse effect of the health of people and the community;
- The fine particulate matter discharged by the Hide Plant Boiler continuing to operate in its current form only has a localised and very minor impact on ambient levels on adjacent farmland, and does not contribute to the elevated concentrations of fine particulate in the sensitive urban areas of Mataura;
- Emissions control technology on the small Hide Plant Boiler (a multi-clone system) is an appropriate level of control for this type of boiler in this location;
- In some conditions the Main Boiler is a notable contributor to elevated concentrations of fine particulate matter in the sensitive urban areas of Mataura;
- The proposed upgrades to the Main Boiler will reduce the amount of fine particulate matter discharged by the Main Boiler by 85% and will have a notable impact on reducing ambient particulate levels in Mataura early in the consent term;
- Following the upgrade any residual air quality issues in Mataura will be due to domestic heating and not the Plant;
- Following the upgrade, the emission of particulates from the Main Boiler will be representative of best practice;
- The technology involved in the proposed upgrades is proven and there is a high degree of certainty it will achieve the environmental outcomes anticipated; and
- The costs of the upgrade option will have significant financial implications for Alliance but can be accommodated if new consents are granted for a long consent term so that the investment can be secured over a sufficiently long period.

A three-year timeframe is considered appropriate for the Thermal Plant Upgrade as it allows sufficient time following the commencement of the new consent term to:

- Make a decision on the preferred upgrade option;
- Complete detailed design of the upgrade;
- Obtain necessary building consents and RMA land use consents for building work in the event Option 2 is selected;
- Complete installation; and
- Complete commissioning.

Alliance considered alternative options before deciding the proposed upgrades are the BPO in this case. Those options included:

- Upgrading the Main Boiler's existing multi-clone system, including installation of a fractionating bag-house and additional combustion controls and monitoring. This option was not preferred as it would achieve a much smaller reduction in the particulate matter discharged by the Main Boiler than the proposed Thermal Plant Upgrade.
- Replacing the Main Boiler with a new electrode boiler. This option would completely remove the discharge from the Main Boiler, however, its operating costs were identified as being prohibitively expensive.

Golder has also undertaken some preliminary assessments to assess the benefits of stack heights for a new BFB which are greater than 29 m above ground level. This indicated no significant further reductions in ground level air quality effects, due to stack heights above 29 m.

9.3 ODOUR

As set out in Section 4.7 of this AEE a range of measures are implemented at the Plant to minimise the potential for odour emissions. After considering the discharges from the odour from the Plant through the lens of the BPO test described in Section 9.1 above, it is assessed that with the addition of the measures set out in Section 7.6, the Plant's operation represents the BPO for its odour discharges:

The proposed option is considered to be the BPO for the following reasons:

- The receiving environment is sensitive to odour, and includes residential areas, a retail area, and an area of cultural significance;
- A number of mitigation measures are implemented at the Plant to minimise the key sources of odour;
- The Plant operating in its current form and subject to the existing management measures is having some residual odour effects on the sensitive areas;
- Golder has identified some additional measures to further minimise these residual odour effects such that they are less than minor in scale;

- The technology involved in implementing the additional measures is relatively simple and there is a high degree of certainty it will achieve the environmental outcomes anticipated; and
- The costs involved in implementing the additional measures can be accommodated by Alliance.

10. CONSULTATION

10.1 INTRODUCTION

Details of the consultation undertaken in respect of these applications is provided below

10.2 ENVIRONMENT SOUTHLAND

On 20 August 2020 Alliance met with Aurora Grant (Consents Manager) and Owen West (Air Quality Scientist) to discuss the applications. An information package was provided which summarised the output of the Golder Reports and Alliance's proposed response to those findings (hereafter referred to as the "**Consultation Summary Document**" a copy of which is provided in **Appendix E**).

Environment Southland staff confirmed that the Council is aware of potential air quality issues in Mataura, and that the Council intends to undertake additional monitoring in the township in the next year to better understand the extent of the issue.

They also confirmed that upgrading the Main Boiler to reduce its particulate emissions within three years of commencement of the new consent term is an appropriate response given the air quality issues present.

10.3 HOKONUI RUNANGA

A copy of the Consultation Summary Document was provided to Hokonui Runanga, and representatives of Alliance (Doyle Richardson and Jess McKee) subsequently met with Riki Parata (Pou Takawaenga Taiao) of Hokonui Runanga to discuss the Consultation Document on 7 September 2020.

Key feedback received by Alliance on the applications was:

- Hokonui Runanga oppose the long-term use of coal at the Plant;
- Hokonui Runanga support installation of the new BFB;
- If a BFB is installed Hokonui Runanga support a reasonably long term of consent but not the 35 years being sought by Alliance; and
- Hokonui Runanga support the proposed review of odour mitigation measures two years after the new measures are commissioned.

At the meeting Alliance also committed to providing Hokonui Runanga copies of these application documents when they are lodged with Environment Southland. This has been done.

10.4 PUBLIC HEALTH SOUTH

Public Health South were sent a copy of the Consultation Summary Document on 26 August 2020 for comment, along with copies of the Golder Associates reports.

Email correspondence was received from Renee Cubitt (Health Protection Officer) on 1 September 2020 noting the improvement in air quality that will be achieved following Thermal Plant Upgrade and stating the proposal looks good. A preference for Option 2 was expressed due to it being 'more sustainable'.

10.5 LOCAL RESIDENTS

10.5.1 Community Meeting

A leaflet was posted to all letter boxes (approximately 700 leaflets) in the Mataura Township on 21 August 2020, inviting Mataura residents to a meeting at 7pm on the 26 August at the Mataura Community Centre to hear about the work being undertaken to re-consent the air discharge activities at the Plant.

An Attendance Register was completed by 10 Attendees.

A slideshow presentation was provided by key Alliance staff with details of the Consultation Summary Document and the proposed Thermal Plant Upgrade.

After discussing the merits of what is proposed attendees expressed general support for the Thermal Plant Upgrade and the additional initiatives to further address odour.

10.5.2 Individual Meetings

Contact was made with odour diary participants and recent complainants for which Alliance had contact details. Visits were made to those who wished to receive an update on the odour mitigation recommendations outlined in the Odour Assessment report compiled by Golder. All residents which were visited expressed general support for the proposed approach for managing odour from the Plant.

11. PROVISIONS OF THE RELEVANT PLANNING DOCUMENTS

11.1 RELEVANT DOCUMENTS

When considering these applications for resource consents, the consent authority must, subject to Part 2, have regard to any relevant provisions of the following planning documents:

- Resource Management (National Environmental Standards for Air Quality) Regulations 2004 (**NES**).
- The Southland Regional Policy Statement (**RPS**).
- The Southland Regional Air Plan (**Air Plan**).

The relevant provisions of these planning documents were considered when assessing the effects of the proposed activities, and in determining how the effects of the activities could best be avoided, remedied or mitigated through the proposed conditions.

An assessment of those provisions, and how the proposed activities sit in relation to them is provided below.

An analysis of the Ngāi Tahu ki Murihiku Natural Resource and Environmental Iwi Management Plan 2008: Te Tangi a Tauira - The Cry of The People ("Te Tangi a Tauira") is also reasonably necessary as this area is clearly of importance to iwi, and the plan's provisions touch directly on the issues under consideration. Therefore, an analysis of how the iwi management plan speaks to the proposal under consideration is provided.

11.2 THE NATIONAL ENVIRONMENTAL STANDARDS ON AIR QUALITY

The NES set a guaranteed minimum level of health protection for all New Zealanders. The NES specifies ambient air quality standards for PM_{10}, SO_2, CO, NO_2, and ozone, and places restrictions on the ability of Environment Southland to grant resource consents to discharge those contaminants if the relevant air quality standards would not be achieved.

The Golder reports have shown that both pre and post the Thermal Plant Upgrade ambient air quality will comply with the relevant NESAQ standards for all contaminants, including PM_{10}.

Therefore, the NESAQ does not prevent Environment Southland from granting resource consent on the terms sought.

11.3 SOUTHLAND REGIONAL POLICY STATEMENT

The RPS was made operative on 9 October 2017. It outlines objectives, policies and methods, which guide the management of Southland's natural resources.

When considering the proposed take and discharge activities, the most relevant provisions are contained in Chapter 9: Air.

The relevant provisions when considering the Plant's discharges state:

> ***Objective AQ.1 – Discharge of contaminants***
>
> *Enable the discharge of contaminants into air while managing the adverse effects of those contaminants on human health and wellbeing, and the environment.*
>
> ***Policy AQ.1 – Adverse effects of discharges***
>
> *Avoid, remedy or mitigate the adverse effects of discharges of contaminants to air on human health, cultural and amenity values and the environment.*
>
> ***Policy AQ.3 – Areas with poor air quality***
>
> *Improve areas with poor air quality, focusing in particular on reducing the adverse effects of activities that discharge particulate matter.*
>
> ***Policy AQ.4 – Maintain or enhance air quality***
>
> *Maintain or enhance air quality in areas where compliance with national environmental standards or guidelines for ambient air quality has been achieved or surpassed.*
>
> ***Policy AQ.5 – Promote best practicable option***
>
> *Promote and facilitate the adoption of the best practicable option to improve air quality.*

The approach taken by Alliance for the long-term operation of the Plant and its boilers was informed by and aligns with these provisions.

With respect to the Plant's thermal emissions the key points are:

- Golder identified that on occasion, and particularly on cold still days, ambient air quality in Mataura Township is significantly degraded in respect of particulate matter, but that there are no known issues for other contaminants discharged by the thermal plant;
- The above provisions direct air quality in Mataura be improved in respect of its ambient particulate concentrations,[4] and maintained or enhanced for other parameters,[5] and that this be achieved by adopting the best practicable option to improve air quality;[6]
- In Mataura Township the main activities which discharge particulate matter are domestic fires and Alliance's thermal plants;

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[4] Policy AQ.3.
[5] Policy AQ.4
[6] Policy AQ.5

- Alliance will do its part in improving air quality in Mataura by completing the Thermal Plant Upgrade;
- For the reasons set out in Section 9, the Thermal Plant Upgrade represents the best practicable option for minimising the effects of the Plant's thermal discharges; and
- Following the Thermal Plant Upgrade Alliance's thermal plants will make a minimal contribution to ambient particulate levels in Mataura and domestic fires will be the sole source of degraded air quality in the Township.

With respect to the Plant's odour emissions, the key policy direction set out above is to avoid, remedy or mitigate the adverse effects of the Plant's operation on amenity values.[7] In accordance with this direction a comprehensive suite of measures to avoid or mitigate odour effects are proposed. These include those described in Section 4 of this AEE, and include various existing measures suggested by Golder.

11.4 THE SOUTHLAND REGIONAL AIR PLAN

There are two parts to the Air Plan:

- Stage 1: Covers emissions from cover emissions from domestic and small-scale heating sources, outdoor burning, application of agrichemicals and fertilisers, and fire training activities.
- Stage 2: Covers emissions from other activities, including industrial and trade premises.

The Stage 2 provisions are most relevant to the proposed activities and are addressed below.

With respect to the Plant's thermal emissions the key objectives and policies in Stage 2 of the Air Plan are the following, contained in Chapter 4 (Ambient Air Quality) and Chapter 5 (Discharges of Contaminants into Air from Industrial or Trade Premises):

> ***Objective 4.2.1 Ambient Air Quality***
>
> *To maintain good ambient air quality for Southland*
>
> ***Policy 4.3.1 Ambient Air Quality Guidelines***
>
> *Have regard to ambient air quality guidelines (Ministry for the Environment 1994).*
>
> ***Objective 5.2.1 Adverse Effects upon the Environment***
>
> *To avoid, remedy or mitigate any adverse effects upon the environment (including the health of people and communities and amenity values) from the discharges of contaminants into air from industrial or trade premises.*
>
> ***Objective 5.2.2 Maori Culture and Traditions***

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7 Policy AQ.1

To ensure that Maori cultural and traditional beliefs are recognised and provided for when dealing with discharges of contaminants into air from industrial or trade premises.

Policy 5.3.1 Protection of the Environment

Protect the environment from adverse effects from the discharge of contaminants into air from industrial or trade premises.

Policy 5.3.2 Upgrading or Change in Process of Existing Facilities

Require the upgrading or change in process of existing industrial and trade processes where they are having significant adverse effects on ambient air quality.

Policy 5.3.5 Maori Culture and Traditions

Recognise Maori cultural and traditional values with regard to the air environment and ensure that these are taken into account with regard to discharges to air from industrial or trade premises.

The approach taken by Alliance for the long-term operation of its Plant was informed by and aligns with these provisions. Key points are:

- The Golder reports identify the Main Boiler as having an adverse effect on ambient air quality in some conditions, and consistent with the direction in Policy 5.3.2 an upgrade to that process will occur within three years of the commencement of the new consent term;
- In accordance with Policy 4.3.1 regard was had to the ambient air quality guidelines when considering the effects of the activity and the need for the Thermal Plant Upgrade;
- Ambient air quality will meet the guideline values for PM_{10} in that document (noting that it does not contain any guideline for $PM_{2.5}$);
- Following the Thermal Plant Upgrade the Alliance plants will make a minimal contribution to ambient particulate levels in Mataura and any residual issues with elevated PM_{10} concentrations in Mataura will be due to domestic fires and not the Alliance Plant; and
- Alliance has consulted with Hokonui Runanga on the proposed activities and the matters that Policy 5.3.5 directs be taken into account when considering these applications are set out in Section 10.3 of this AEE.

With respect to the Plant's discharge of odour, the most relevant provisions are those set out above for industrial and trade premises, and the following in Section 7 of Stage 2 of the Air Plan which address odour:

Objective 7.2.1 Protection of the health of people and communities

To protect the health of people and communities from any adverse effects from odour discharges.

Objective 7.2.2 Protection of cultural and amenity values

To protect areas of cultural and amenity value from any adverse effects from odour discharges.

Policy 7.3.1 The health of people and communities

Avoid, remedy or mitigate the impact on the health of people and communities from offensive or objectionable odours.

Policy 7.3.2 Areas of Cultural or Amenity Value

Avoid, remedy or mitigate the impact of offensive or objectionable odours on areas of cultural or amenity value.

The approach taken by Alliance for the long-term operation of its Plant was informed by and aligns with these provisions. Key points to note are:

- In accordance with this direction a comprehensive suite of measures to avoid or mitigate odour effects are proposed.
- With those measures in place Golder assess the odour effects of the Plant's operation to be minor or less than minor, and to not be objectionable or offense.

11.5 TE TANGI A TAUIRA - THE CRY OF THE PEOPLE

In 2008, Te Tangi a Tauira: Ngāi Tahu ki Murihiku Natural Resource and Environmental Iwi Management Plan (**Te Tangi a Tauira**) was published. This Iwi Management Plan consolidates Ngāi Tahu ki Murihiku values, knowledge and perspectives on natural resource and environmental management issues.

Alliance acknowledges that Te Tangi a Tauira is an important planning document designed to assist tangata whenua in carrying out kaitiaki roles and responsibilities, and that tangata whenua are best placed to assess the application against its provisions. However, Alliance understands that the following Ngā Kaupapa policy in Te Tangi a Tauira, which address air quality, are likely to be important when considering effects on cultural values:

3.2.1 Discharges to Air

1. *Discourage discharges from industrial and trade premises that will have an impact on mahinga kai, taonga species, biodiversity, wāhi tapu and wāhi taonga.*
2. *Ensure that the processes used during activities that discharge to air are supervised and monitored to ensure that contaminant emissions are minimised.*
3. *Encourage existing activities that emit contaminants to air to evaluate, and where practical implement new technologies to reduce adverse effects on air quality.*
9. *Discourage and prevent discharges to air that will have impacts on cultural well-being and community health.*
10. *Ensure that discharges of contaminants into the air such as dust, smoke and odour do not affect the amenity values of areas which are of cultural*

and historical significance to iwi.

12. *Engage Ngāi Tahu ki Murihiku early in the consenting and permitting process for activities whereby there is discharge to air, particularly agrichemical and aerial spraying/topdressing and activities causing offensive odours. Discharges must not cause objectionable or offensive odour to the extent that is causes adverse effects beyond the boundaries of the consent holder's property.*
13. *Advocate for robust consent conditions with a maximum twenty-five years. Changes to consent conditions must be notified to affected parties and all consent conditions monitored routinely.*

3.2.2 Amenity Values

4. *Ngāi Tahu ki Murihiku shall provide qualified recommendations with respect to concerns raised related to odour and offensive discharge, from rural, urban and industrial activities.*

Of note when considering these matters:

- With respect to Policy 3.2.1(1), Golder has identified the discharges to air from the site will meet all relevant guideline values for the protection of biological values and the discharges will not have any physical adverse effect on mahinga kai, taonga species or biodiversity.
- In accordance with Policy 3.2.1(2) robust requirements for supervising activities and monitoring emissions will be required by consent conditions.
- In accordance with Policy 3.2.1(3) Alliance has completed a thorough evaluation of the emissions control technology used on site and proposes significant upgrades to that technology early in the new consent term.
- With respect to Policy 3.2.1(9) the only contaminant of concern with respect to community health is fine particulate matter. Alliance will do its part in improving air quality and community health in Mataura by completing the Thermal Plant Upgrade which will reduce the amount of fine particulate matter emitted by the Main Boiler by 85%. Following that upgrade Alliances thermal plant will make a minimal contribution to ambient particulate levels in Mataura, and any residual community health issues will be due to domestic heating.
- With respect to Policy 3.2.1(1), (10) and (12) Golder has identified the Plant may be causing some residual offsite odour and identified additional measures to reduce those effects which Alliance will implement early in the consent term;
- In accordance with Policy 3.2.1(12) and Policy 3.2.2(4), Alliance has and continues to engage with Hokonui Runanga on the future operation of the Plant, including in respect of its discharges to air; and
- With respect to Policy 13 the preference for a consent duration of no more than 25 years is acknowledged. This preference was also raised during consultation with

Hokonui Runanga (see Section 10.3 of this AEE). However, Alliance considers a longer consent duration is required here to allow the significant financial investment proposed in the Thermal Plant Upgrade to be justified and secured over an appropriate timeframe.

12. STATUTORY ASSESSMENT

12.1 INTRODUCTION

This section of the AEE sets out the framework under the RMA that applies to the resource consents that are being sought from Environment Southland. It addresses:

- Section 104 which specifies the matters Environment Southland must have regard to when considering an application for resource consent; and
- Section 105 which specifies additional matters which must be considered by Environment Southland when considering the applications for discharge permits.

12.2 SECTION 104

Section 104 of the RMA identifies the matters that a consent authority must have regard to, subject to Part 2 of the Act, when considering an application for resource consent. It states:

> *(1) When considering an application for a resource consent and any submissions received, the consent authority must, subject to Part 2, have regard to–*
>
> *(a) any actual and potential effects on the environment of allowing the activity; and*
>
> *(ab) any measure proposed or agreed to by the applicant for the purpose of ensuring positive effects on the environment to offset or compensate for any adverse effects on the environment that will or may result from allowing the activity; and*
>
> *(b) any relevant provisions of—*
>
> *(i) a national environmental standard:*
>
> *(ii) other regulations:*
>
> *(iii) a national policy statement:*
>
> *(iv) a New Zealand coastal policy statement:*
>
> *(v) a regional policy statement or proposed regional policy statement:*
>
> *(vi) a plan or proposed plan; and*
>
> *(c) any other matter the consent authority considers relevant and reasonably necessary to determine the application.*
>
> *(2) When forming an opinion for the purposes of subsection (1)(a), a consent authority may disregard an adverse effect of the activity on the environment if a national environmental standard or the plan permits an activity with that effect.*
>
> *(2A) When considering an application affected by section 124 or 165ZH(1)(c), the*

consent authority must have regard to the value of the investment of the existing consent holder.

(2B) …

Section 104 of the RMA does not give primacy to any of the matters to which a consent authority is required to have regard. All of the relevant matters are to be given such weight as the consent authority deems appropriate in the circumstances, and all matters listed in Section 104(1) are subject to Part 2 of the RMA.

An assessment of the proposed activities against the relevant matters set out in Section 104 of the RMA is provided in the sections below.

12.2.1 The Actual and Potential Effects of Allowing the Activities

The actual and potential effects of allowing the activities are set out in Sections 6, 7 and 8 of this AEE.

The granting of consents enabling the continued operation of the Plant will maintain the economic wellbeing of people and communities within the Gore District and the Southland region by:

- Maintaining significant direct and indirect employment opportunities for local residents (the Plant employs approximately 500 people in the peak of the season);
- Maintaining significant direct and indirect wages and salaries for local residents (the Plant contributed approximately $22 million in wages and salaries for the 2017 / 2018 and $30 million for the 2018/2019 season);
- Maintaining significant levels of direct and indirect expenditure with local businesses;
- Maintaining population and economic activity levels within local communities, thereby maintaining the breadth and quality level of services available to local residents and businesses;
- Providing greater employment choice for local residents; and
- Continuing Alliance's contributions to local community activities, in its role as a responsible employer and "good corporate citizen".

Key points of relevance when considering the emissions from the Thermal Plant are:

- The only parameter of concern is fine particulate (PM_{10} and $PM_{2.5}$).
- PM_{10} and $PM_{2.5}$ concentrations are elevated in Mataura. While ambient air quality complies with the NESAQ for 24-hour PM_{10} it does not appear to comply with the WHO guideline for 24-hour $PM_{2.5}$ which central government has flagged for inclusion in the NESAQ in the near future.

- For the most part these elevated levels occur on cold still days when domestic fires are the dominant cause of elevated concentrations. However, in other meteorological conditions, the Main Boiler, can, on occasion be the dominant source.
- Within three years of the commencement of the new consent term Alliance will upgrade the Plant's Main Boiler with either a baghouse or new BFB. This will reduce the amount of fine particulate discharged by the Main Boiler by approximately 85%, bring its emissions control technology in line with best practice, and mean the Plants Main Boiler is no longer a contributor of any consequence to ambient PM_{10} and $PM_{2.5}$ concentrations in Mataura.
- While there may be residual issues with elevated PM_{10} and $PM_{2.5}$ concentrations in the Mataura airshed, those issues would be due to domestic fires, and not the Plant.

Key points of relevance when considering the emission of odours from the Plant are:

- Following installation of the new DAF solids decanter in August 2017 there was a significant increase in odour complaints. Additional mitigation was installed to address this issue, and, while there was a subsequent significant reduction in the number of odour complaints received, Alliance has continued to receive a small number of complaints about Plant odour (up to 2 – 3 per month).
- From an evaluation of the complains record, and the results from the Alliance Mataura odour diary programme Golder concluded that the site may still be producing an excessive frequency of recognisable odour, which has more than minor potential effects.
- Golder has assessed the remaining odour associated with the DAF solids decanting activity is likely to be the key source of existing odour effects beyond the site boundary. Two other sources of odour at the site associated with the storage and loadout of compost solids and rendering by products also likely contribute to the existing level of odour effects beyond the site boundary.
- Golder has recommended further mitigation measures be implemented at the Plant to address these residual odour issues.
- With the successful implementation of those additional measures, and maintenance of existing odour controls via good site management practices, Golder has assessed the potential for off-site exposure to any short-term unpleasant odour will be reduced to be minor or less.

12.2.2 Measures Proposed to Offset or Compensate for Any Adverse Effects on the Environment

No measures are proposed to offset or compensate for any adverse effects on the environment. All adverse effects are addressed via avoidance, remediation and mitigation.

12.2.3 Relevant Provisions of the Planning Documents

The provisions of the relevant planning documents, and an assessment of how the proposed activities sit in relation to them is provided in Section 10 of this AEE.

Key points of relevance are:

- Ambient air quality complies with the NESAQ and it does not prevent consent being granted on the terms sought.
- The approach taken by Alliance for the long-term operation of the Plant, including a significant upgrade to the Main Boiler early in the consent term, was informed by and aligns with the RPS provisions, particularly its direction to:
  - Enable the discharge of contaminants into air while managing the adverse effects of those contaminants on human health and wellbeing, and the environment;
  - Improve areas with poor air quality, focusing in particular on reducing the adverse effects of activities that discharge particulate matter; and
  - Promote and facilitate the adoption of the best practicable option to improve air quality.
- The approach taken by Alliance for the long term operation of the Plant, including the proposed upgrades to the Main Boiler and odour generating activities early in the consent term, was informed by and aligns with the Air Plan provisions, particularly its direction to:
  - Protect the environment from adverse effects from the discharge of contaminants into air from industrial or trade premises;
  - Upgrading or change in process of existing industrial and trade processes where they are having significant adverse effects on ambient air quality;
  - Avoid, remedy or mitigate the impact of offensive or objectionable odours on the health of people and communities, and areas of cultural value.

12.2.4 Other Matters

12.2.4.1 Resource Management Amendment Act 2020

On 3 June 2020 parliament passed the Resource Management Amendment Act 2020. The only matter of relevance to these applications is as of 31 December 2021 Councils may consider discharges to air of greenhouse gas emissions when the current sections prohibiting councils from considering discharges are repealed (that is, sections 70A, 70B, 104E and 104F). Option 2, replacing the Main Boiler with a BFB would reduce the greenhouse gas emissions from the Plant.

12.2.5 Value of Investment of the Consent Holder

When considering these applications, the consent authority must have regard to the value of the investment of Alliance which is reliant on the proposed activities.

That investment is considerable. The latest estimate (December 2018) for the Plant's insured value is $225 million, and much of this value is sunk i.e. it could not be recovered if the plant was forced to downsize, close or be relocated.

12.2.6 Part 2

12.2.6.1 Section 5

The purpose of the RMA (Section 5) is to promote the sustainable management of natural and physical resources. The Act defines "sustainable management" as:

> *"managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural wellbeing and for their health and safety while—*
>
> *(a) Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and*
>
> *(b) Safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and*
>
> *(c) Avoiding, remedying, or mitigating any adverse effects of activities on the environment."*

In practice, there are two general elements of "sustainable management" in the context of Section 5 that must be considered when assessing the resource consent application. They are:

- Enabling people and communities to provide for their social, economic and cultural wellbeing; and
- Safeguarding environmental quality and avoiding, remedying or mitigating adverse effects.

Enabling people and communities to provide for their social, economic and cultural wellbeing

With respect to the likely implications of granting the consents as sought in terms of enabling people and communities to provide for their social and economic wellbeing, it is clear from the economic report produced by Brown Copeland & Associates in **Appendix D** that the Plant plays an important role in the local economy, and is also an important part of the local community. The Plant provides substantial employment, both directly and indirectly, and provides important social context to the area. The Plant is reliant on being able to operate under the consents sought in this application. Not granting the resource consents as sought would place the ongoing operation of the Plant in question.

Safeguarding Life-Supporting Capacity

As set out in Sections 6 of this AEE, a comprehensive assessment of the effects of the proposed activities on the receiving environment by Golder has determined that fine particulate levels in the ambient air of Mataura may be having an adverse health effect on those who live there. The Thermal Plant Upgrade will remove the Plant as a notable source of this degradation and help contribute to a long-term improvement in the life-supporting capacity of the air.

Requirement of Avoid, Remedy or Mitigate

Section 5(2)(c) of the RMA requires that adverse effects of activities on the environment are "avoided, remedied or mitigated". It is not required that all effects be avoided, or that there is no net effect on the environment, or that all effects are compensated for in some way. Rather, Section 5(2)(c) is about doing what is reasonably necessary, given the circumstances of the particular case, to lessen the severity of effects. Some flexibility is necessary when exploring mitigation measures that can be used to reduce the impact of adverse effects, to ensure that the mitigation itself is sustainable.

The ongoing approach used in relation to avoiding, remedying or mitigating the effects of the Plant is consistent with these principles.

12.2.6.2 Sections 6, 7 and 8

Sections 6, 7 and 8 of the RMA set out the principles to be applied in achieving the purpose of the Act. With respect to the principles contained in Sections 6, 7 and 8 of the RMA:

- They are subordinate to the overriding purpose of the Act, as set out in Section 5.
- Each plays a part in the overall consideration of whether the purpose of the Act has been achieved in a particular situation.
- They are not an end in themselves, but an accessory to the principal purpose.

With respect to Section 6, which contains matters of national importance that shall be recognised and provided for, only Section 6(e) and Section 6(g) that relate to Maori values and which are addressed below are relevant.

Section 7 contains other relevant matters to which particular regard must be given. Several of these are relevant to this application; notably Section 7(b), the efficient use of natural and physical resources; Section 7(c), the maintenance and enhancement of amenity values and Section 7(f), maintenance and enhancement of the quality of the environment.

With respect to Section 7(b), the economic assessment has identified a number of reasons why the continued use of the Plant represents an efficient use of natural and physical resources. The Plant is existing, and there is significant investment costs in the location and equipment at the site; the Plant has access to a skilled labour force of sufficient scale to ensure that it operates effectively; the Plant is appropriately located to receive livestock that is within the immediate and surrounding area; and the Plant has appropriate infrastructure support including access to road and rail networks.

The operation of the Plant in accordance with the proposed consent conditions, including the proposed Thermal Plant Upgrade and implementing the additional odour mitigation measures, would maintain and enhance amenity values and the quality of the environment relative to existing conditions, in accordance with Sections 7(c) and 7(f).

12.2.6.3 Maori Relationship/Kaitiakitanga/Treaty Principles

With respect to the sections within Part 2 that relate to tangata whenua, the Mataura River and adjacent land, including the Mataura Falls in the immediate vicinity of the Plant, has high cultural significance for tangata whenua.

Alliance recognises and values the role of Hokonui Runanga as tangata whenua and kaitiaki of the Mataura River and has and continues to engage with Hokonui Runanga in respect of the applications, and how the effects of the activity could be avoided, remedied or mitigated.

It is intended that through this ongoing engagement process, appropriate mechanisms will be identified which provide for Sections 6(e), 7(a) and 8 matters in relation to the ongoing operation of the Plant.

12.2.7 Summary

After considering all the relevant matters under Part 2 and Section 104, granting the resource consents with appropriate conditions would promote the purpose of the Act and would constitute sustainable management of natural and physical resources for the following reasons:

- It allows the use of natural and physical resources in a way which enable people and the community to provide for their social, cultural and economic wellbeing; and
- It safeguards the life-supporting capacity of air, water and soil, and ensures that adverse effects are appropriately avoided, remedied or mitigated.

12.3 SECTION 105

Section 105 of the RMA sets out additional matters which must be considered by a consent authority when considering an application for a discharge permit. Section 105(1) of the RMA states:

> *"If an application is for a discharge permit or coastal permit to do something that would contravene section 15 or section 15B, the consent authority must, in addition to the matters in section 104(1), have regard to—*
>
> *(a) the nature of the discharge and the sensitivity of the receiving environment to adverse effects; and*
>
> *(b) the applicant's reasons for the proposed choice; and*
>
> *(c) any possible alternative methods of discharge, including discharge into any other receiving environment.*

These matters are addressed in Section 10, which outlines why the proposed discharge method represents the best practicable option.

13. CONCLUDING STATEMENT

This AEE is in support of applications to ‘re-consent’ the discharge or contaminants and odour to air from the Plant such that it can continue to operate and contribute in a major way to the social and economic wellbeing of the surrounding community.

The proposed activities include a substantial upgrade to the Plant’s Main Boiler which will reduce its fine particulate emissions by 85%, and implementation of additional odour management measures.

Alliance is seeking a 35 year consent term for the replacement consent being sought. A 35-year consent term suitably recognises the existing asset value of the Plant and the significant economic contribution it provides to the Southland Region. A 35-year consent term also means the significant financial investment involved in the Thermal Plant Upgrade can be justified and secured over an appropriate timeframe.

An assessment of the potential effects of the proposal on the environment is provided in Sections 6 to 8 of this AEE, as well as the various technical assessments commissioned by Alliance. By way of summary, it is considered that the project can be undertaken in a manner that appropriately avoids, remedies or mitigates adverse effects on the environment.

With respect to the statutory planning framework that applies to the applications, it is concluded that the development of the project in the manner proposed by Alliance will align comfortably with the overall management intentions specified in the relevant national and regional planning documents.

Finally, it is noted that Alliance has consulted with interested / potentially affected parties with respect to these applications. This consultation has informed the various environmental assessments and will continue throughout the resource consent process and during the subsequent operation of the Plant.

A

APPENDIX A

Golder Associates (NZ)

Limited Alliance Mataura Assessment of Coal Fired Boiler Discharges to Air

August 2020

REPORT

Alliance Mataura

Assessment of Coal-Fired Boiler Discharges to Air

Submitted to:

Alliance Group Limited

PO Box 1410, Invercargill

Submitted by:

Golder Associates (NZ) Limited

Level 1, 214 Durham Street, Christchurch 8011

+64 3 377 5696

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August 2020

Distribution List

Doyle Richardson | Alliance Group Limited

Executive Summary

An assessment of cumulative air quality impacts associated with the operation of the Alliance Group Ltd (Alliance) two coal fired boilers (CFBs) at Mataura, Southland is presented in this report. The assessment was based on dispersion modelling of CFB discharges to air and direct ambient monitoring of respirable particulate at several locations within Mataura.

It confirmed the smaller CFB, used at the hide processing plant, produces minimal air quality effects in its own right, and makes a minimal contribution to ambient air quality effects (and in turn cumulative ambient concentrations) in areas affected by the site's main coal-fired boiler. It also concluded the mitigation technology on this smaller CFB is appropriate.

With respect to sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) air quality impacts, the predictions of CFB contributions to ambient levels are sufficiently low to conclude that these are only likely to cause less than minor effects.

The air quality effects from the main site boiler (CFB 2) were assessed for the assumption of operating at 64% of its maximum rated capacity (MRC). At this operating rate, the discharge rate of PM_{10} to atmosphere is approximately 90 % of the existing permitted consent limit of 10 kg/hr.

The PM_{10} and associated $PM_{2.5}$ emissions (estimated at 80 % of the PM_{10}) were established for CFB 2 when operating at a peak hourly average rate of 64% MCR. By comparison, the peak 24-hour average operating rate for CFB 2 was found to be 53% MCR during the 2018/2019 processing year. Cumulative 24-hour and annual average concentrations of ambient PM_{10} and $PM_{2.5}$ within Mataura were predicted, which could approach or exceed relevant health-based guidelines and standards.

From the analysis of ambient monitoring data, background sources of ambient particulate appear to significantly degrade the air quality within Mataura township during autumn and winter months and particularly on cold still days. During such days, the CFBs were predicted have a small contribution to the cumulative ambient levels.

The ambient monitoring of cumulative levels at Alliance's southern site boundary indicates the Ministry for the Environment Ambient Air Quality Guidelines (MfE AAQGs) for annual average PM_{10} and the WHO guideline for annual average $PM_{2.5}$ would be complied with.

It was concluded that the existing cumulative levels of ambient particulate in Mataura are significantly degraded by domestic heating emissions and these cumulative levels may cause more than minor health effects on people. Whilst the Alliance CFBs make a negligible contribution to these cumulative levels on most days, there are some days when contributions from CFB 2, are a significant particulate matter source.

The recommended mitigations include the installation of a bag-house filter to treat the CFB 2 exhaust air, or the replacement of this CFB with an alternative heating plant that generates lower particulate emissions than currently occurs.

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APPENDICES

1.0 INTRODUCTION

This report[1] presents an assessment of air quality effects resulting from air contaminants discharged from two coal-fired boilers (CFBs) operated at the Alliance Group Limited (Alliance) meat processing and hide processing plants at Mataura, Southland. The main plant (meat processing) is located at the centre of Mataura, approximately 12 km to the southwest of Gore township, as shown in Figure 1. The hide processing plant is sited approximately 2 km north of the main site.

Alliance holds an existing resource consent (Environment Southland Consent No. AUTH-20158002) that authorises air discharges from the site, which expires on 15 December 2020. The existing permit covers the discharges from the following boilers at its main site and hide salting site:

- A 9,400 kilowatt (kW) Babcock and Wilcox spreader stoker boiler (CFB 2);
- A 3,800 kW back up spreader stoker boiler to CFB 1 (this is a back-up to CFB 2);
- A 923 kW Boag spreader stoker boiler (CFB 3) at the hide salting plant; and
- A 160 kW CFB boiler at the main site (for office heating - currently unused).

This report will form part of an assessment of effects (AEE) and an associated application for renewal of the site's existing air discharge consent. The new application includes the operation of CFB 1 & 2 at the main site and CFB 3 at the hide salting site.

The objective of this assessment is to ascertain the air quality related effects on the surrounding environment that would result from the continued operation of the site's CFBs. An ambient particulate monitoring and modelling based assessment of short and long-term air contaminant exposure concentrations (arising from the CFB air discharges and background contaminant levels), was used to evaluate the environmental significance of cumulative air quality effects in urban and other areas surrounding the Alliance site. This also enabled the background ambient particulate levels to be established for several locations within Mataura.

The scope of this report includes the prediction of ambient air contaminant concentrations due to the coal-fired boiler emissions, their cumulative effects with existing background air quality and mitigation of coal-fired boiler emissions. The air contaminant impacts assessed by this report included common air pollutants (i.e., respirable particulate matter (PM_{10} and $PM_{2.5}$), sulfur dioxide (SO_2) and nitrogen dioxide (NO_2)).

The current and potential future mitigation of air contaminant emissions from the site's coal-fired boilers is also summarised in this report.

[1] Your attention is drawn to the document "Report Limitations" in Appendix A.

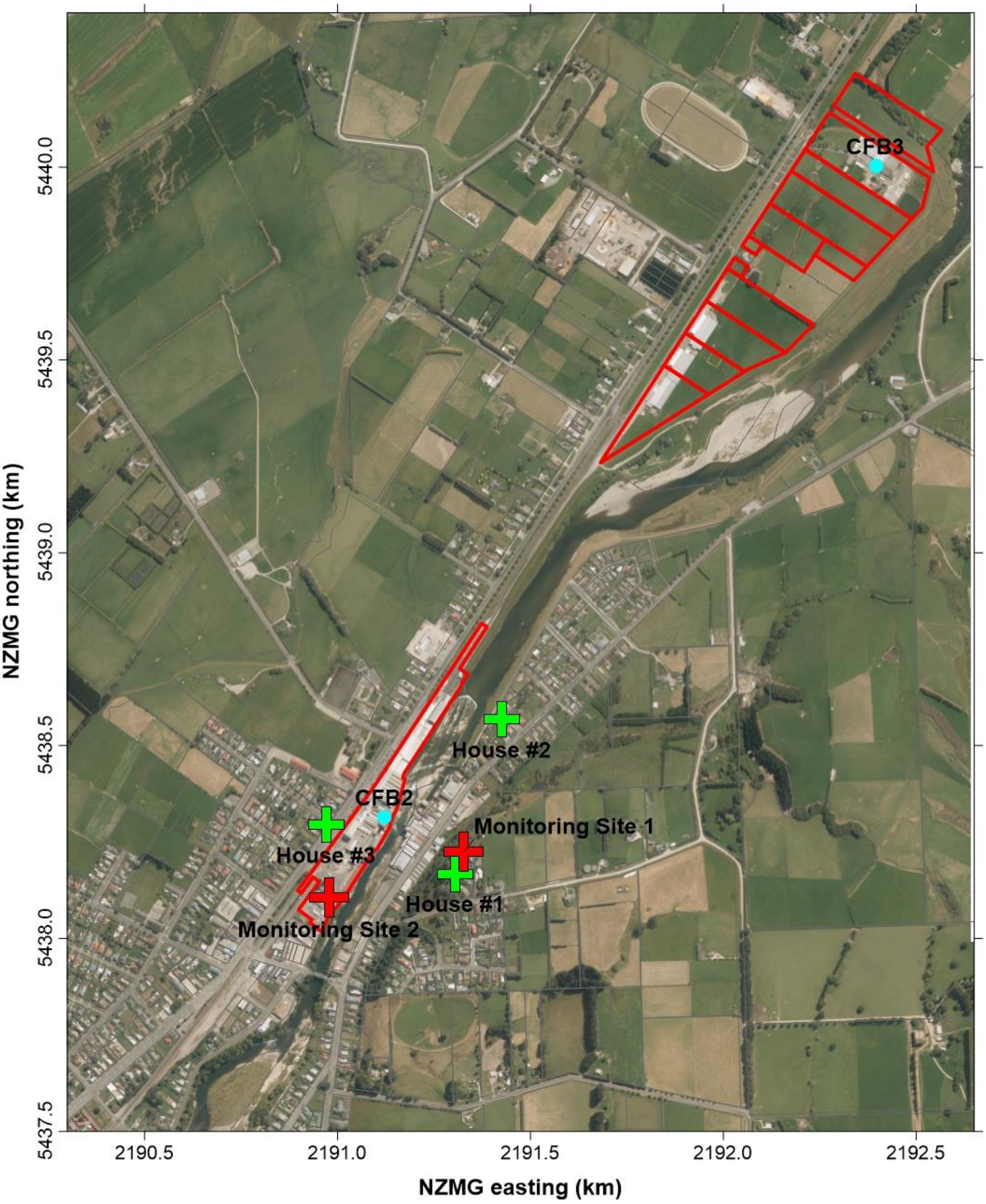

Figure 1: Alliance Mataura site and surroundings.

2.0 SITE AND BOILER INFORMATION

2.1 General

Alliance Mataura is a meat processing plant that primarily processes approximately 1000 head of cattle per day during the peak season. The hide salting plant and CFB 3 are situated at the northern extent of the site and 2 kms from the main process plant and CFB 1 & 2 (see Figure 1). As such, a low potential for cumulative impacts upon air quality due to the combined effects of CFB 3 with emissions from CFB 1 & 2 was anticipated. However, all process and hide salting plant CFB emissions to air were modelled simultaneously to enable the cumulative air quality assessment.

The site typically operates its peak season from November to July, and shoulder season from August to October.

2.2 Energy Plant

The CFBs are fired on a lignite coal that is supplied from the Newvale coal mine. CFB 2 operates up to 24-hours a day and seven days per week in peak season, and 14 hours per day and five days per week during shoulder season. Alliance commissioned a report by DETA Consulting (2020), which indicated the maximum theoretical energy demand from CFB 2 could be 6.4 MW. However, the actual peak demand of the current operation was assessed by Golder to be 6.0 MW (i.e., 64 % MCR). This is discussed further in Section 2.3.

CFB 3 operates up to 35 hours per week over three days in peak season. Coal usage records indicate a maximum and average weekly usage of 7 tonnes and 2 tonnes respectively. This infers a maximum hourly coal combustion rate of 200 kg/hr (as received). This indicates that CFB 3 is normally operated at approximately 40 % of its maximum continuous capacity rating (MCR).

CFB 2 has a 30 m high stack with an efflux diameter of 2 m, whereas CFB 3 has a 20 m high stack with a discharge diameter of 0.6 m.

The location of the boilers and the processing site layout is shown in Figure 1. The stoichiometric calculations of stack discharge parameters are presented in Appendix B.

2.3 Steam Generation (CFB 2)

Records of steam generation rates for June 2018 to June 2019 (i.e. the 2018/2019 processing season) were accessed from the Alliance Mataura SCADA system. This includes over thirty thousand 15-minute records of steam production rate (Tonnes/hr) and gauge pressure (Bar).

The analysis of hourly varying steam generation for peak processing days (occurring in mid-June 2018), which had the highest peak hourly steam demand (kg/hr) and the highest daily steam demand (tonnes/day) are presented in Figure 2 and Figure 3.

Table 1 provides a summary of the daily average % MCR output rates from CFB 2, which indicates a maximum daily average output of 53 % MCR. The 2018-2019 peak hourly steam rate of 8,692 kg/hr equates to 64 % MCR. (NB: at 100 % MCR, CFB 2 produces 13,600 kg/hr at 10 Bar). Note, 68 % MCR is considered the current operational maximum.

Figure 4 shows the cumulative distribution of CFB 2 (including some small infrequency contributions from CFB 1) energy output rates for the 2018-2019 year, which shows that the 50th percentile energy output rate (accounting for shut-downs throughout the year) is 29 % MCR.

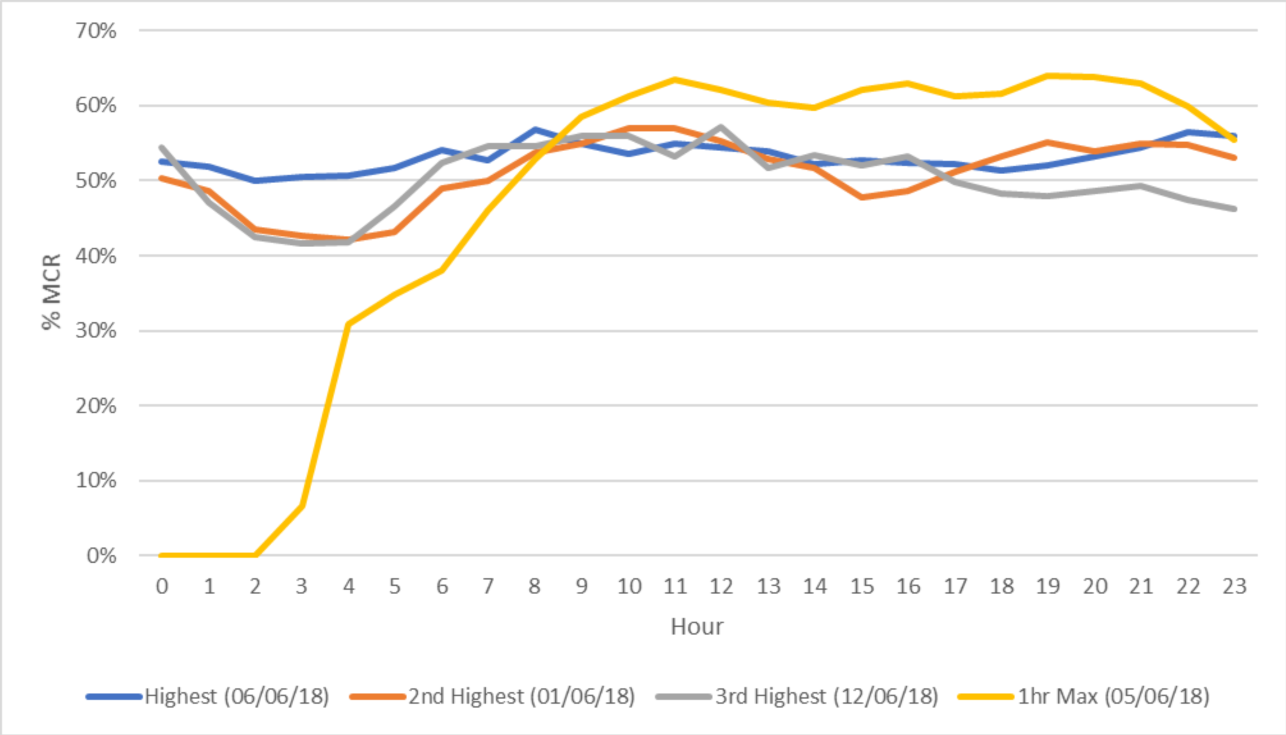

Figure 2: Hourly varying CFB 2 steam output for peak processing days (1, 5, 6 and 12 June 2018).

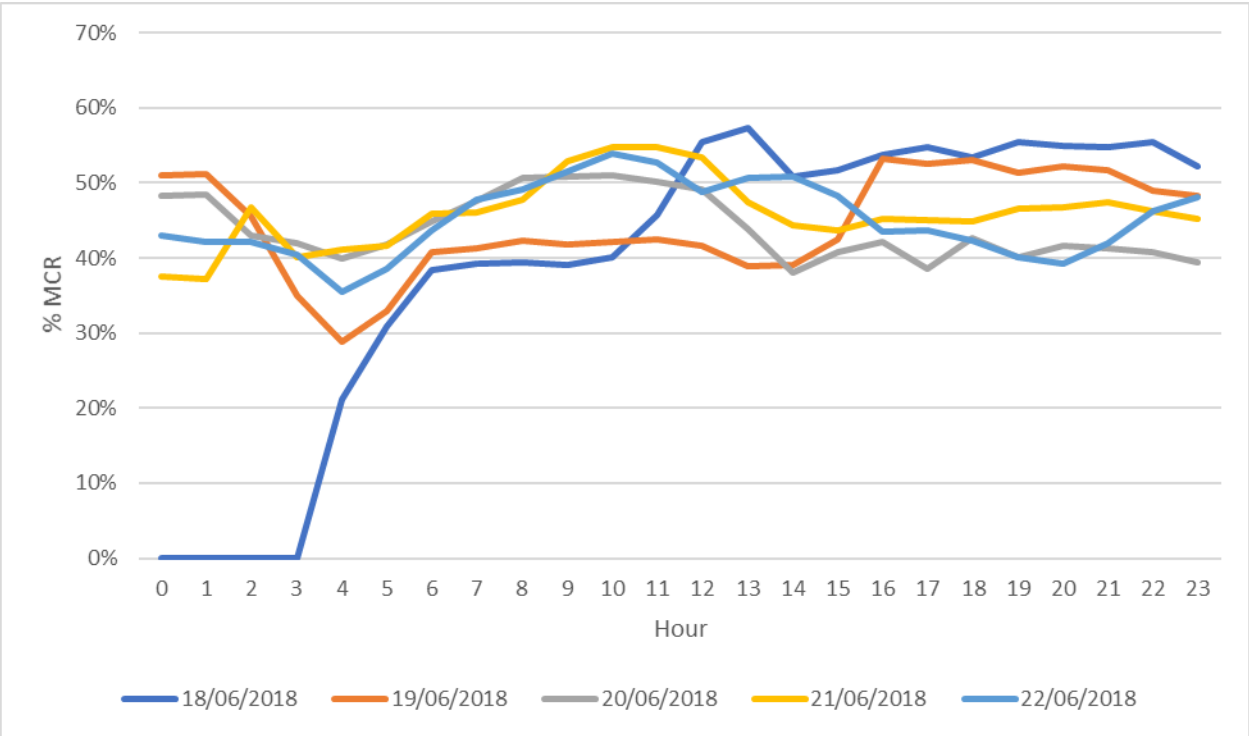

Figure 3: Hourly varying CFB 2 steam output for peak processing week (18 to 22 June 2018).

Table 1: Summary of daily average % MCR for CFB 2 for peak processing days#.

Date	Maximum 1-hour average % MCR	24-hour average % MCR	Maximum 1-hour steam production rate (kg/hr)	Daily steam output (tonnes)
06/06/2018	57 %	53 %	7,730	174
01/06/2018	57 %	51 %	7,762	167
12/06/2018	57 %	50 %	7,780	164
05/06/2018	64 %	47 %	8,692	154
18/06/2018	57 %	39 %	7,804	128
19/06/2018	53 %	45 %	7,236	145
20/06/2018	51 %	44 %	6,934	144
21/06/2018	55 %	46 %	7,455	150
22/06/2018	54 %	45 %	7,343	148

Notes: # All results include relatively small and infrequent contributions to steam output from the back-up CFB 1.

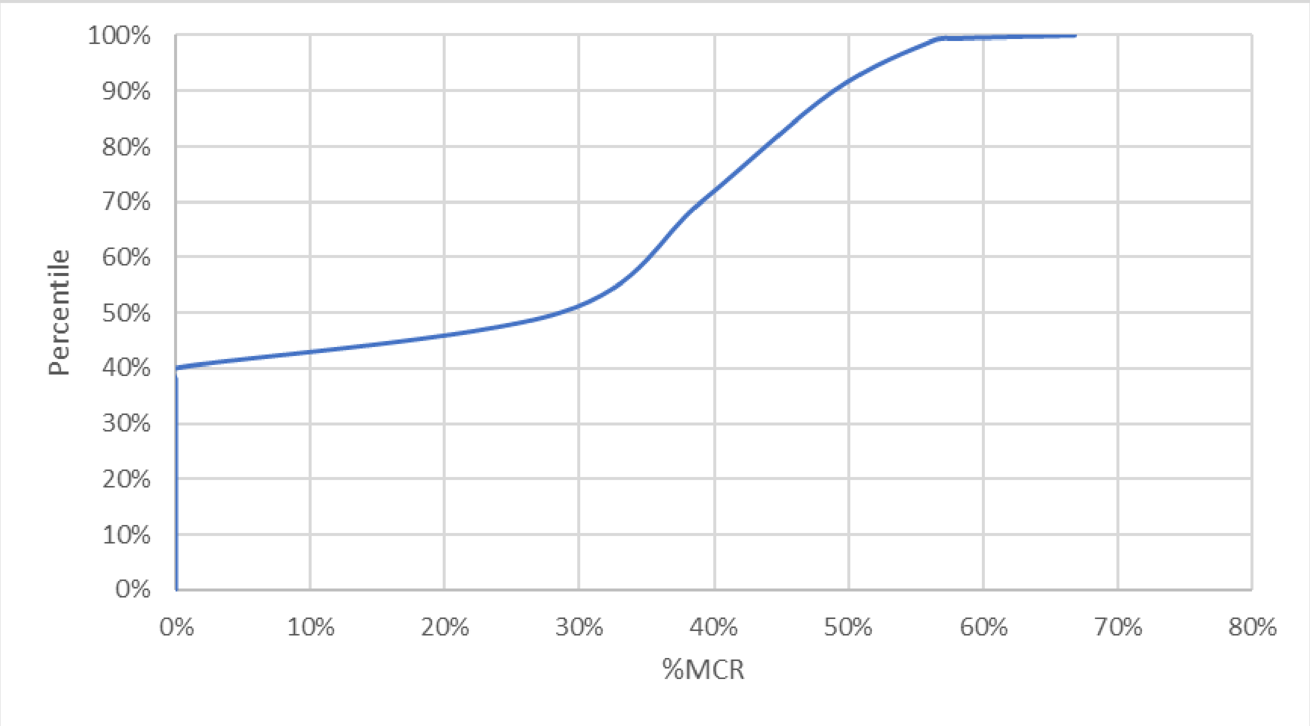

Figure 4: Cumulative distribution of CFB 2 steam output (June 2018-June 2019).

3.0 NATURE OF AIR DISCHARGES

3.1 General

The CFBs produce hot exhaust air streams containing combustion products and particulates. The latter arise due to a wide range of processes including fly ash carry over, un-combusted carbon (soot) and from the condensation of un-combusted organic volatiles.

The main portion of the exhaust consists of nitrogen (N_2) and residual oxygen (O_2) from the combustion air. The primary products of combustion include carbon dioxide (CO_2), sulfur dioxide (SO_2), carbon monoxide (CO), water (H_2O) and nitrogen oxides (NO_x). The latter is discharged as NO (nitrogen oxide, approximately 90 %), NO_2 (nitrogen dioxide, approximately 10 %) and some trace levels of nitrous oxide (N_2O).

There is also a range of products of incomplete combustion (PICs) that mainly include volatile organic compounds (VOCs, including trace levels of methane), metals and dioxin like compounds.

The condensation of semi-volatile VOCs within the boiler stack and un-burnt carbon particulates (soot) are a key source of fine respirable particulate ($PM_{2.5}$), whereas PM_{10} and larger suspended particulates are derived from these sources as well as larger fractions of fine fly ash and coal fines. VOCs also include trace levels of poly aromatic hydrocarbons and dioxin like compounds.

Given the above, the primary air pollutant impacts that were assessed included SO_2, PM_{10}, $PM_{2.5}$ and NO_2. Ambient impacts of CO from coal-fired boiler plants site are typically very low when compared against ambient health guidelines and standard and therefore are not assessed in this assessment. The emissions of greenhouse gases, such as CO_2, do not cause local health effects and are not included in the scope of this assessment.

3.2 Coal Analysis

Newvale lignite is used to fire CFB 2 and 3 at the Alliance Mataura site. Test results for this coal's composition and energy content for the period of June 2016 to February 2018 are summarised in Table 2.

Table 2: Newvale coal properties.

Property	Value	Source
Moisture	40.0 %	Average of testing from June 2016 to February 2018
Ash	3.6 %	Average of testing from June 2016 to February 2018
Volatile	30.3 %	Average of testing from June 2016 to February 2018
Fixed Carbon	26.1 %	Average of testing from June 2016 to February 2018
Gross Calorific Value (as received basis)	15.0 MJ/kg	Average of testing from June 2016 to February 2018
Hydrogen (dry basis)	4.8 %	CRANZ 1978
Oxygen (dry basis)	24.6 %	CRANZ 1978
Nitrogen (dry basis)	0.6 %	CRANZ 1978
Sulfur (as received basis)	Min 0.38 % Average 0.4 % Max 0.43 %	Testing from June 2016 to February 2018

3.3 Stoichiometric Calculations

The stack exhaust flow rates (actual and normalised to standard atmospheric pressure and temperature) for each CFB were calculated using stoichiometric equations that utilise the coal's elemental composition and specific coal usage rates. These calculations, combined with knowledge of the excess combustion air or residual exhaust oxygen content (vol. % dry), can be used to accurately calculate the exhaust air flows per unit mass of combusted coal.

The maximum coal usage rate for each CFB is established from their respective energy output, the thermal efficiency of the CFBs and the reported energy content (calorific value) of the as-received coal.

Historical stack test results for particulate emissions typically report normalised and actual exhaust air flows including the associated oxygen content. These results were used to confirm that the calculated boiler exhaust flow rates were accurate.

A summary of the stoichiometry calculations is provided in Appendix B. The resulting boiler stack discharge parameters for each boiler versus operating rate (% MCR) are summarised in Table 3.

Table 3: Stack discharge parameters.

Parameter	CFB 2 (B&W)	CFB 3 (Boag)
	64 % MCR	40 % MCR
Maximum capacity rating (kW)	9400	923
Stack height (m) a.g.l	30	20
Stack diameter (m)	2.0	0.6
Efflux velocity (m/s)	2.8	2.3
Stack oxygen (vol. % dry)	8	5
Efflux temperature (°C)	230	250
Assumed efficiency (%)	65	50
Fuel burning rate (tonne/hour)	2.32	0.2

3.4 Contaminant Emission Rates

3.4.1 Particulates

Stack testing results are summarised in Appendix C and these indicated the maximum in-stack PM_{10} concentrations to be 640 mg/Nm^3 (corrected to 12 vol.% CO_2 and dry basis), when CFB 2 is running at 30 % of its MCR. This in-stack concentration of PM_{10} was assumed for CFB 2 when operating at 64 % MCR, which produces a mass emission rate of 9 kg/hr.

No stack testing was carried out for CFB 3. This boiler runs at a low MCR (i.e., 40 %), is a similar design and is fired on the same coal. Therefore, the same maximum in-stack PM_{10} concentration is assumed as for CFB 3.

The associated PM_{10} discharge rates for each boiler versus operating rate for the above in-stack concentrations are calculated using combustion stoichiometry (see Appendix B) and results are as follows:

- CFB 2: 2.51 g/s (64 % MCR);
- CFB 3: 0.21 g/s (40 % MCR).

Appendix D provides ambient monitoring results for PM_{10} and $PM_{2.5}$. An analysis of CFB 2 contributions above measured background concentrations, established the maximum fraction of $PM_{2.5}$ within the PM_{10} discharged from CFB 2, to be 80 %.

The PM_{10} discharge rate at 64 % MCR for CFB 2 is 90 % of the existing discharge consent limit for PM_{10} of 10 kg/hr specified in Condition 9 of AUTH-20158002 (issued in 2015).

3.4.2 Nitrogen oxides

The total NO_x emissions from the combustion of coal were calculated using United States Environmental Protection Agency (USEPA) “AP42” emission factors for boilers burning lignite coal (USEPA 1998b, Table 1.7-1). For spreader stoker boilers the emission factor for NO_x formation is 2.9 kg of NOx per tonne of coal burned.

Based on the above NO_x emission factor and maximum coal burning rates listed in Table 3 then the following NO_x emissions (as NO_2 mass equivalents) versus operating rate are calculated:

- CFB 2: 1.9 g/s (64 % MCR);
- CFB 3: 0.16 g/s (40 % MCR).

Typically, 90 % of oxides of nitrogen (NO_x) mass discharged from a CFB occur in the form of nitrogen monoxide (NO). The remainder of the NO_x discharge (approximately 10 %), is in the form of nitrogen dioxide (NO_2), with trace levels of nitrates (NO_3) – the latter minor fraction form secondary particulate but are sufficient minor exclude from further consideration in this assessment.

Once discharged, NO undergoes oxidation within the atmosphere to form NO_2. The proportion of NO to NO_2 conversion post discharge is calculated based on typical ozone background concentrations and distance from the discharge point. The methodology used to calculate the NO conversion rate is documented in Appendix E.

3.4.3 Sulfur dioxide

The test results for coal sulfur content from June 2016 to February 2018 give as-received sulfur contents that range from 0.38 wt.% to 0.43 wt.% with an average of 0.4 wt.%. These values are consistent with other published coal sulfur values for New Vale coal (CANZ 2010).

The existing consent condition specified the maximum sulfur content of the coal blend to be 0.6 wt.% (as received). However, for this assessment a more realistic albeit conservative maximum level of 0.45 wt. % is assumed for calculating maximum SO_2 emission rates when assuming 5 % retention of sulfur in the ash for CFB 2 and CFB 3, respectively.

Given the above, maximum SO_2 emission rates for each CFB were assumed as follows:

- CFB 2: peak rate of 5.5 g/s (64 % MCR);
- CFB 3: peak rate of 0.47 g/s (40 % MCR).

3.4.4 Summary of emission rates

A summary of the emission rates for each of the boilers that was assumed for the assessment of air quality effects is provided in Table 4.

Table 4: Contaminant emission rates from CFBs assumed for the assessment.

Contaminants	Emission rate (g/s)	
	CFB No. 2 (B&W)	CFB No. 3 (Boag)
	64 % MCR	40 % MCR
SO_2	5.5	0.47
NO_x	1.9	0.16
PM_{10}	2.5	0.21
$PM_{2.5}$*	2.0	0.17

Notes: * Based on assumption of $PM_{2.5}$:PM_{10} fraction of 80 % (See Appendix B).

4.0 RECEIVING ENVIRONMENT

4.1 General

Mataura is an urban area in Southland with a population of 1,629 people and 672households, according to 2018 census information (Stats NZ, 2018). Mataura is predominantly residential with commercial and industrial areas. The main source of air pollution in Mataura is from home heating using coal and wood, Industrial emissions also contribute to air pollution.

The site is located near the centre of the township and is surrounded by predominantly residential dwellings in all directions, except for directly due north of the plant. The nearest residential dwellings are 110 m to the west, 200 m to the south and 300 m north east of the main coal-fired boiler (CFB 2). Houses are also located on elevated terrain are situated 210 m east of CFB 2.

There are commercial properties and buildings are located adjacent to the main Alliance processing site on the eastern side of the Mataura River and are 50 m or more from CFB 2.

The smaller CFB 3 is located 2 kms north of the main CFB 2 and is surrounded by rural land. The nearest residential dwelling is 410 m north northeast of CFB 3.

There are recreational and public facilities surrounding the site include a golf club, school, and various community halls – these are located further away than the nearby residential dwellings and are less sensitive to air contaminant emissions from the site's CFBs.

4.2 Wind Patterns

The site wind patterns are significantly influenced by the raised terrain running along the eastern side of the Mataura River. As such, southerly and northerly wind conditions tend to align with a north northeast to south southwest bearing and cold air drainage flows can be expected to move along this same bearing and towards the south southwest towards town. Wind roses from the Alliance Mataura ambient monitoring data (April to July 2018) and CALMET data set (2003) are shown in Figure 5. Note that the Mataura monitoring data in this figure only covers the 2018 autumn-winter months. This explains the absence of stronger winds shown for a full year in the CALMET data set. This aside the modelled CALMET wind pattern is consistent with that measured in 2018.

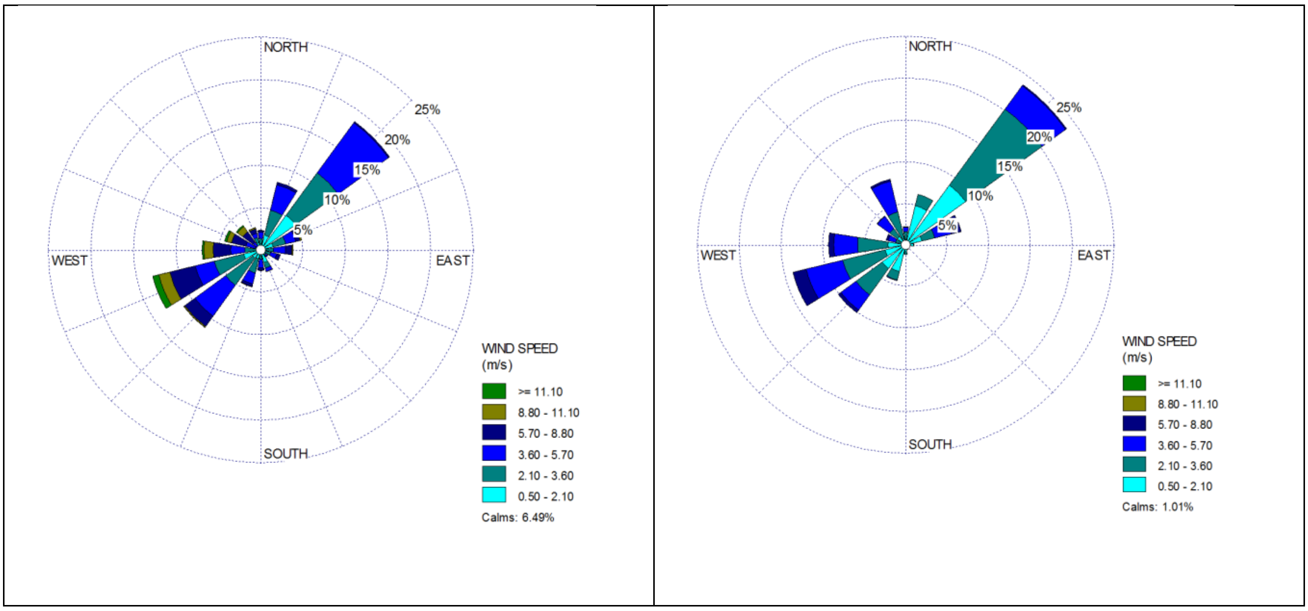

Figure 5: Wind roses: (left) CALMET, (right) ambient monitoring site.

4.3 Existing Ambient Air Quality

Historical ambient PM_{10} monitoring programmes by Environment Southland and Alliance have previously indicated the Mataura airshed is in compliance with the MfE's National Environmental Standards (NESAQ) for PM_{10}. However, ambient monitoring reported by Golder (2018) for the period of March to early July 2018 indicates that compliance with the current NESAQ for ambient PM_{10} is not certain. This monitoring also indicates that compliance with proposed NESAQ amendments (currently under consultation) for ambient $PM_{2.5}$ are also not certain. Further, residential home heating is the predominant source of ambient PM_{10} and $PM_{2.5}$ in Mataura during autumn and winter months.

4.3.1 Particulate

Ambient monitoring results for PM_{10} and $PM_{2.5}$ have been produced by Alliance during 2018 at two locations. The first being the elevated terrain immediately to the east of the CFB 2 stack (i.e., at Hillcrest Avenue), which was undertaken to meet consent monitoring requirements and was reported by Golder (2018). The second monitoring programme was undertaken at the southern boundary of the Alliance site as shown in Figure 1. The setup of this monitoring is described in Section 5.4 and the data is discussed in Section 6.0 and Appendix D.

A summary of the monitoring results from both programmes are provided in Table 5 and Table 6, Figure 6 and Figure 7.

Table 5: PM_{10} Percentiles (24-Hour Average) measured in Mataura during 2018.

Station	24-Hour Average PM_{10} Concentration (µg/m³)						NESAQ
	10th percentile	25th percentile	50th percentile	75th percentile	95th percentile	Max	(µg/m³)
Hillcrest Avenue*	5	7	11	12	15	19	50
Southern boundary#	8	12	16	23	32	46	50

Notes: * Measured from 8 February to 26 March 2018 (Golder, 2018). # Measured from April – 4 July 2018.

Table 6: $PM_{2.5}$ Percentiles (24-Hour Average) measured in Mataura during 2018.

Station	24-Hour Average $PM_{2.5}$ Concentration (µg/m³)						WHO
	10th percentile	25th percentile	50th percentile	75th percentile	95th percentile	Max	(µg/m³)
Hillcrest Avenue	2	3	5	5	7	9	25
Southern boundary	4	7	10	15	23	33	25

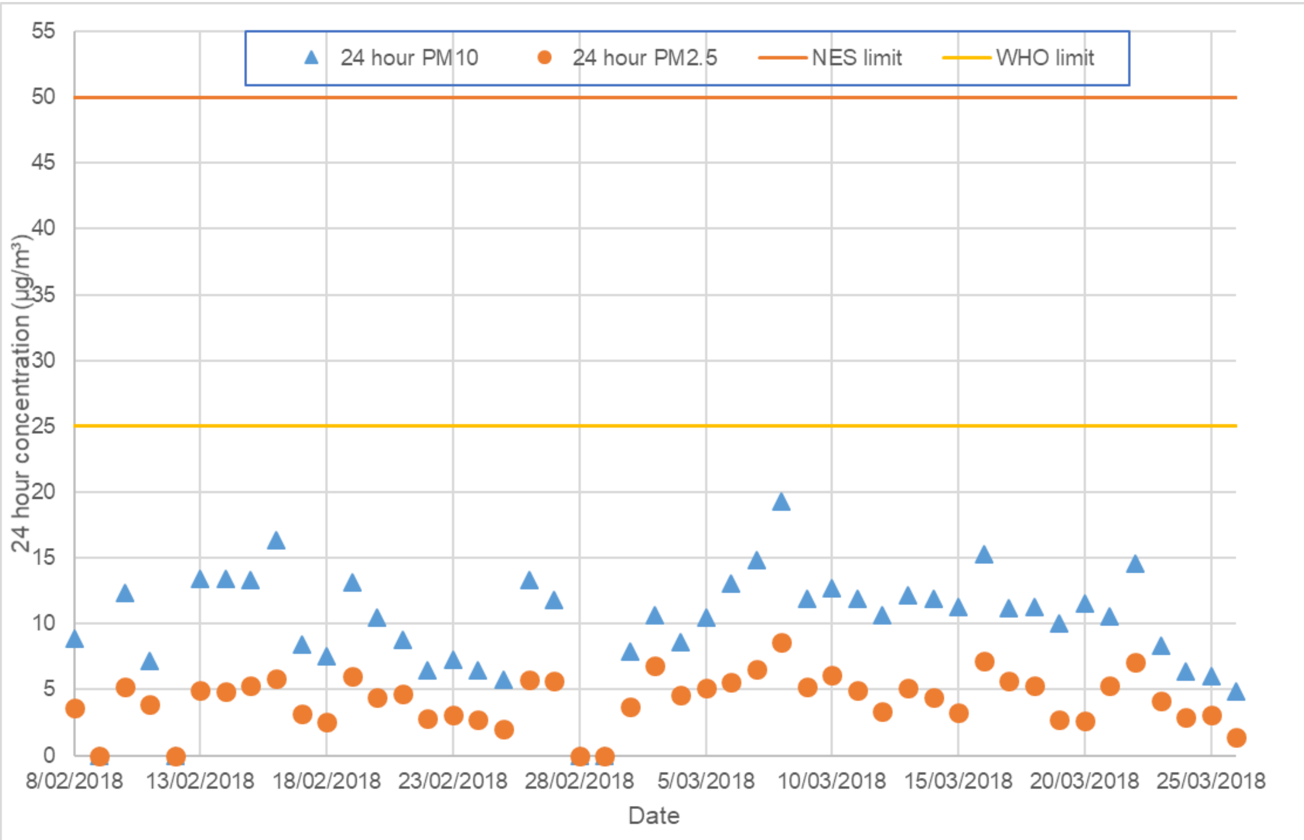

Figure 6: Hillcrest Avenue Monitoring station 24-hour average PM_{10} and $PM_{2.5}$ concentrations.

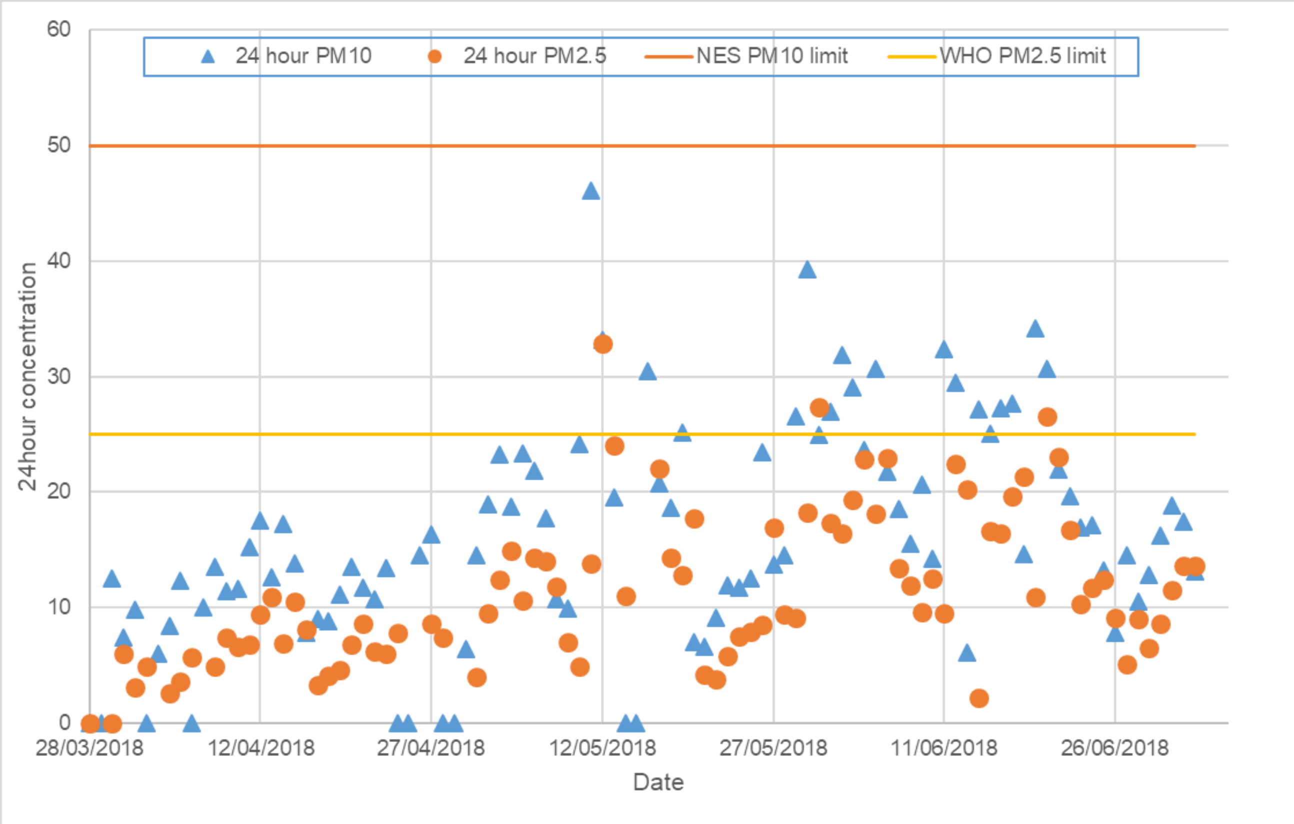

Figure 7: Southern Boundary Monitoring station 24-hour average PM_{10} and $PM_{2.5}$ concentrations.

4.3.2 Sulphur dioxide

Golder is not aware of recent SO_2 monitoring data that is representative of background for the main township of Mataura. Therefore, data available from Edendale has been reviewed. This monitoring is described in Golder 2013 and summarised in Table 7. Other South Island towns that have had a historical use of coal and where ambient monitoring has been completed include Timaru. The SO_2 monitoring (MfE 2003) in Timaru (1998 to 2001) can also provide an indication of ambient SO_2 concentrations in Mataura (see Table 8). Based on the data from these other South Island towns, background SO_2 concentrations are estimated to be 120 µg/m³, 30 µg/m³ and 5 µg/m³ for 1-hour, 24-hour and annual average, respectively.

Table 7: Summary of the Fonterra Edendale SO_2 monitoring results (Golder 2013).

Processing season	Max. 1-hour SO_2 conc. (µg/m³)	Max. 24-hour SO_2 conc. (µg/m³)	annual average SO_2 conc. (µg/m³)
2002	46	10	3
2003	35	10	2

Table 8: Summary of the Environment Canterbury Timaru SO_2 monitoring (MfE 2003).

Year	Max. 1-hour SO_2 conc. (µg/m³)	Max. 24-hour SO_2 conc. (µg/m³)
1998	92	27
1999	111	36
2000	165	31
2001	123	21

4.3.3 Nitrogen dioxide

Golder is not aware of any publicly available ambient NO_2 monitoring data in Mataura and which would be representative of the of the site and receiving environment. In these circumstances, the Ministry for Environment (MfE) good practice guide (MfE 2016) recommends using default background air quality values developed by the New Zealand Transport Agency (NZTA 2014) for NO_2 by census area units (CAU) [2]. For Mataura, these background NO_2 values are 58 µg/m³, 38 µg/m³ and 13 µg/m³ for NO_2 (1-hour, 24-hour and annual average, respectively).

These default background values are expected to be conservatively representative for the location of the site and receiving environment, and therefore have been used for this assessment.

4.3.4 Summary of the background air quality

The background SO_2 and NO_2 air quality values used for this assessment are provided in Table 9 and the assumed background PM concentrations are provided in Table 10. The values in these table are used in the assessment of cumulative effects provided in Section 8.0.

Table 9: Summary of SO_2 and NO_2 background air quality concentrations.

Contaminant	Averaging period	Background concentration (µg/m³)
SO_2	1-hour	120
	24-hour	30
	Annual	5
NO_2	1-hour	60
	24-hour	40
	Annual	13

[2] CAU number 610400, Mataura.

Table 10: Summary of estimated Background 24-Hour particulate versus weather conditions.

Daily weather category	Daily average wind speed (m/s)	Daily average temp.	Percentage of time conditions occur*	PM_{10} (24-hour) µg/m^3			$PM_{2.5}$ (24-hour) µg/m^3		
				Mean	Upper confidence level		Mean	Upper confidence level	
					75th	99th #		75th	99th #
A	<2	<5 °C	2 %	24	29	38	17	21	29
B	<2	≥5 °C	9 %	20	22	26	13	15	18
C	≥2 and <3	all	25 %	13	13	15	8	9	9
D	≥3	all	64 %	11	12	14	6	7	8

Notes: * Based on annual CALMET meteorological dataset for 2003. # This means that 99 % of ambient concentrations are expected to be lower than this number during the weather category.

Table 11: Summary of estimated Background Annual average particulate.

Location in Mataura	PM_{10} (annual) µg/m^3	$PM_{2.5}$ (annual) µg/m^3
	Mean	Mean
Township	12	7
Hill top areas	10	4

5.0 ASSESSMENT METHODOLOGY

5.1 General

This assessment was undertaken using a standard air atmospheric dispersion modelling to predict ambient air quality (AAQ) concentrations beyond the Alliance site boundary at ground level due to the discharges from CFB 2 and CFB 3. These predictions provide the incremental effects on air quality due to the CFB emissions to air. Background contaminant concentrations were then added to model predictions of CFB impacts to assess cumulative ambient air contaminant concentrations beyond the site boundary.

The modelling-based assessment of CFBs ambient impacts was supplemented by ambient monitoring data for PM_{10} and $PM_{2.5}$. This was established for various wind speeds, directions and ambient temperatures throughout the operational weekdays and non-operational weekend periods. This information was used to establish existing background PM_{10} and $PM_{2.5}$ ambient levels, which are not associated with CFB discharges.

The ambient monitoring information was also used to estimate the contribution of CFB 2 emissions to ambient particulate levels at the southern boundary of the site, as well as the ratio of $PM_{2.5}$ to PM_{10} within the CFB discharge to air.

The assessment of cumulative air quality effects due the Alliance CFBs and existing background levels was therefore assessed via a combination of modelled and monitored particulate concentrations.

For other contaminants including SO_2 and NO_2, no recent ambient monitoring data were available. Consequently, estimated background levels of these contaminants were established from monitoring data produced in similar environments to Mataura.

Predicted cumulative ambient concentrations of contaminants were assessed for compliance against relevant health-based criteria.

5.2 Assessment Criteria

5.2.1 General

Relevant sources of air quality assessment criteria in order of highest priority are listed as follows:

- The ambient air quality standards contained in the NESAQ;
- The Ambient Air Quality Guidelines (AAQG) (MfE/MoH, 2002);
- The Regional Air Quality Plan for Southland (unless more stringent than above criteria);
- World Health Organization (WHO 2005);
- California reference levels (OEHAA, 2012).

The Ministry for the Environment (MfE, 2008) provides recommendations regarding the priority of the various sources of air quality criteria. The order of the air quality criteria reflects these recommendations. World Health Organisation guidelines and California reference levels (OEHAA, 2012) should be used for criteria that is not covered by the higher priority sources (i.e., NESAQ, AAQG, Regional Plans).

While the AAQGs are not mandatory, the NESAQ are, and their requirements over-ride those of any regional plan except where such a plan imposes stricter requirements. The NESAQ, AAQG and WHO are discussed below.

5.2.2 National Environmental Standards

The Ministry for the Environment's NESAQ regulations include criteria for air pollutants that are relevant to the CFB 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 12 for each air contaminant.

Regulation 14 of the NESAQ sets out the locations that ambient air quality standards apply at any place, as follows:

- That is in an airshed; and
- That is in the open air; and
- Where people are likely to be exposed to the contaminant.

However, the NESAQ also states that 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 that are specifically gazetted as airshed, and any remaining areas of the region that are not gazetted. There are no polluted airsheds sufficiently close to Mataura that are likely to be impacted by CFB emissions.

In summary, the NESAQ for air quality applies in all areas of New Zealand, in the open air, wherever people may be exposed over the relevant time averaging period. The exception is that if the discharge is authorised by a resource consent, then the standards do not apply to the site to which that consent applies. Therefore, the key areas for this assessment in terms of NESAQ compliance are the residential surrounding the Alliance Mataura site.

5.2.3 National Ambient Air Quality Guidelines

The AAQGs applicable to this assessment include some of the same contaminants as covered by the NESAQ 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 12.

5.2.4 The Regional Air Quality Plan

There are no specific AAQ criteria that the Southland regional air quality plan specifies that require consideration for this assessment.

5.2.5 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. The MfE is current proposing to adopt these ambient guidelines as National Standards.

The WHO guideline for 24-hour SO_2 has not been adopted in New Zealand (either as national standard or guideline, or by any regional council). The current MfE guideline for 24-hour SO_2 is relevant for this assessment.

5.2.6 Summary of criteria

A summary of the air quality criteria used for this assessment are presented in Table 12. The $PM_{2.5}$ criteria are 50 % of those specified for PM_{10}. The $PM_{2.5}$ fraction makes up approximately 80 % of the total mass of PM_{10} discharged from the CFBs.

Table 12: Summary of standards and guidelines relevant to this application.

Contaminant	Guideline/standard (µg/m³)	Averaging period	Allowable exceedances per year	Source
SO_2	350	1-hour	9	NESAQ
	570	1-hour	0	NESAQ
	120	24-hour	0	AAQG
	30	Annual	0	AAQG
NO_2	200	1-hour	9	NESAQ
	100	24-hour	0	AAQG
PM_{10}	50	24-hour	1	NESAQ
	20	Annual	0	AAQG
$PM_{2.5}$	25	24-hour	3*	WHO Proposed NESAQ
	10	Annual	0*	WHO Proposed NESAQ

Notes: * Proposed in update to NESAQ.

5.3 Atmospheric Dispersion Modelling

Dispersion modelling was carried out using CALPUFF, version 7.2.1. CALPUFF is used commonly throughout the world to model AAQ impacts of a variety of sources, including industrial ventilation outlets. Version 6 of the model is described by TRC (2011a). CALPUFF's dispersion modelling is driven by complex CALMET meteorological inputs and is a more appropriate system for modelling point source industrial discharges to air. The CALMET input files provide key information on the terrain and land use variations and hourly varying meteorology in three dimensions. These files are themselves created using a combination of data from prognostic weather model, TAPM version 4 and data from climate stations. The inputs and setup are described in Appendix F. In summary, the ambient effects modelling process requires the following order of modelling and inputs:

- TAPM weather modelling for one year for the Southland region but starting for approximately 1000 km by 1000 km grid.
- CALMET diagnostic meteorological modelling for the same years for the Mataura area using inputs from TAPM and local meteorological data and terrain and land use information. Nested CALMET modelling using finer resolution terrain and land use information.
- CALPUFF dispersion modelling of AAQ impacts due to the CFB discharges to air using CALMET meteorological inputs and CFB stack discharge parameters.
- Data sets outputted from CALPUFF providing ambient contaminant concentrations within the Mataura area for ground level and elevated receptors.

The complex terrain precludes the use of Gaussian models such as AERMOD for modelling ambient impacts from the CFB stacks.

5.3.1 Dispersion model configuration

Appendix G provides a summary of the CALPUFF input settings. It is noted that the PDF function for convective meteorological conditions was turned on for air dispersion modelling.

5.3.2 Time varying discharge parameters

Hourly varying inputs files were not developed for the CALPUFF modelling. Instead, the normal maximum operating rates for each CFB (64 % MCR for CFB 2 and 40 % MCR for CFB 3) were assumed to apply to all hours of the year.

The use of fixed worst-case input parameter files for the AAQ modelling is considered to result in overstated predictions of long term average AAQ impacts but realistic peak short-term impacts (i.e., 1-hour and 24-hour averaging periods).

5.3.3 Meteorological modelling

The meteorological input files that were key inputs to CALPUFF were generated using its companion model, CALMET. This provides hourly, three-dimensional fields of meteorological parameters including as wind, temperature, humidity, isolation and rainfall. 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 a combination of local surface stations and outputs of the prognostic model TAPM (for an introduction to TAPM, see Hurley et al., 2005). The setup configuration of the CALMET modelling run is provided in Appendix F.

5.3.4 Building effects and elevated receptors

There are surrounding tall buildings on the Alliance site (but not off-site) that could influence the dispersion of the plume discharged from CFB 2. Building heights and footprints were inputted to the CALPUFF configuration along with the local terrain heights and land use information available via the CALMET data files.

5.3.5 Nitrogen dioxide formation

The procedures for accounting for the transformation of NO_x emissions into ambient hourly and annual average NO_2 concentrations is provided in Appendix E.

5.4 Ambient Particulate Monitoring

5.4.1 General

Ambient monitoring of particulate matter (PM_{10} and $PM_{2.5}$) concentrations was carried out at two sites in 2018. The first ambient air quality monitoring programme (hillside monitoring programme) was carried out by Golder (2018) over the period of 8 February to 26 March 2018. The second monitoring programme (onsite monitoring programme) was undertaken by Golder over the period of 28 March to 4 July 2018. During the monitoring period, CFB 2 operated from 3 am on Mondays to 2 am on Saturdays.

5.4.2 Monitoring locations and period

The two monitoring programmes were respective carried out from 8 February to 26 March 2018 and from 28 March to 4 July 2018. The locations of two monitoring sites are shown in Figure 1.

This first monitoring station was located at the hillside approximately 200 m east of the main boiler and was accessed from Hillcrest Avenue. The location was chosen as it was predicted by the previous dispersion modelling reported by Montgomery Watson (2000) to be the highest impacted offsite location with respect to PM_{10} concentration.

The second monitoring site was located inside the Alliance property boundary, approximately 250 m south southwest of the CFB 2 stack. The location was selected because the wind rose developed from the first monitoring programme data showed a predominant wind direction from CFB 2 towards this location.

5.4.3 Monitoring methods

Ambient PM_{10} and $PM_{2.5}$ were measured simultaneously with a broadband spectroscopy-based instrument (T640x PM Mass Monitor). The equipment was installed and operated by Golder.

The Model T640x PM monitor is not included in Schedule 2 of New Zealand's National Air Quality Standards for Air Quality which defines the required methods for monitoring PM_{10}. However, this monitor has been approved by the United States Environmental Protection Agency (USEPA) as a Federal Equivalent Method to their reference method for the determination of particulate matter as PM_{10}.

The particulate monitoring programme included the concurrent measurement of wind speed, wind direction, temperature, and relative humidity.

5.4.4 Monitoring bias adjustment

To account for any systematic bias in the monitoring method co-location study results for a trial operated by the Canterbury Regional Council (CRC) during September and October 2018 were used to establish a preliminary K-factor for Golder's T640x unit. This co-location study compared the CRCs and Golder's T640x units to ambient PM_{10} and $PM_{2.5}$ measurements within the Timaru airshed against parallel results obtained from NESAQ compliant methods - a TEOM and Partisol monitors.

The results of this study indicated K factors for Golders T640x unit for 24-hour average PM_{10} and $PM_{2.5}$ of 0.8 and 0.9 respectively.

6.0 AMBIENT PARTICULATE MONITORING RESULTS

6.1 Cumulative Concentrations

Measured cumulative ambient concentrations of PM_{10} and $PM_{2.5}$ at the two ambient monitoring sites are provided in Table 5 and Table 6. These levels are compliant with the NESAQ for 24-hour average PM_{10}, but not the WHO for 24-hour average $PM_{2.5}$.

The 50th percentile values for these colder months also provide an estimate of the long-term average PM_{10} and $PM_{2.5}$ concentrations that occurs during winter months.

The ambient particulate levels measured at Alliance's southern site boundary are elevated and sometimes approach the NESAQ for PM_{10} and exceed the WHO criteria for $PM_{2.5}$. The outcomes of this cumulative assessment are presented in Section 8.0.

6.2 Background Particulate Concentrations

As expected, the 24-hour average monitoring results ambient particulate varies with meteorological conditions. Under cold calm winter days, the measured PM_{10} and $PM_{2.5}$ concentrations are more elevated compared to windier days. This is likely to be due to discharges from home heating appliances that are expected to be more significant on colder days with low wind speeds. Therefore, typical 24-hour background particulate concentrations were established as function of the prevalent wind conditions for a specific day. These values are discussed in Section 4.0 and results are provided in Table 10.

6.3 CFB Contribution to Cumulative Concentrations

Incremental impacts of PM_{10} and $PM_{2.5}$ ambient concentrations due to CFB 2 emissions were estimated using a similar approach to that described in Section 4.3.1 for establishing background levels at the southern Alliance boundary monitoring site.

To determine the incremental impact of the CFB 2 emissions upon monitored cumulative concentrations, the 24-hour average background concentration were subtracted (established as described in Section 4.0) from the measured cumulative 24-hour PM_{10} and $PM_{2.5}$ concentrations for any one day.

The reliability of the above method depends on the accuracy of the assumed background concentrations for hours when the wind directed CFB 2 emissions towards the monitor. In particular, that these concentrations were consistent with background levels measure for other wind directions on a specific day. The analysis of the monitoring data indicated that this assumption was not valid for the days that recorded the higher ranked impacts (Appendix D). However, this appeared reasonable for days of recorded 24-hour PM_{10} and $PM_{2.5}$ concentrations that were the 20th rank or lower.

7.0 AIR DISCHARGE MODELLING RESULTS

7.1 Introduction

This section of the report provides a summary of the dispersion modelling predictions for ground level concentrations (GLCs) of contaminants discharged from the CFBs. In Section 8.0, the results in this section for CFB impacts are combined with estimated background ambient air contaminant concentrations to assess cumulative impacts.

Model predicted concentrations are as follows:

- 9th highest (99.9th percentile) 1-hour average concentration (the most probably maximum value);
- Maximum 24-hour average concentrations; and
- Annual average concentrations.

Predicted GLCs are presented for the three most impacted off-site residential dwellings. The GLC contour plots are presented for the different averaging periods that are relevant to each contaminant's standard and guideline criteria. The GLC contour plots highlight the following:

- Site boundary - indicated by the red line;
- Location of the boiler stacks - marked with a light blue dot;
- Location of the most impacted dwellings - marked with a green cross;
- Location of the ambient monitoring site - marked with a red cross.

The dispersion modelling predictions presented in this section do not include the existing background ambient concentrations of air contaminants. Section 8.0 provides a cumulative assessment of air quality effects by combining modelling results for CFB impacts (presented in this section) with the estimated background air contaminant levels that are summarised in Section 4.0.

7.2 Particulate Matter

7.2.1 Respirable particulate - PM_{10}

Contour plots of the predicted maximum 24-hour average and annual average PM_{10} concentrations are provided in Figure 8 and Figure 9 respectively. The residential dwelling (House #1) is predicted to be exposed to the single highest increase in 24-hour average PM_{10} (i.e., 28 µg/m^3) due to CFB 2 emissions when operating at 64 % MCR for the day. The distant CFB 3 has an insignificant contribution to PM_{10}. This same dwelling is close to the location of maximum annual average PM_{10} of 2 µg/m^3.

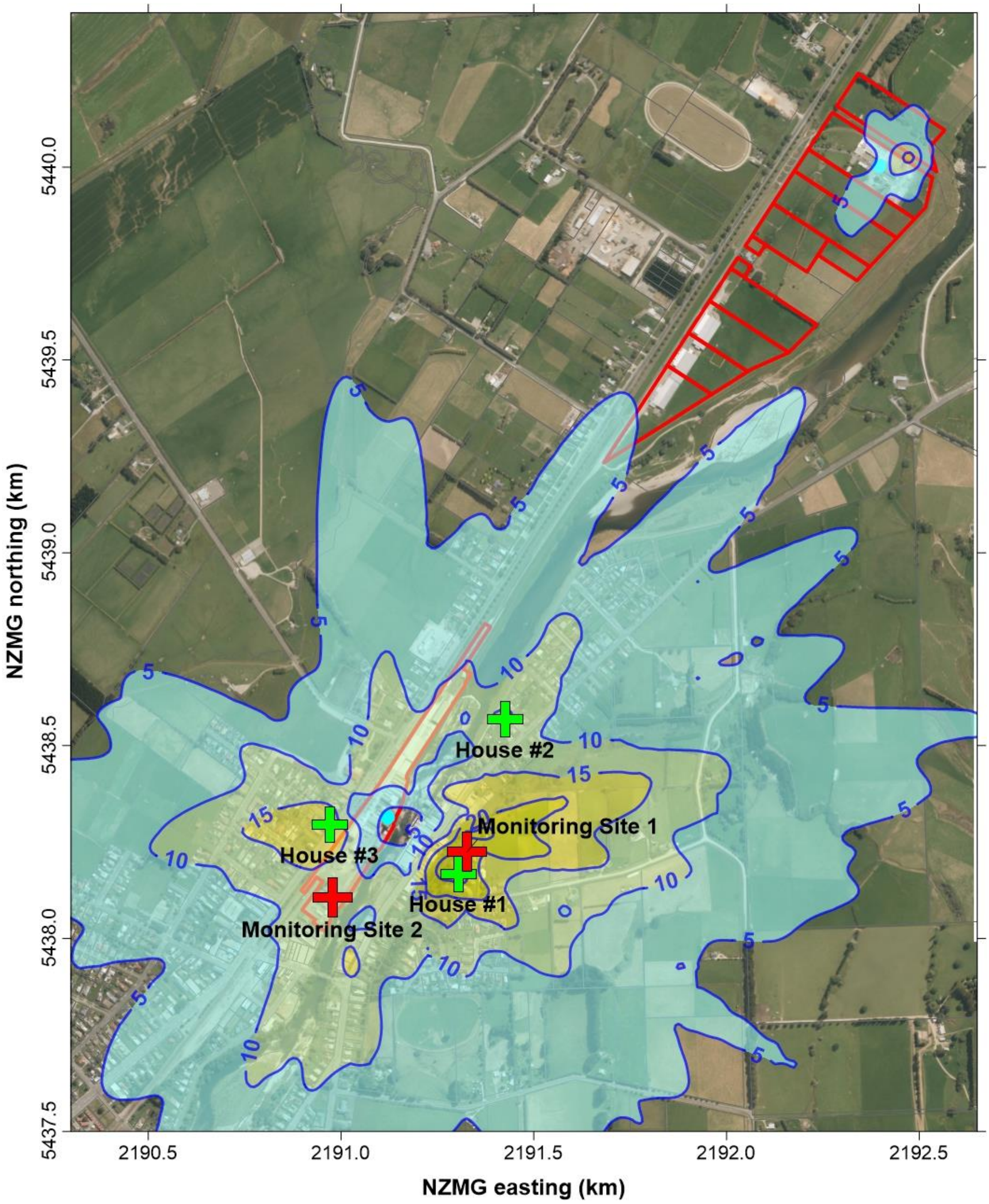

Figure 8: Predicted maximum 24-hour average PM_{10} ground level concentrations (µg/m^3), excluding background concentrations. CFB 2 at 64% MCR, CFB 3 at 40 % MCR.

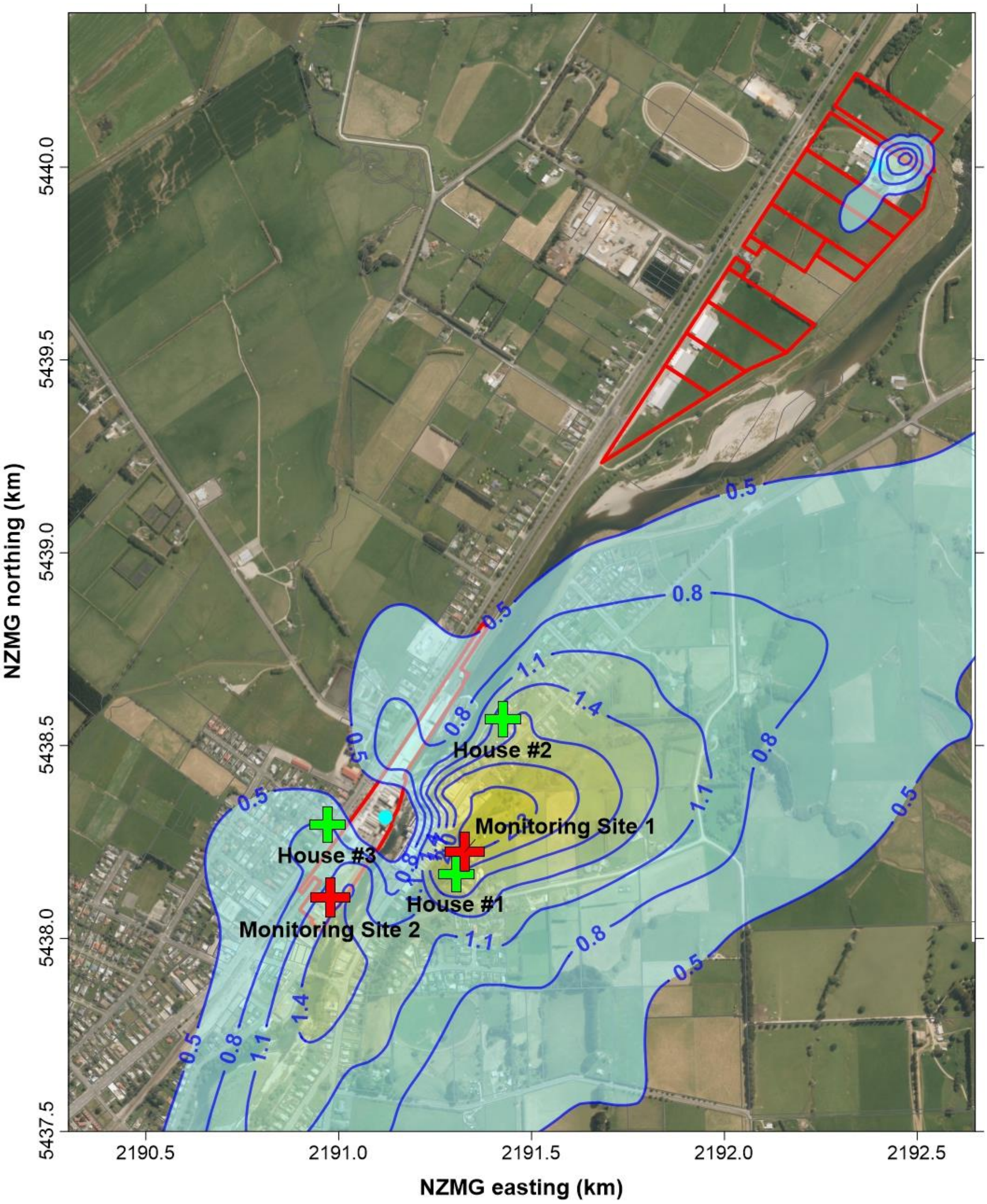

Figure 9: Predicted maximum annual average PM_{10} ground level concentrations ($\mu g/m^3$), excluding background concentrations. CFB 2 at 64% MCR, CFB 3 at 40 % MCR.

7.2.2 Fine particulate - $PM_{2.5}$

Contour plots of the predicted maximum 24-hour average and annual average $PM_{2.5}$ concentrations are provided in Figure 10 and, Figure 11 respectively.

The residential dwelling (House #1) is predicted have the highest increase in 24-hour average $PM_{2.5}$ (i.e., 23 µg/m³) due to CFB 2 operating at 64% MCR. This same dwelling is close the location of maximum annual average $PM_{2.5}$ of 1.5 µg/m³. The distant CFB 3 causes an insignificant impact at this general location.

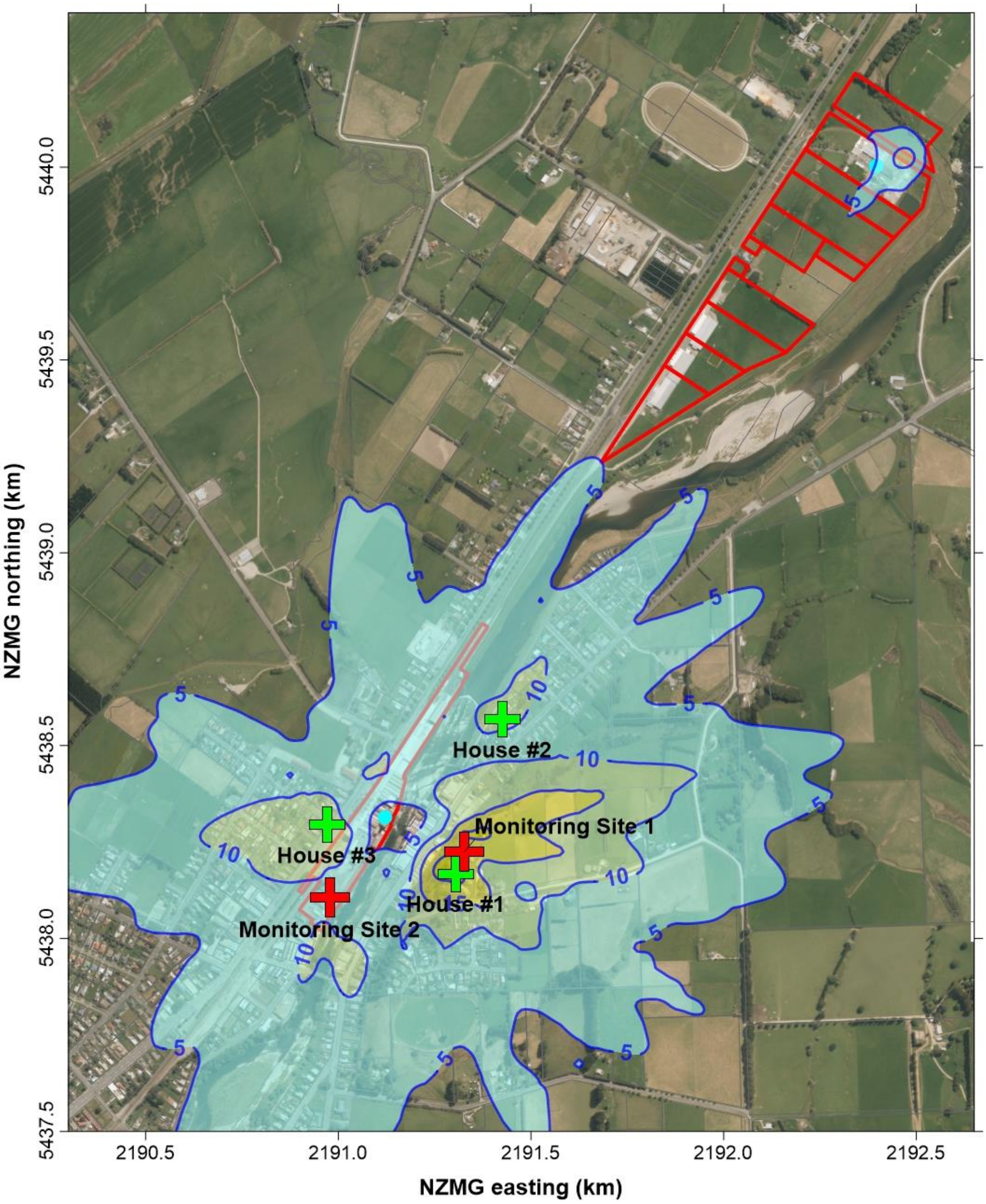

Figure 10: Predicted maximum 24-hour average $PM_{2.5}$ ground level concentrations (µg/m³), excluding background concentrations. CFB 2 at 64% MCR, CFB 3 at 40 % MCR.

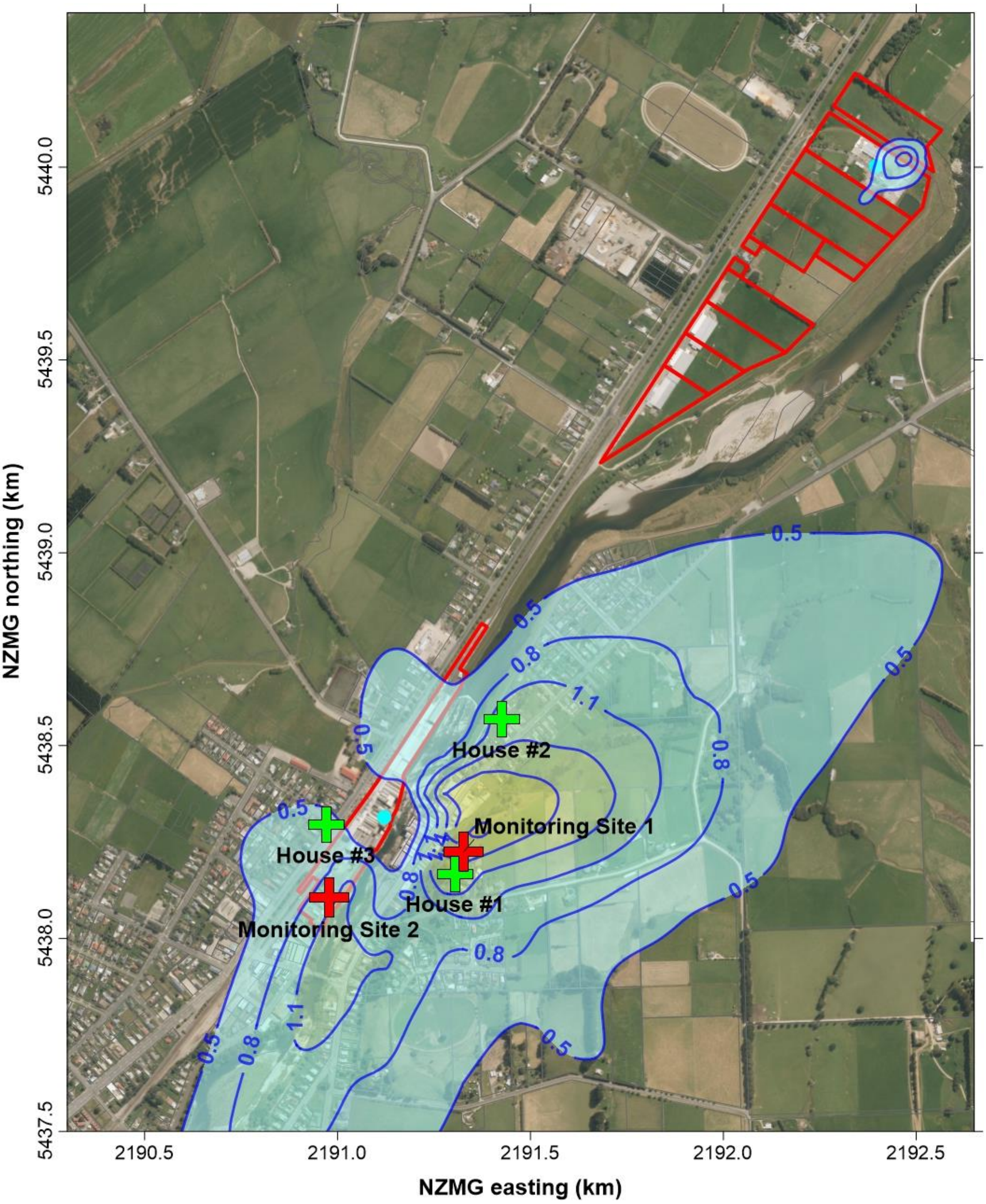

Figure 11: Predicted maximum annual average $PM_{2.5}$ ground level concentrations (µg/m^3), excluding background concentrations. CFB 2 at 64% MCR, CFB 3 at 40 % MCR.

7.3 Nitrogen Dioxide

Contour plots of the predicted 1-hour average (99.9th percentile value) and maximum modelled 24-hour average concentrations are provided in Figure 12 and Figure 13 respectively.

The highest 1-hour NO_2 impact of 20 µg/m^3 occurs 250 m northeast of CFB 3[3].

The most impacted residential dwelling (House #2) is predicted to have a maximum increase in 1-hour average NO_2 of 7 µg/m^3 due to CFB 2 operating at 64 % MCR.

Residential dwelling (House #1) is close to the maximum 24-hour NO_2 impact of 3 µg/m^3, that occurs 200 m southeast of CFB 2.

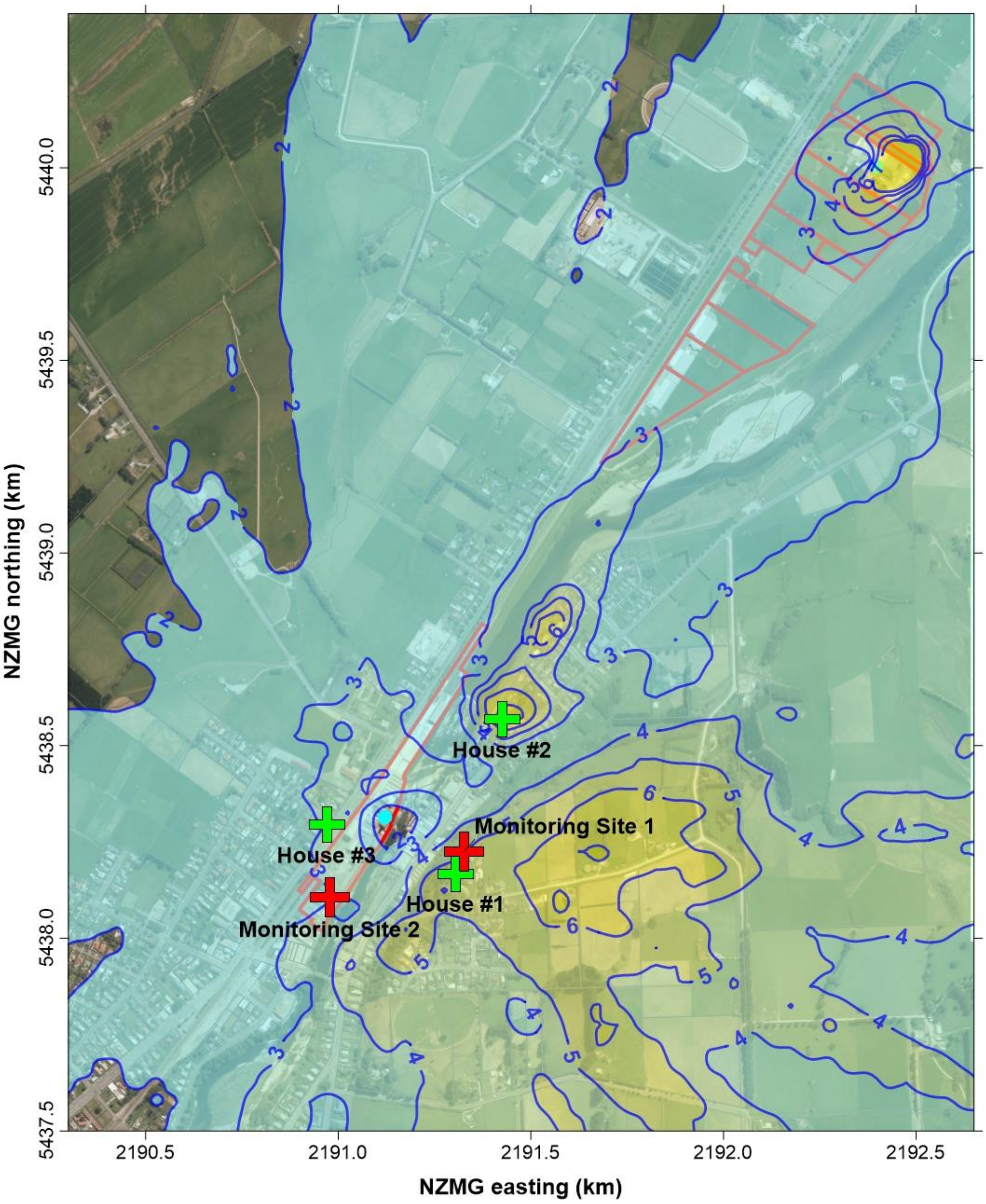

Figure 12: Predicted maximum 1-hour average NO_2 ground level concentrations (µg/m^3) (99.9th percentile value), excluding background concentrations. CFB 2 at 64% MCR, CFB 3 at 40 % MCR.

[3] Note this is at a small area inside the 6 µg/m^3 adjacent to the site boundary.

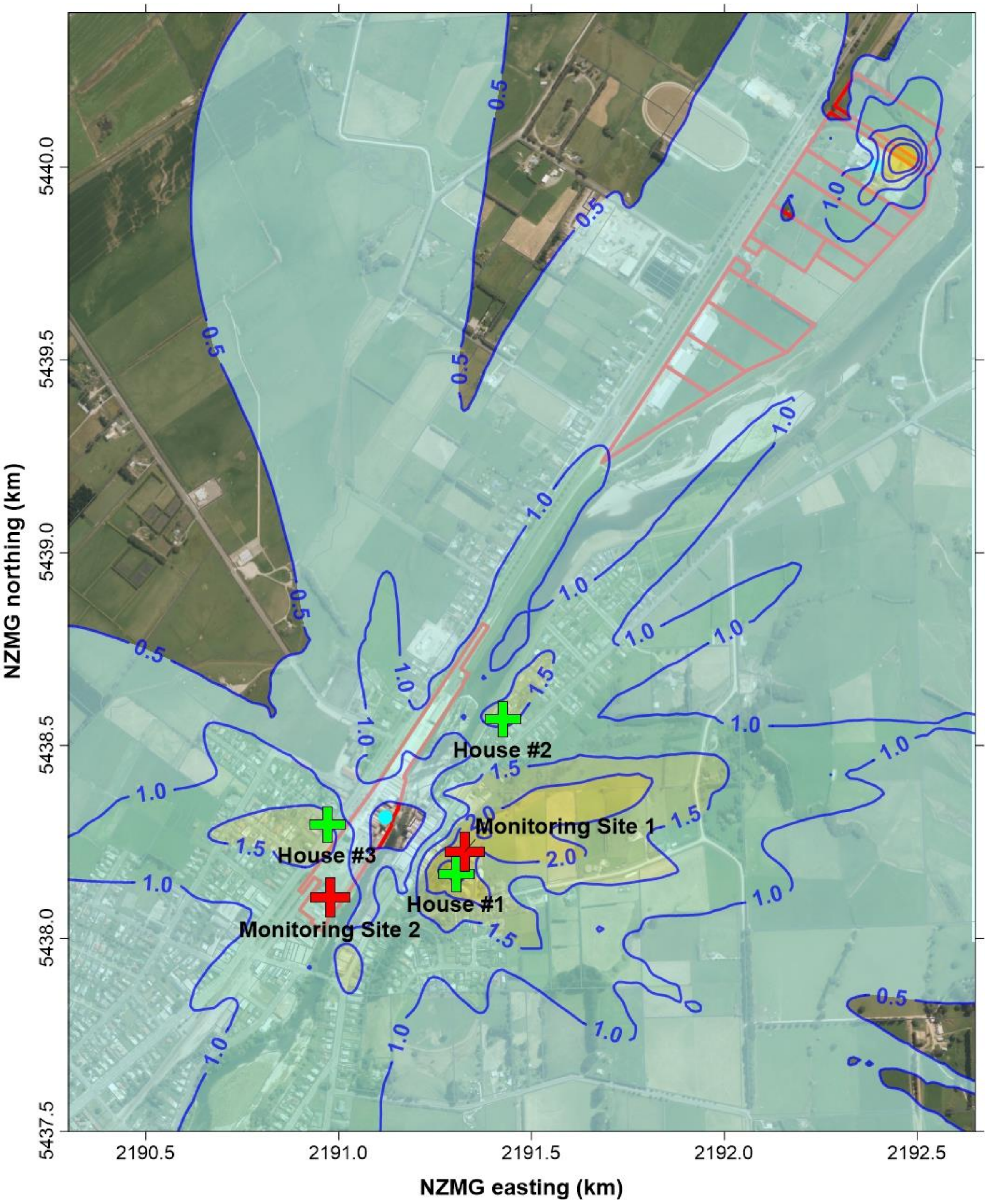

Figure 13: Predicted maximum 24-hour average NO_2 ground level concentrations (µg/m^3), excluding background concentrations. CFB 2 at 64% MCR, CFB 3 at 40 % MCR.

7.4 Sulfur Dioxide

Contour plots of the predicted 1-hour maximum (99.9th percentile modelled value), 24-hour average and annual average SO_2 concentrations are provided in Figure 14, Figure 15 and Figure 16, respectively.

The most impacted residential dwellings (House #2) are predicted to have a maximum increase in 1-hour average SO_2 of almost 141 µg/m³ due to CFB 2 operating at 64 % MCR. The highest 1-hour SO_2 impact of 174 µg/m³ occurs 250 m northeast of CFB 3[4].

The predicted maximum 24-hour SO_2 impact of 65 µg/m³ occurs near House #1. The maximum annual average SO_2 impact of 6 µg/m³ occurs 250 m east of CFB 2.

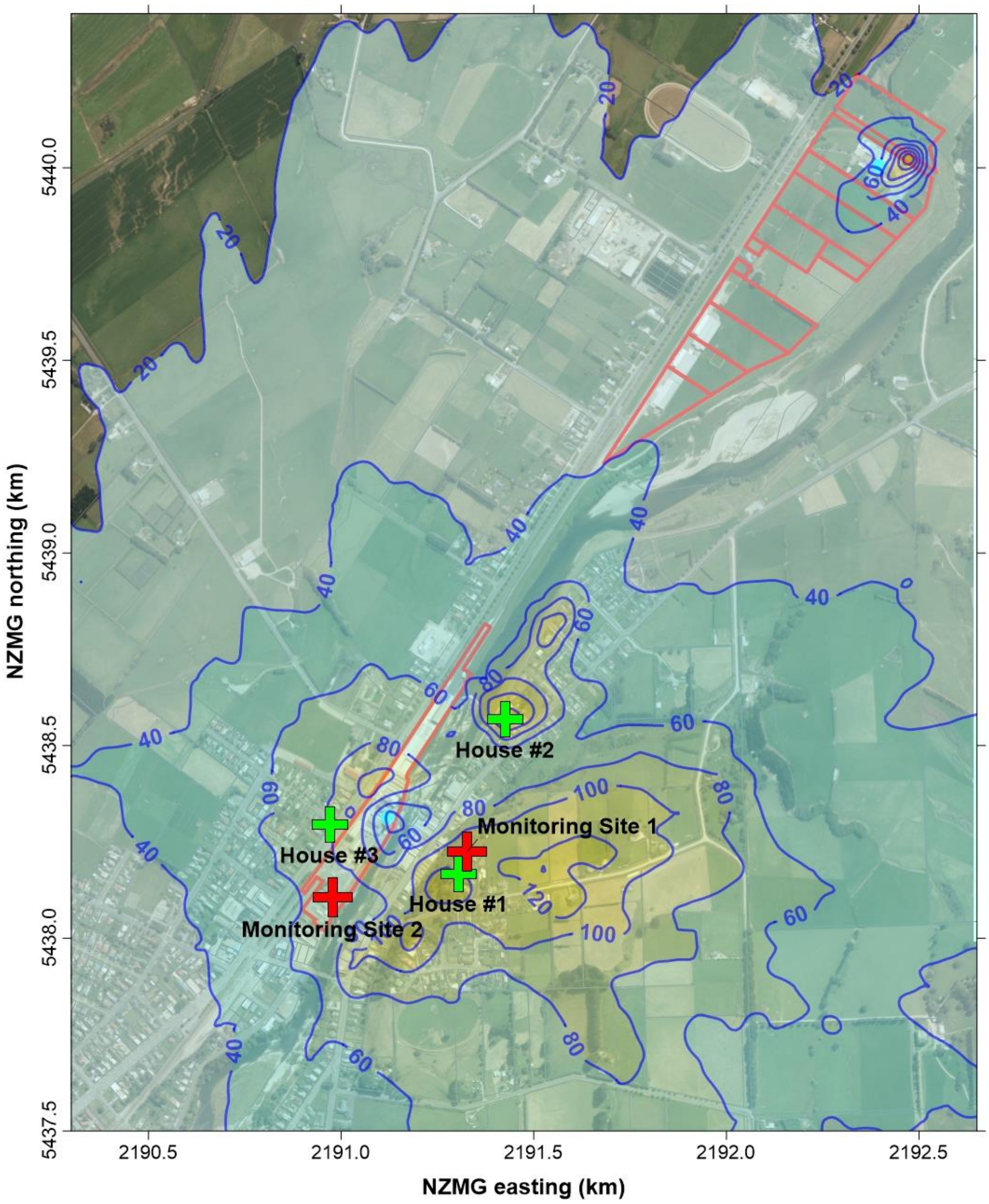

Figure 14: Predicted maximum 1-hour average SO_2 ground level concentrations (µg/m³) (modelled 99.9th percentile value), excluding background concentrations. CFB 2 at 64% MCR, CFB 3 at 40 % MCR.

[4] Note this is at a small area inside the 60 µg/m³ adjacent to the site boundary.

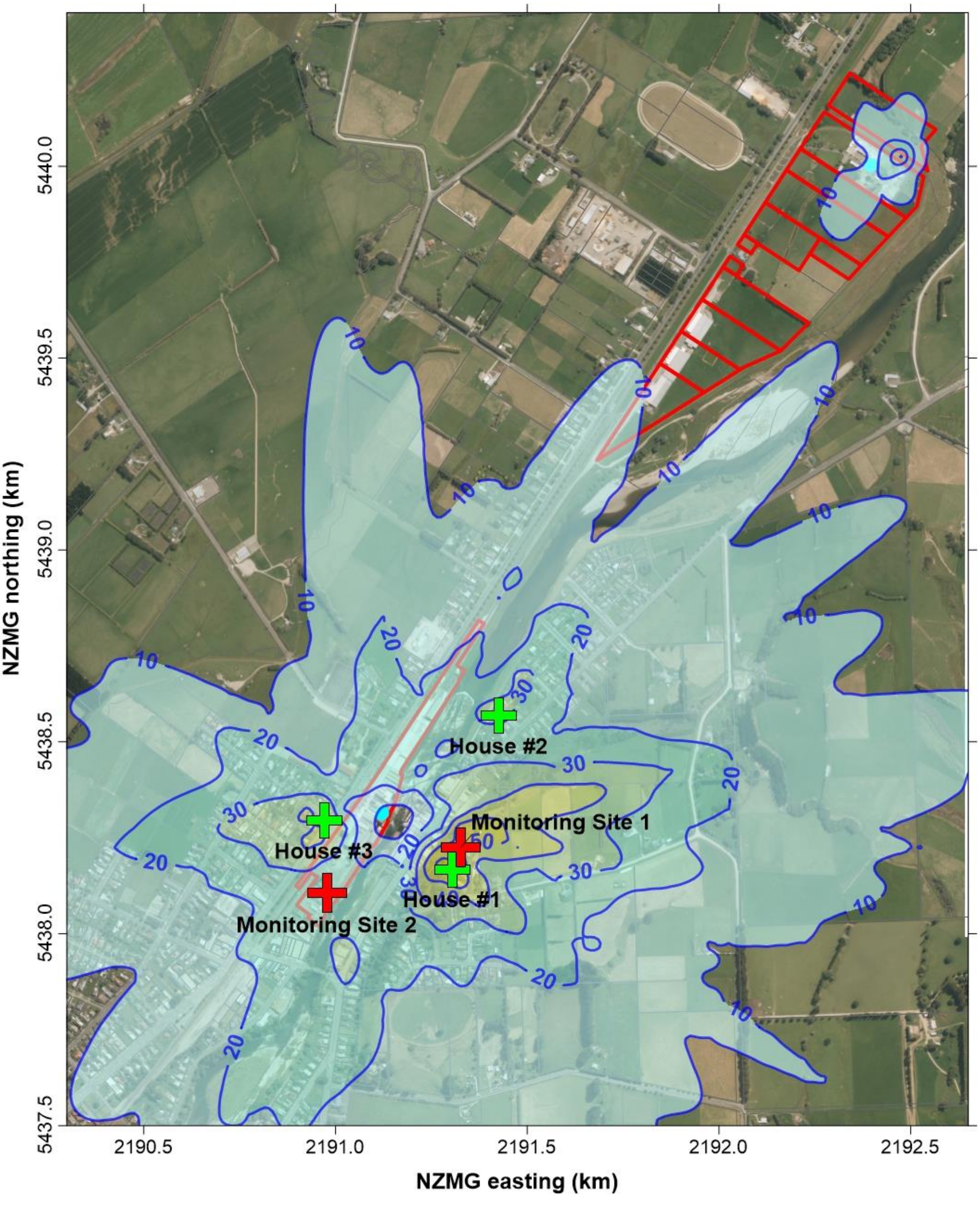

Figure 15: Predicted maximum 24-hour average SO_2 ground level concentrations(µg/m^3), excluding background concentrations. CFB 2 at 64% MCR, CFB 3 at 40 % MCR.

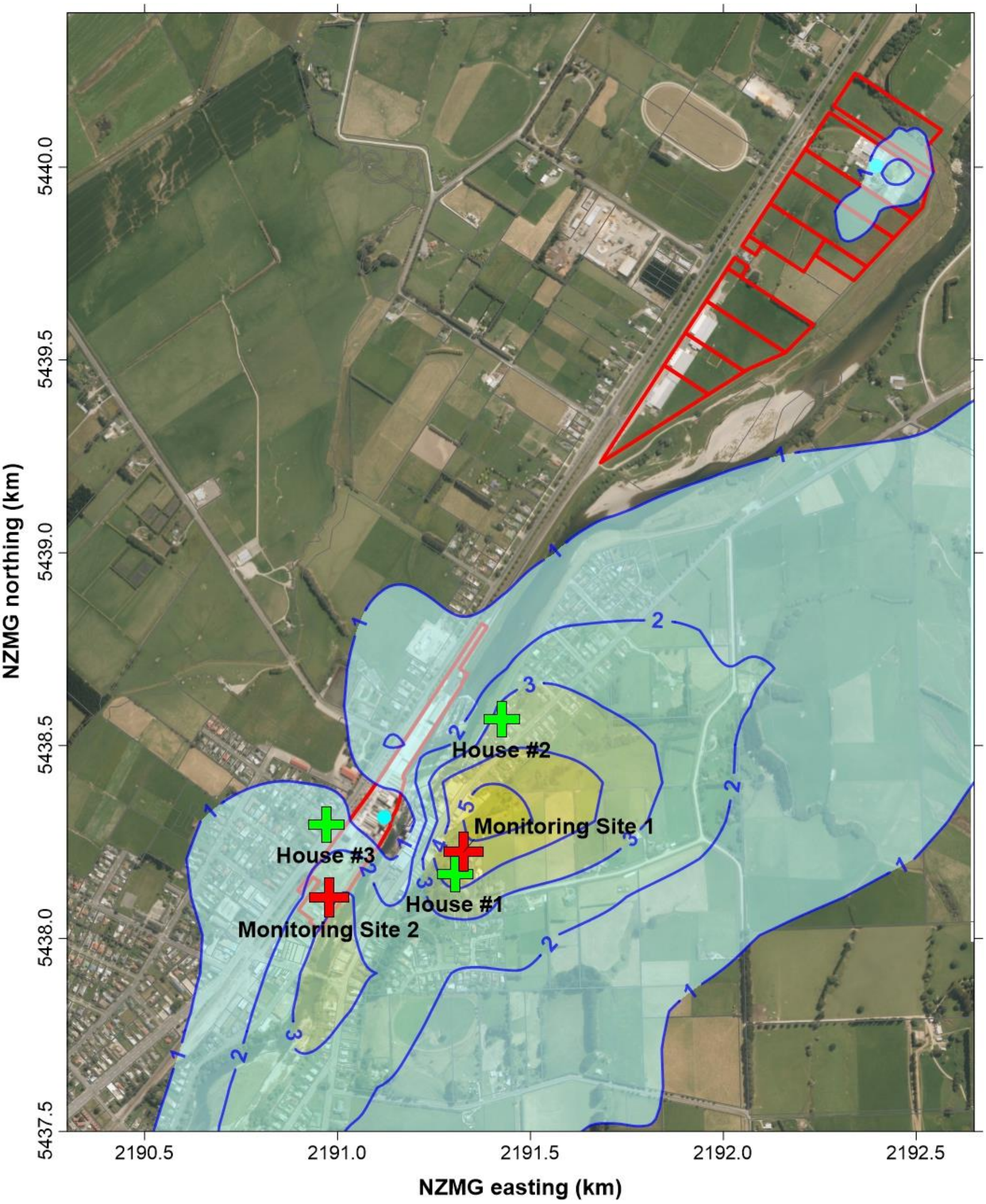

Figure 16: Predicted annual average SO_2 ground level concentrations (μg/m³), excluding background concentrations. CFB 2 at 64% MCR, CFB 3 at 40 % MCR.

8.0 ASSESSMENT OF CUMULATIVE AIR QUALITY

8.1 Ambient Particulate Monitoring

8.1.1 Annual averages

The monitored 50th percentile values presented in Table 5 and Table 6, provide an indication of the annual average PM_{10} and $PM_{2.5}$ exposure levels at Hillcrest Avenue. The 50th percentile values for PM_{10} and $PM_{2.5}$ are respectively 11 µg/m^3 and 5 µg/m^3. Therefore, the monitoring results for PM_{10} and $PM_{2.5}$ indicates that both the MfE AAQG for PM_{10} (i.e., 20 µg/m^3) and WHO for $PM_{2.5}$ (10 µg/m^3) are likely to be readily met at the Hillcrest Avenue site.

The monitored 50th percentile values at the southern boundary of the Alliance site are likely to be conservative estimates of the annual average PM_{10} and $PM_{2.5}$ concentrations. This is because the monitoring was during autumn and winter months. The 50th percentiles presented in Table 5 of 16 µg/m^3 for PM_{10} is 80 % of MfE AAQG annual average criterion of 20 µg/m^3, therefore indicating the annual average should be met at this location.

The 50th percentile value in Table 6 for $PM_{2.5}$ reached the WHO annual average guideline value of 10 µg/m^3. When considering the average over a year, the WHO guideline (and proposed NESAQ for annual average $PM_{2.5}$) are expected to be complied with at the southern boundary of the Alliance site.

8.1.2 24-hour averages

The ambient levels of 24-hour PM_{10} and $PM_{2.5}$ which were measured at Hillcrest Avenue and Alliance's southern boundary during February to July 2018 are represented in Figure 17 and Figure 18 respectively. These indicate that the NESAQ for 24-hour PM_{10} of 50 µg/m^3 was complied with on all days at both sites.

Monitoring at the southern boundary of the Alliance site found that the WHO guideline for 24-hour $PM_{2.5}$ of 25 µg/m^3 was exceeded on three days (there were a total of 98 days monitoring covering June to July 2018).

CFB 2 was upwind of the monitor for 23 hours during the day of highest recorded $PM_{2.5}$ impact (11 May 2018). The daily average conditions on this day are classed as Category C and background PM_{10} would have been in the order of 8 µg/m^3 and not likely to be elevated (see Table 10) – indicating CFB 2 to be the primary source on that day. The modelling of CFB 2 particulate emissions (as specified in Section 3.4.1) does not explain the extent of the monitored $PM_{2.5}$ value on this day, and this indicates that CFB 2 can sometimes discharge particulate at levels above that assumed for this assessment.

For the two days that each produced the 2nd highest ambient 24-hour $PM_{2.5}$ concentration, CFB 2 was upwind of the monitor for 6 and 10 hours, respectively. The daily average conditions on these days are classed as Category A and therefore associated with elevated background levels (see Table 10).

These results further indicate that on days when the background air quality in Mataura is poor, CFB 2 can cause an increase of off-site 24-hour $PM_{2.5}$ concentration within the order 5 µg/m^3.

Overall, the results indicate that during the winter or autumn, days of poor air quality are primarily caused by background sources (this is most likely to be associated with domestic heating emissions).

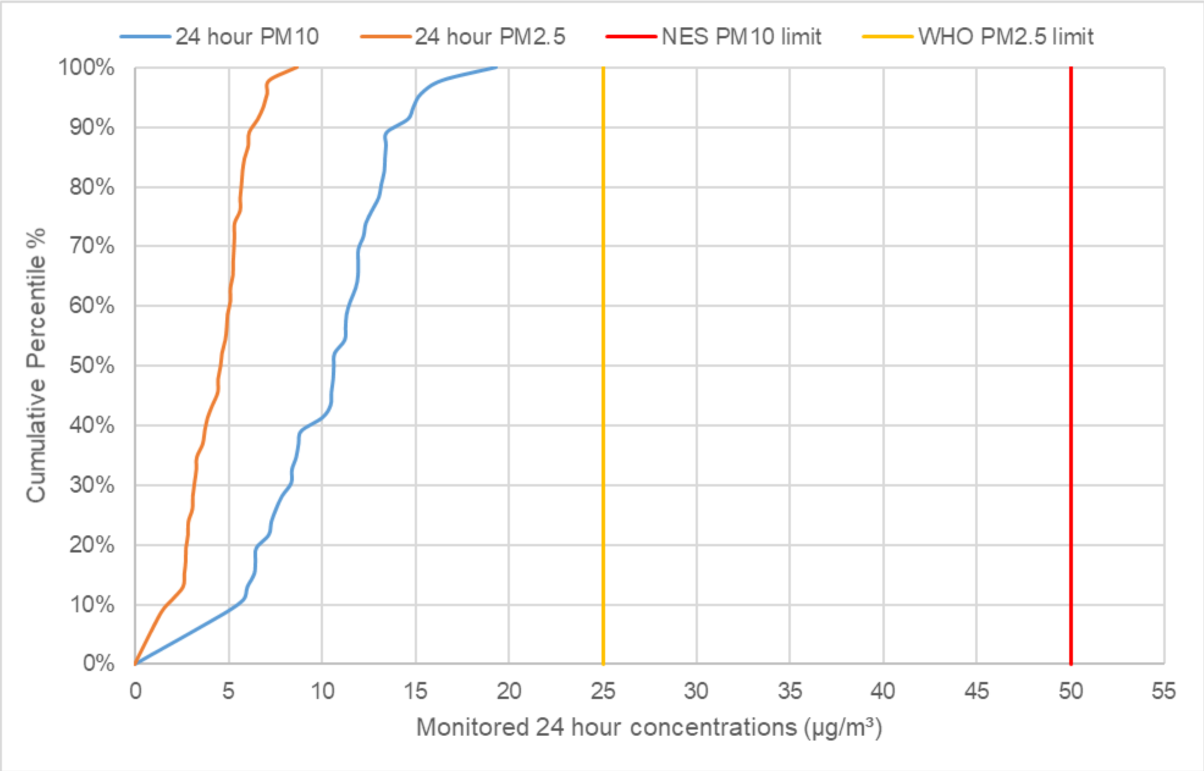

Figure 17: Cumulative percentile of PM_{10} and $PM_{2.5}$ at Hillcrest (8 February to 26 March 2018).

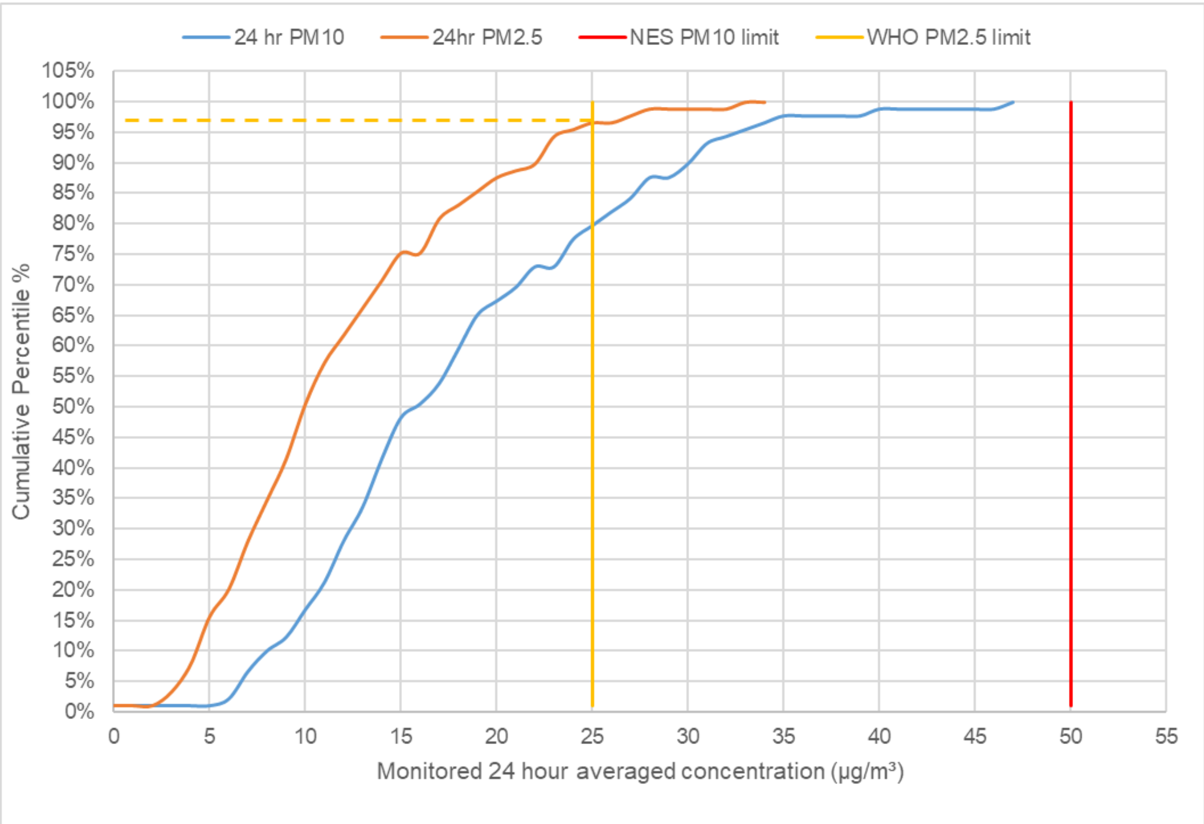

Figure 18: Cumulative percentile of PM_{10} and $PM_{2.5}$ at Alliance Southern Boundary (28 March to 3 July 2018).

8.2 Evaluation of Modelling Results

8.2.1 General

The cumulative assessment of modelling results for the CFBs (with CFB 2 at 64 % MCR), combined with background particulate levels are discussed below for the following:

- Alliance's southern boundary (ASB);
- the most impacted off-site location (MIL); and
- the most impacted residential dwellings (MIRDs).

8.2.2 Southern boundary monitoring location

Based on the ambient monitoring undertaken at the ASB, the likely background contributions are presented in Table 10 (Section 4.3) as a function of daily average weather conditions (specified as four categories A, B, C and D).

Model predicted CFBs impacts and associated background concentrations are summarised in Tables 1, 2 and 3 in Appendix H. These tables provide a cumulative assessment of ambient particulate impacts at Alliance's southern site boundary.

Tables 1 and 2 relate to occasions when the CFB 2 is predicted to cause its highest effect on 24-hourly average impacts at the ASB and indicate the following:

- Cumulative 24-hour PM_{10} are estimated to be up to 52 % of NESAQ;
- Cumulative 24-hour $PM_{2.5}$ are estimated to be up to 72 % of WHO.

The results in Table 3 in Appendix H relates to the occasions when background 24-hour average particulate levels were most dominant. The results indicate that on those days when non-compliance with the WHO guideline for 24-hour $PM_{2.5}$ was recorded at the ASB, that this was primarily caused by existing background levels. On these days of highest monitoring particulate, the CFBs contributed approximately 8 % of the WHO criterion for 24-hour $PM_{2.5}$.

The above cumulative assessment of modelled CFB impacts and monitored background particulate levels indicates that the primary source of degraded air quality within Mataura is likely to be domestic fires. However, this finding is not consistent with the analysis of the highest monitored 24-hour $PM_{2.5}$ values discussed in Section 8.1. This analysis implicates CFB 2 as the primary cause of WHO guideline exceedance for some of the days of highest monitored 24-hour PM_{10} and $PM_{2.5}$ impact. This inconsistency is mostly likely to be a result of CFB 2 particulate emissions being higher than those assumed by the modelling.

8.2.3 Most impacted off-site location

The modelled CFB impacts and assessment of cumulative PM_{10} and $PM_{2.5}$ concentrations at the most impacted off-site location (**MIL**) are summarised in Table 4 and Table 5 in Appendix H. The MIL in this instance, is where the modelling predicts CFB emissions to cause the highest off-site impact of 24-hour average GLCs. The MIL location is relatively close (i.e., approximately 30 m away) to residential dwellings (House #1).

For days when the CFB 2 is predicted to cause its highest level of ambient impact at the MIL, the results indicate that:

- Cumulative 24-hour PM_{10} are estimated to be up to 88 % of NESAQ;
- Cumulative annual PM_{10} are estimated to be up to 70 % MfE AAQG;
- Cumulative 24-hour $PM_{2.5}$ are estimated to be up to 128 % of WHO;
- Cumulative annual $PM_{2.5}$ are estimated to be up to 90 % of WHO.

It should be noted that the prediction of 24-hour and annual impacts are expected to be conservative as the modelling has assumed the CFB 2 operating at 64 % MCR on every hour. However analysis of boiler steam records (Section 2.3) confirm the maximum 24-hour average output equates to 53 % MCR and the annual average output is 30 % MCR (as shown in Figure 4). Therefore, the modelled 24-hour and annual air quality impacts are likely to be approximately 15 % and 100 % higher respectively, than the actual impacts.

Therefore, the assessment of 24-hour PM_{10} and $PM_{2.5}$ impacts due to the CFBs are slightly conservative, whereas the annual average predictions are likely to be overstated by at least a factor of 2.

8.2.4 Most impacted residential dwellings

The most impacted residential dwelling (MIRD), occurs at House #1 as shown in Figure 8. The predicted CFB impacts and assessment of cumulative PM_{10} and $PM_{2.5}$ concentrations House #1 are summarised in Tables 6, 7, 8 and 9 in Appendix H.

The results in Tables 6 and 7 indicate that when the CFB 2 causes its highest level of ambient impact at House #1 that:

- cumulative 24-hour PM_{10} are estimated to be up to 84 % of NESAQ
- cumulative 24-hour $PM_{2.5}$ are estimated to be up to 124 % of the WHO criterion, for the day when the CFB 2 is predicted to be 92 % of the criterion (23 µg/m^3)

The proposed NESAQ for $PM_{2.5}$ allows for three exceedances of 25 µg/m^3 (as a 24-hour average) per year. Based on monitoring results near House #1 (see Section 8.1.2), the proposed NESAQ for $PM_{2.5}$ is likely to be complied with, while allowing for the modelled peak 24-hour impact due to CFB 2's emissions.

The results in Table 8 and Table 9 (in Appendix H) relate to the ambient conditions when background 24-hourly average PM_{10} and $PM_{2.5}$ levels are most dominant (cold winter days). These results indicate that on winter days with the most elevated background particulate levels, the cumulative impacts at House #1 are estimated as follows:

- cumulative 24-hour PM_{10} are estimated to be up to 80 % of NESAQ
- cumulative 24-hour $PM_{2.5}$ are estimated to be up to 120 % of WHO

The modelling results indicate that the CFBs would make a negligible contribution with respect to non-compliance with the WHO limit for $PM_{2.5}$. For example, following the three highest days of cumulative impact (which are above the criterion), the CFBs are predicted to cause an impact at the MIRD that is less than 0.5 % of the criterion. The exceedance is effectively caused by the background sources of $PM_{2.5}$.

Houses #2 and #3 as shown in Figure 8, are predicted to have cumulative respirable particulate impacts that are very similar, or lower effects, comparing to those summarised for House #1. See results in Table 10 and Table 11 (House #2) and Table 12 and Table 13 (House #3) in Appendix H**.**

8.3 Sulfur Dioxide and Nitrogen Dioxide

A cumulative assessment of SO_2 and NO_2 impacts due to the CFBs and background levels are presented in Table 13 for the MIL and MIRD. In this instance, the MIL is the narrow strip of land to the northeast of CFB 3 for 1-hour averages, and 200 m to the southeast of CFB 2 for 24-hour and annual averages

The MIRD is House #2 for 1-hour averages and House #1 for 24-hour and annual averages. For both these air contaminants, the predicted worst-case cumulative impacts are well within their respective NESAQ and MfE AAQG criteria for all relevant averaging periods.

With reference to the figures in Section 7.0, these impacts are isolated to small areas surrounding the site and for other locations the levels are further reduced. Given the extent of predicted compliance with relevant health-based criteria then the cumulative effects of these contaminants are likely to have a less than minor potential to cause adverse effects on people, flora or fauna.

Table 13: Peak SO_2 and NOx GLCs due to CFBs predicted at MIL and MIRD.

Pollutants	Maximum off-site (µg/m³)		Most impacted house (µg/m³)		Background (µg/m³)	Criterion (µg/m³)
	Modelled GLCs	Cumulative GLCs	Modelled GLCs	Cumulative GLCs		
1-hour SO_2	174	294	141	261	120	**570 (maximum) 350 (99.9th percentile)**
24-hour SO_2	65	95	62	92	30	**120**
Annual SO_2	6	11	4	9	5	**30**
1-hour NO_2	20	80	7	67	60	**200**
24-hour NO_2	4	43	3	43	40	**100**

9.0 DISCUSSION

9.1 Ambient Particulate Monitoring

From the analysis of ambient monitoring data obtained from the southern site boundary (including April, May and June 2018), cumulative concentrations of 24-hour PM_{10}, while significantly degraded by domestic heating emissions, are expected to meet the NESAQ for daily exposure. However, the monitoring found the WHO ambient criteria for daily $PM_{2.5}$ exposure to be exceeded on three days during the 3 months of monitoring.

On two of these days, background sources are the likely primary driver of these exceedances. It is noted that the proposed NESAQ for daily $PM_{2.5}$ exposure allows for three days of exceedance of the WHO criteria, therefore is possible that the proposed NESAQ would be met, although given the limited monitoring period, this outcome is not certain.

The average PM_{10} and $PM_{2.5}$ concentrations over the 98 days of monitoring were within the MfE AAQG and WHO criteria for annual average PM_{10} and $PM_{2.5}$ respectively

In summary, the ambient monitoring at the southern site boundary indicates that background sources are the primary cause of degraded air quality in Mataura during autumn and winter months.

On the isolated occasion when CFB 2 was the primary driver of degraded air quality which exceeded the WHO criterion, the particulate emissions from CFB 2 were probably above the modelled discharge of 9 kg/hr.

9.2 Modelled CFB Impacts

The modelling assessment indicated the hide salting plant boiler (CFB 3) only causes minor air quality effects beyond the site boundary, and that it would also cause minimal cumulative air quality effects with contaminant emissions from CFB 2.

On days where background air quality is not significantly affected by domestic fires in Mataura, CFB 2 can cause off-site 24-hour exposures of $PM_{2.5}$ in the order of 20 µg/m^3 (when discharging at a maximum of 9 kg/hr of PM_{10}) and it was the primary driver of a predicted exceedance of the WHO criterion at the nearest house (House #1).

The increases in ambient 24-hour PM_{10} due to CFB 2 emissions are also significant on days, which are not significantly affected by domestic fires. Nevertheless, the NESAQ for 24-hour PM_{10} is likely to be complied with given that CFB 2 discharges PM_{10} at a maximum of 9 kg/hr at 64% MCR. This finding is valid on the basis that background ambient PM_{10} levels, as measured in 2018, are representative of Mataura's winter-time conditions.

During winter days, when background ambient PM_{10} and $PM_{2.5}$ are most affected by domestic fire emissions, CFB 2 and CFB 3 are expected to cause only small contributions to off-site cumulative particulate levels within Mataura. Again, this outcome is contingent on the maximum PM_{10} discharge rate of 9 kg/hr from CFB 2.

With regards to SO_2 and NO_2 air quality impacts, the modelling results for CFB contributions to ambient levels are sufficiently low to conclude that these are only likely to cause less than minor effects.

10.0 MITIGATION

The existing CFBs have multi-clone systems for reducing particulate emissions, which is an appropriate level of control for the small CFB 3. The larger CFB 2 discharges PM_{10} at in-stack concentrations that are relatively high despite the operation of a multi-clone to treat this CFBs exhaust air. Furthermore, there is a prospect that these emissions from CFB 2 can exceed 9 kg/hr, for which the level of cumulative effect is considered to be unacceptably high.

The existing multi-clone that treats CFB 2's exhaust does not appear to be effective at reducing emission to around 300 mg/Nm^3 (at 12 vol% CO_2 and STP, dry conditions), or lower. Therefore, given the extent of monitored and modelled impacts assessed in this report, the existing multi-clone, boiler combustion controls and discharge stack do not appear to represent the Best Practical Option (BPO) for minimising the effects of particulate discharges to atmosphere.

Potential options for achieving the BPO are considered to include:

- Upgrading the CFB 2's multi-clone, including a fractionating bag-house and combustion controls and monitoring;
- Treat all exhaust combustion exhaust through a bag-house filter prior to discharging treated exhaust via the existing stack; and
- Replace CFB 2 with a new energy plant (with, or without a baghouse filter), which has a much lower PM_{10} emission rate than the existing plant.

The first option above, may not achieve the required reduction in PM_{10} emissions to air, such that cumulative effects are acceptably low over the longer term. Investment in this option therefore has considerable financial risk. Note, a fractionating bag-house treats the underflow airstream from the base of a new multi-clone and therefore helps ensures a treated exhaust in-stack concentration of 250 mg/Nm^3 (at 12 vol% CO_2 and STP, dry conditions) or lower, is routinely achieved.

Either of the second two mitigation options above provide high certainty of adequate particulate emission reductions from the main site's energy plant which achieves a sustainable level of air quality effect. However, it is not clear which option would be most cost effective. The air quality effects of both options have been assessed by Golder (2020).

11.0 CONCLUSIONS

The main conclusions of this report are as follows:

- Existing background sources of particulate are the primary cause of degraded air quality (associated with high ambient particulate) in Mataura during autumn/winter months.
- The air contaminant emissions from the Alliance CFBs generally cause a low contribution to cumulative air quality impacts with Mataura.
- The CFB 2 particulate emissions are sometimes the primary driver of degraded air quality occurring on raised terrain to the east of the site, and on days when background ambient particulate levels are not significantly affected by domestic fire emissions.
- For days when CFB 2 operates at a maximum rate of 64 %MCR and within the maximum PM_{10} discharge rate of 9 kg/hr, the NESAQ for PM_{10}, is likely to be approached, and complied with beyond the site boundary. This is on the basis that background ambient PM_{10} levels, as measured in 2018, are representative of Mataura's winter-time levels.
- While CFB 2 operates at a maximum rate of 64 %MCR and within the maximum $PM_{2.5}$ discharge rate of 7.2 kg/hr, the proposed NESAQ for $PM_{2.5}$, may be approached and complied with at all locations, but this outcome is not certain. It is more probable that the current WHO guideline for 24-hour $PM_{2.5}$ would not be met on a few days per year.
- Annual average concentrations of PM_{10} and $PM_{2.5}$ are not likely to exceed existing MfE AAQGs or the proposed NESAQ for $PM_{2.5}$.
- The off-site impacts of particulate discharges from the CFBs, when combined with existing background levels within Mataura, may be causing more than minor effects on people.

- Emissions of NO_x (i.e., NO and NO_2) and SO_2 from the CFB's are likely to cause only a less than minor potential for health effects upon people.
- Reducing CFB 2 emissions will assist in reducing these effects and ensure compliance with the existing and future NESAQ for PM_{10} and $PM_{2.5}$. However existing wintertime air quality is likely to remain significantly degraded due to domestic fire emissions, irrespective of any future CFB 2 emission reductions.
- The installation of a bag-house filter and retrofitting this to the existing CFB 2 plant, or replacing CFB 2 with a new energy plant (with or without a baghouse filter) is likely to achieve acceptable environmental effects and most likely to represent the BPO in the longer term.

12.0 REFERENCES

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APPENDIX A

Report Limitations

Report Limitations

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APPENDIX B

Stoichiometry Calculations

COMBUSTION CALCULATIONS

03 Oct 2018
1793285 - Hides CFB, 923 kW
40% MCR, 5% O_2 normal operation

Parameter	Value	Unit	Comment / source of data
FUEL ULTIMATE ANALYSIS	New Vale		
Carbon:	69.44	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Hydrogen:	4.76	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Oxygen:	24.40	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Nitrogen:	0.60	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Sulphur:	0.80	%wt (DAF basis)	Assume max 0.45% wt as received
Fuel moisture content:	40.0	%wt (as received basis)	Average of testings from Jun 2016 to Feb 2018
Ash content:	3.6	%wt (as received basis)	
DAF portion:	0.564	kg/kg fuel (as received basis)	
AIR REQUIREMENTS			
Theoretical O_2 required:	62.82	moles/kg (DAF basis)	
Excess air:	30.95	%	
Total O_2 required:	82.26	moles/kg (DAF basis)	
Flue gas CO_2 content:	14.88	%vol dry	
Flue gas O_2 content:	5.00	%vol dry	
APPLIANCE DETAILS			
Power Output:	923	kW	Based on 2000 AEE
Percentage of MCR:	43	%	Calculated based on max coal burning rate
Effective power output:	393	kW	
Efficiency:	50	%	Assume the same as the main CFB
As rcvd fuel CV:	14360	kJ/kg	Based on average GCV from June 2016 to January 2018
Equivalent Stack diameter:	0.60	m	Based on 2000 AEE
Heat produced by combustion:	786	kW	
Heat loss:	393	kW	
Maximum fuel burning rate:	0.05	kg/s (as received basis)	
	0.20	t/h (as received basis)	Max weekly coal burning rate 2017
STACK PROPERTIES			
Temperature:	523.15	K	Based on 2000 AEE
WET flow rate (POC sheet):	21.10	m³/kg DAF fuel	
Actual volumetric flow rate:	0.65	m³/s	
Stack x-sectional area:	0.28	m²	
Efflux velocity:	2.30	m/s	
DRY flow rate @ STP (POC sheet):	8.72	Nm³/kg DAF fuel	
	0.27	Nm³/sec	
	969	Nm³/hour	
WET flow rate @ STP (POC sheet):	11.02	Nm³/kg DAF fuel	
	0.34	Nm³/sec	
	1,224	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 Associates

03 Oct 2018

1793285 - Hides CFB, 923 kW

40% MCR, 12% CO_2 standard operation

Parameter	Value	Unit	Comment / source of data
FUEL ULTIMATE ANALYSIS	New Vale		
Carbon:	69.44	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Hydrogen:	4.76	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Oxygen:	24.40	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Nitrogen:	0.60	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Sulphur:	0.80	%wt (DAF basis)	Assume max 0.45% wt as received
Fuel moisture content:	40.0	%wt (as received basis)	Average of testings from Jun 2016 to Feb 2018
Ash content:	3.6	%wt (as received basis)	
DAF portion:	0.564	kg/kg fuel (as received basis)	
AIR REQUIREMENTS			
Theoretical O_2 required:	62.82	moles/kg (DAF basis)	
Excess air:	61.82	%	
Total O_2 required:	101.66	moles/kg (DAF basis)	
Flue gas CO_2 content:	12.01	%vol dry	
Flue gas O_2 content:	8.06	%vol dry	
APPLIANCE DETAILS			
Power Output:	923	kW	Based on 2000 AEE
Percentage of MCR:	43	%	Calculated based on max coal burning rate
Effective power output:	393	kW	
Efficiency:	50	%	Assume the same as the main CFB
As rcvd fuel CV:	14360	kJ/kg	Based on average GCV from June 2016 to January 2018
Equivalent Stack diameter:	0.60	m	Based on 2000 AEE
Heat produced by combustion:	786	kW	
Heat loss:	393	kW	
Maximum fuel burning rate:	0.05	kg/s (as received basis)	
	0.20	t/h (as received basis)	Max weekly coal burning rate 2017
STACK PROPERTIES			
Temperature:	523.15	K	Based on 2000 AEE
WET flow rate (POC sheet):	25.09	m³/kg DAF fuel	
Actual volumetric flow rate:	0.77	m³/s	
Stack x-sectional area:	0.28	m²	
Efflux velocity:	2.74	m/s	
DRY flow rate @ STP (POC sheet):	10.80	Nm³/kg DAF fuel	
	0.33	Nm³/sec	
	1,200	Nm³/hour	
WET flow rate @ STP (POC sheet):	13.10	Nm³/kg DAF fuel	
	0.40	Nm³/sec	
	1,455	Nm³/hour	
EMISSION CALCULATIONS			
SO_2 emission rate (no ash retention):	0.49	g/s	
SO_2 emission rate (5% ash retention):	**0.47**	g/s	
	1.68	kg/hr	
NO_X emission factor:	2.90	kg/tonne	US-EPA AP42 Table 1.7-1 (5.8 lb/ton)
NO_X emission rate:	**0.16**	g/s	Assume the same type of boiler
PM10 concentration:	640	mg/m³ @ dry STP 12% CO2	
PM_{10} emission rate:	**0.21**	g/s	
PM_{10} emission rate:	1	kg/hr	
Assume PM2.5 concentration:	512	mg/m³ @ dry STP 12% CO2	Assume 80% PM10 is PM2.5
$PM_{2.5}$ emission rate:	**0.17**	g/s	
$PM_{2.5}$ emission rate:	0.61	kg/hr	

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

11 Aug 2020
1793285 - Babcock & Wilcox Boiler No. 2
64% MCR, 8% O_2 normal operation

Parameter	Value	Unit	Comment / source of data
FUEL ULTIMATE ANALYSIS	New Vale		
Carbon:	69.44	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Hydrogen:	4.76	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Oxygen:	24.40	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Nitrogen:	0.60	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Sulphur:	0.80	%wt (DAF basis)	Assume max 0.45% wt as received
Fuel moisture content:	40.0	%wt (as received basis)	Average of coal analysis from Jun 2016 to Feb 2018
Ash content:	3.6	%wt (as received basis)	
DAF portion:	0.564	kg/kg fuel (as received basis)	
AIR REQUIREMENTS			
Theoretical O_2 required:	62.82	moles/kg (DAF basis)	
Excess air:	61.02	%	
Total O_2 required:	101.15	moles/kg (DAF basis)	
Flue gas CO_2 content:	12.07	%vol dry	
Flue gas O_2 content:	8.00	%vol dry	
APPLIANCE DETAILS			
Power Output:	9400	kW	
Percentage of MCR:	64	%	
Effective power output:	6016	kW	
Efficiency:	65.00	%	Based on email comms from Deta 5 August 2020
As rcvd fuel CV:	14360	kJ/kg	Based on average GCV from June 2016 to January 2018
Equivalent Stack diameter:	2.00	m	Based on 2000 AEE
Heat produced by combustion:	9255	kW	
Heat loss:	3239	kW	
Maximum fuel burning rate:	0.64	kg/s (as received basis)	
	2.32	t/h (as received basis)	
STACK PROPERTIES			
Temperature:	503.15	K	Min Temp based on stack testing from 2013 to 2016
WET flow rate (POC sheet):	24.03	m³/kg DAF fuel	
Actual volumetric flow rate:	8.73	m³/s	
Stack x-sectional area:	3.14	m²	
Efflux velocity:	2.78	m/s	Used in the model
DRY flow rate @ STP (POC sheet):	10.75	Nm³/kg DAF fuel	
	3.91	Nm³/sec	
	14,062	Nm³/hour	
WET flow rate @ STP (POC sheet):	13.05	Nm³/kg DAF fuel	
	4.74	Nm³/sec	
	17,071	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

11 Aug 2020
1793285 - Babcock & Wilcox Boiler No. 2
64% MCR, 12% CO_2 standard operation

Parameter	Value	Unit	Comment / source of data
FUEL ULTIMATE ANALYSIS	New Vale		
Carbon:	69.44	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Hydrogen:	4.76	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Oxygen:	24.40	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Nitrogen:	0.60	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Sulphur:	0.80	%wt (DAF basis)	Assume max 0.45% wt as received
Fuel moisture content:	40.0	%wt (as received basis)	Average of coal analysis from Jun 2016 to Feb 2018
Ash content:	3.6	%wt (as received basis)	
DAF portion:	0.564	kg/kg fuel (as received basis)	
AIR REQUIREMENTS			
Theoretical O_2 required:	62.82	moles/kg (DAF basis)	
Excess air:	62.01	%	
Total O_2 required:	101.78	moles/kg (DAF basis)	
Flue gas CO_2 content:	12.00	%vol dry	
Flue gas O_2 content:	8.08	%vol dry	
APPLIANCE DETAILS			
Power Output:	9400	kW	
Percentage of MCR:	64	%	
Effective power output:	6016	kW	
Efficiency:	65.00	%	Based on email comms from Deta 5 August 2020
As rcvd fuel CV:	14360	kJ/kg	Based on min CV-AR from June 2016 to January 2018
Equivalent Stack diameter:	2.00	m	Based on 2000 AEE
Heat produced by combustion:	9255	kW	
Heat loss:	3239	kW	
Maximum fuel burning rate:	0.64	kg/s (as received basis)	
	2.32	t/h (as received basis)	
STACK PROPERTIES			
Temperature:	503.15	K	Min Temp based on stack testing from 2013 to 2016
WET flow rate (POC sheet):	24.15	m³/kg DAF fuel	
Actual volumetric flow rate:	8.78	m³/s	
Stack x-sectional area:	3.14	m²	
DRY flow rate @ STP (POC sheet):	10.81	Nm³/kg DAF fuel	
	3.93	Nm³/sec	
	14,150	Nm³/hour	
WET flow rate @ STP (POC sheet):	13.11	Nm³/kg DAF fuel	
	4.77	Nm³/sec	
	17,159	Nm³/hour	
EMISSION CALCULATIONS			
SO_2 emission rate (no ash retention):	5.80	g/s	
SO_2 emission rate (5% ash retention):	**5.51**	g/s	
	19.84	kg/hr	
NO_X emission factor:	2.90	kg/tonne	US-EPA AP42 Table 1.7-1 (5.8 lb/ton)
NO_X emission rate:	**1.87**	g/s	
PM10 concentration:	640	mg/m³ @ dry STP 12% CO2	Max. concentration based on stack testing from 2013 to 16
PM_{10} emission rate:	**2.52**	g/s	
PM_{10} emission rate:	9	kg/hr	
Assume PM2.5 concentration:	512	mg/m³ @ dry STP 12% CO2	Assume 80% PM10 is PM2.5
$PM_{2.5}$ emission rate:	**2.01**	g/s	
$PM_{2.5}$ emission rate:	7.24	kg/hr	

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

APPENDIX C

Stack Test Reports

Stack Testing Summary

	Consent limits	2001	2003	2005	2007	2009	2011	2013	2014	2015	2016
Stack Temp (^oC)		259	260	230	220	211	210	250	272	230	230
Stack Vel. (m/sec)		13.5	14.2	12	12	11.6	15.0	7.9	7.6	7.2	7.5
Actual Flow Rate (m^3/s)		27.6	29	19		17.45		13.8	12.45	12.4	
Dry Flow Rate (Nm^3/s)		13.3	13.5	9.2	9.3	9	12	6.6	5.7	6.2	5.9
TSP Conc. (mg/Nm^3 12 % CO2 dry STP)		714	579	900	960	410	280	390	420(1)	680	640
TSP Emission (kg/hr)	21	19	17.2	18	21	9.7	6.0	4.7	5.4	5.1	6.3
PM_{10} Conc. (mg/Nm^3 12 % CO2 dry STP)					300	270	220	320	255(2)	640(3)	600
PM_{10} Emission (kg/hr)	10				6.8	12	5	4	3.5	4.8	5.9
Percentage of PM_{10} (%)					32 %	43.8 %	81 %	92 %	82 %	94 %	93 %

Notes: (1) The TSP concentration of 280 mg/m^3 in the stack testing report was under 8 % CO_2 dry STP condition. The calculated concentration of 420 mg/m^3 was corrected to 12 % CO_2 dry STP condition. (2) The reported PM_{10} concentration of 170 mg/m^3 was under 8 % CO_2 dry STP condition. The calculated concentration of 255 mg/m^3 was corrected to 12 % CO_2 dry STP condition. (3) The PM_{10} concentration of 640 mg/m^3 is based on the averaged mass rate and 12 % CO_2 at dry STP condition flow.

APPENDIX D

Ambient Particulate Monitoring

1.0 AMBIENT PARTICULATE MONITORING

1.1 Overview

Ambient monitoring for PM_{10} and $PM_{2.5}$ have been completed by Alliance during 2018 at two locations. The first being the elevated terrain immediately to the east of the CFB 1 stack (i.e., at Hillcrest Avenue), which was undertaken to meet consent monitoring requirements and was reported by Golder (2018). The second monitoring programme was undertaken at the southern boundary of the Alliance site as shown in Figure 1.

1.2 Monitoring Periods and Locations

Ambient monitoring of particulate matter (PM_{10} and $PM_{2.5}$) concentrations was carried out at two sites in 2018.

This first monitoring station was located at the hillside approximately 200 m east of the main boiler and was accessed from Hillcrest Avenue. The location was chosen as it was predicted by the previous dispersion modelling reported by Montgomery Watson (2000) to be the highest impacted offsite location with respect to PM_{10} concentration. The Hillside monitoring programme was carried out by Golder (2018) over the period of 8 February to 26 March 2018.

The second monitoring site was located inside the Alliance property boundary, approximately 250 m south southwest of the main CFB 1 stack. The location was selected because the wind data from the first monitoring programme data showed a predominant wind direction from CFB 1 towards this location. The Southern boundary programme was undertaken by Golder over the period of 28 March to 4 July 2018.

During both the monitoring period, the site has confirmed that CFB1 operated at 30 % MCR from 3 am on Mondays to 2 am on Saturdays.

1.3 Monitoring Method

Ambient PM_{10} and $PM_{2.5}$ were measured simultaneously with a broadband spectroscopy-based instrument (T640x PM Mass Monitor). The equipment was installed and operated by Golder.

The Model T640x PM Mass Monitor is not included in Schedule 2 of New Zealand's National Air Quality Standards for Air Quality which defines the required methods for monitoring PM_{10}. However, this monitor has been approved by the United States Environmental Protection Agency (USEPA) as a Federal Equivalent Method to their reference method for the determination of particulate matter as PM_{10}.

This site-specific monitoring programme also included the meteorological parameters of wind speed and direction, temperature and relative humidity.

1.4 Monitoring Bias Adjustment

To account for any systematic bias in the monitoring method co-location study results for a trial operated by the Canterbury Regional Council (CRC) during September and October 2018 were used to establish a preliminary K-factor for Golder's T6040x unit. This co-location study compared the CRCs and Golder's T640 units to ambient PM_{10} and $PM_{2.5}$ measurements within the Timaru airshed against parallel results obtained from NES compliant methods - a TEOM and Partisol monitors.

The preliminary results of this study have been analysed and indicate K factors for Golders T640x unit for 24-hour average PM_{10} and $PM_{2.5}$ of 0.8 and 0.9 respectively.

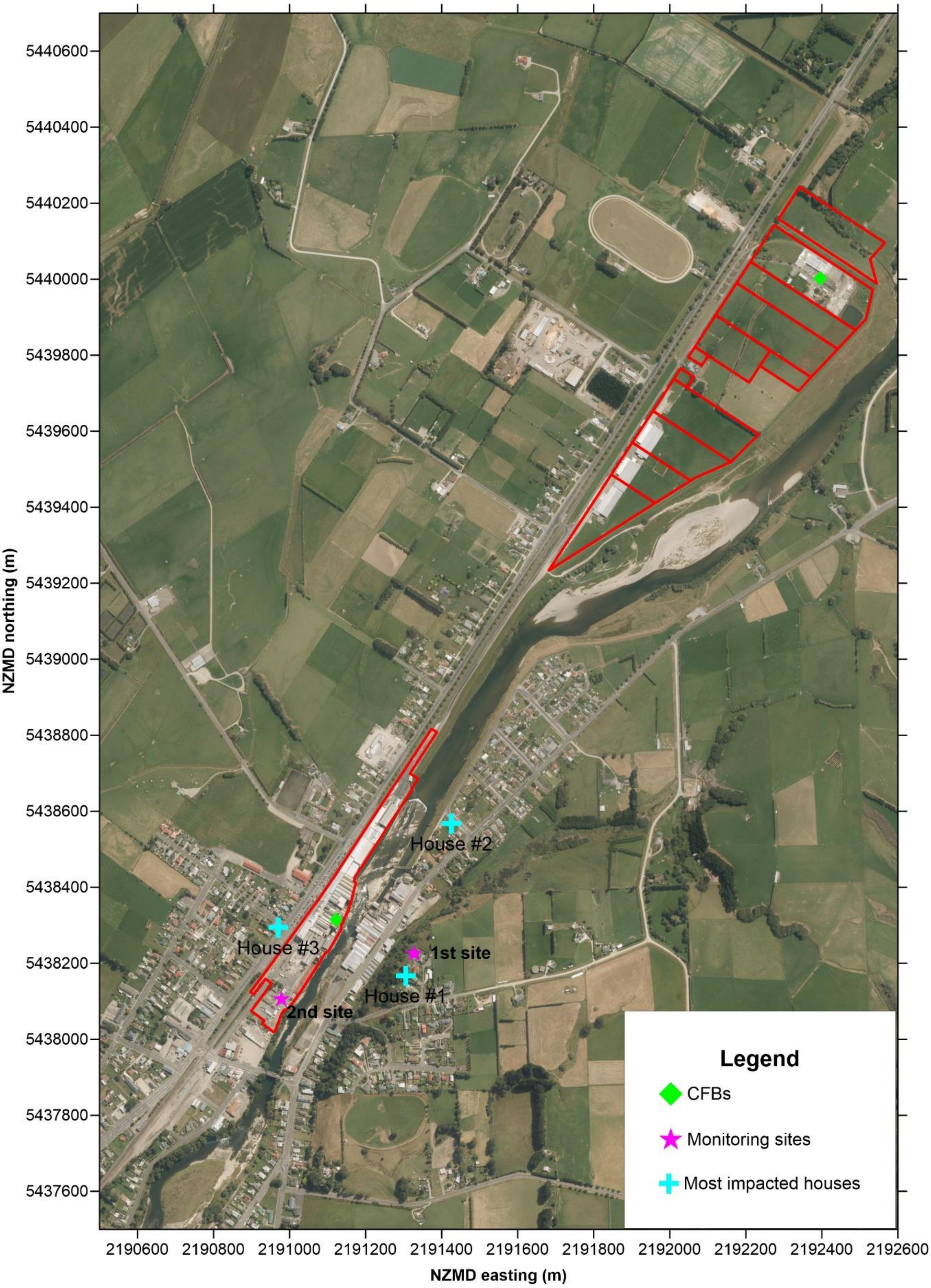


Figure 1: Alliance Mataura Site and Surrounds.

2.0 AMBIENT PARTICULATE MONITORING RESULTS

2.1 Cumulative Concentrations

Measured cumulative ambient concentrations of PM_{10} and $PM_{2.5}$ at the two ambient monitoring sites in Mataura are provided in Table 1 and Table 2. These levels are compliant with the NES for 24-hour average PM_{10} but not the WHO for 24-hour average $PM_{2.5}$.

The 50th percentile values for these colder months also provide an estimate of the long term average PM_{10} and $PM_{2.5}$ concentrations that would occur at these two sites during winter months.

Whilst the NES criteria are complied with, the ambient particulate levels measured at Alliance's southern site boundary are significantly elevated, such that they approach this key criteria. Further assessment and evaluation of the monitoring results in discussed below with respect to what extent the Alliance CFBs contribute to these elevated levels versus the contributions from background source and especially domestic home heating emissions.

A summary of the monitoring results from both programmes are provided in Table 1 and Table 2, Figure 2 and Figure 3.

Table 1: PM_{10} Percentiles (24 Hour Average) measured in Mataura during 2018.

Station	24-hour average PM_{10} concentration (µg/m³)						NES
	10th percentile	25th percentile	50th percentile	75th percentile	95th percentile	Max	(µg/m³)
Hillcrest Avenue*	5	7	11	12	15	19	50
Southern boundary#	8	12	16	23	32	46	50

Notes: * Measured from 8 February to 26 March 2018 (Golder 2018). # Measured from April-4 July 2018.

Table 2: $PM_{2.5}$ Percentiles (24 Hour Average) measured in Mataura during 2018.

Station	24-hour average $PM_{2.5}$ concentration (µg/m³)						WHO
	10th percentile	25th percentile	50th percentile	75th percentile	95th percentile	Max	(µg/m³)
Hillcrest Avenue	2	3	5	5	7	9	25
Southern boundary	4	7	10	15	23	33	25

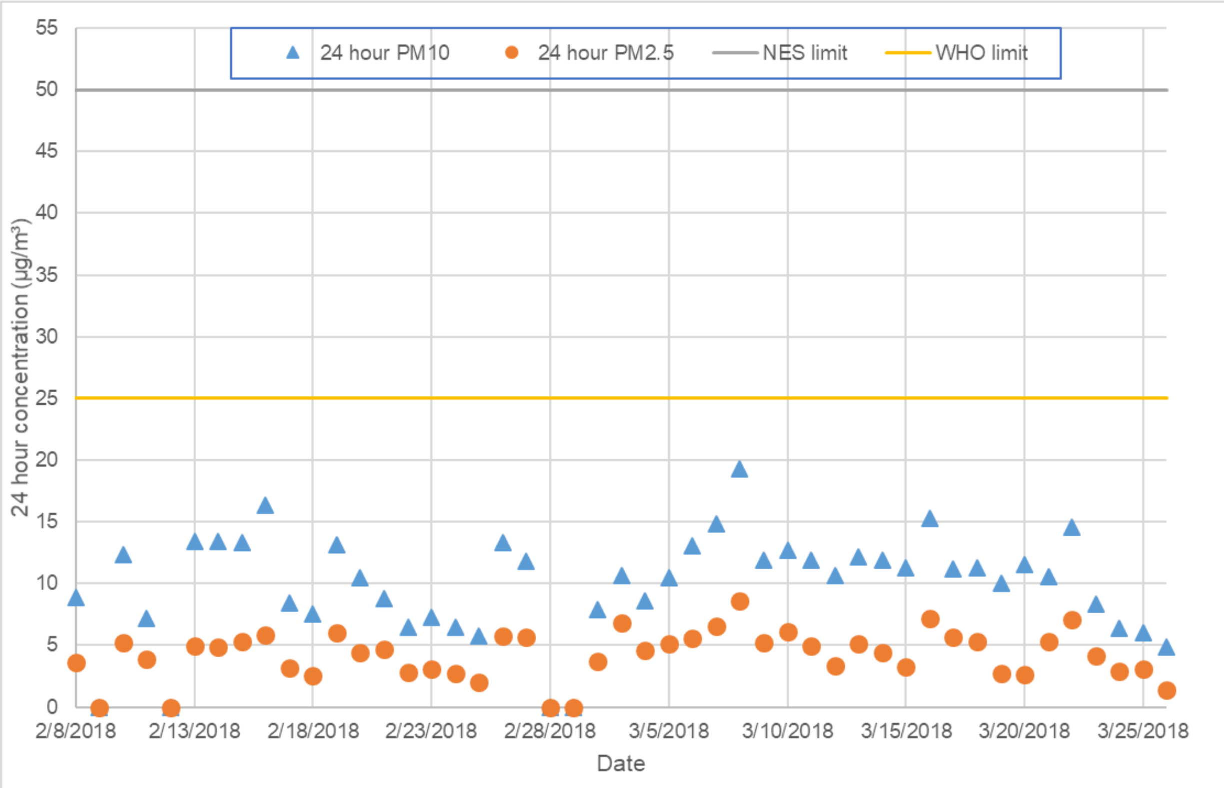


Figure 2: Hillcrest Avenue Monitoring station 24-hour average PM_{10} and $PM_{2.5}$ concentrations.

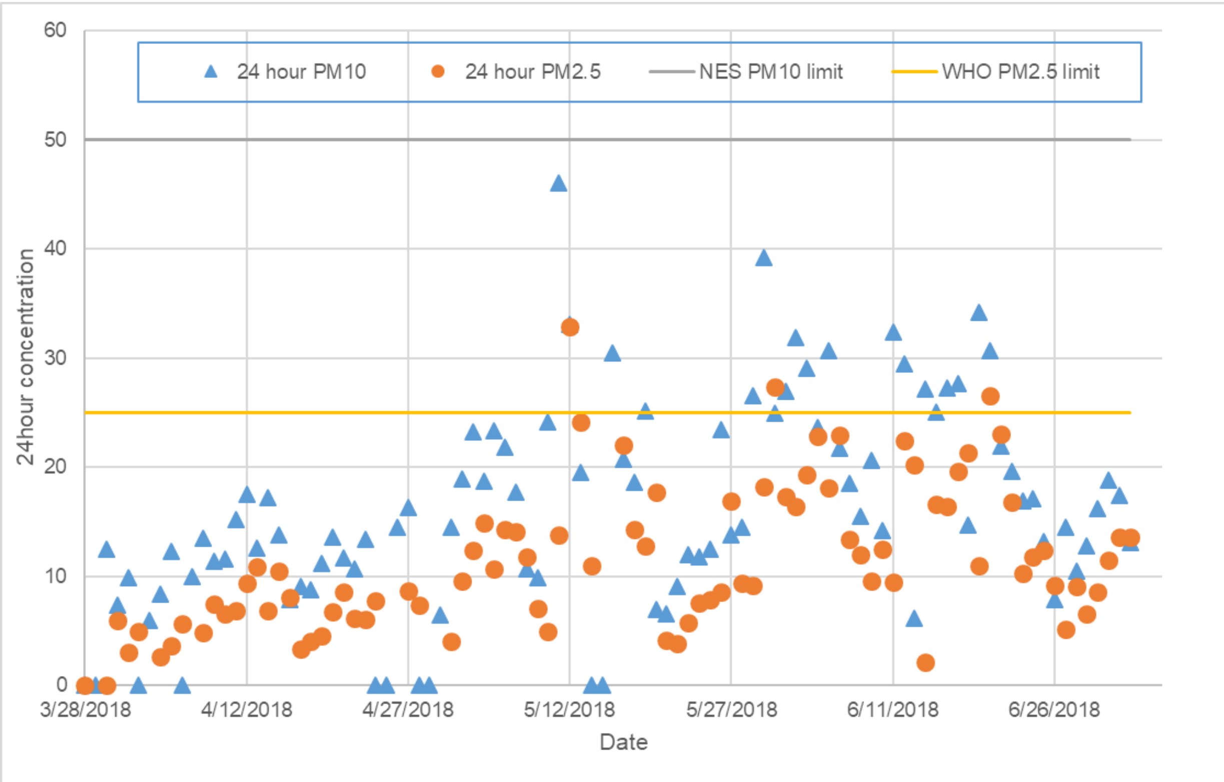


Figure 3: Southern Boundary Monitoring station 24-hour average PM_{10} and $PM_{2.5}$ concentrations.

3.0 ANALYSIS OF AMBIENT MONITORING

3.1 Background Concentrations

Background PM_{10} and $PM_{2.5}$ concentrations within Mataura township were established from the monitoring undertaken at the southern Alliance boundary. The background levels were segregated from cumulative results by analysing monitored data for every hour of each day for the 90 days of monitoring.

For the vast majority of days when the CFB 1 influenced the monitor for less than 12 hours, the hourly PM_{10} and $PM_{2.5}$ concentrations (not influenced by CFB 1) were collated and used to estimate the 24-hour background concentration for that day that has no CFB influence. This is considered to provide an accurate estimate of background concentrations for all 90 days of monitoring for April, May, June up to July 4th 2018 with the CFB 1 influenced removed and for a central location within Mataura.

The 90 days of estimated 24-hour background PM_{10} and $PM_{2.5}$ concentrations (mean values) were evaluated against daily average wind speed and temperature criteria so that appropriate background levels could be added to modelled ambient impacts due to the CFBs alone. Upper limits of mean values have been estimated at 75 % and 99 % confidence levels. The results of data analysis are provided in Table 3. And annual averages (based on percentage of time conditions occur) is provided in Table 4.

Table 3: Summary of estimated background 24-hour particulate versus weather conditions.

Daily weather category	Daily average wind speed (m/s)	Daily average temp.	Percentage of time conditions occur*	PM_{10} (24 hour) µg/m^3			$PM_{2.5}$ (24 hour) µg/m^3		
				Mean	Upper 75th confidence limit#	Upper 99th confidence limit**	Mean	Upper 75th confidence limit	Upper 99th confidence limit
A	<2	<5 °C	2 %	24	29	38	17	21	29
B	<2	≥5 °C	9 %	20	22	26	13	15	18
C	≥2 and <3	all	25 %	13	13	15	8	9	9
D	≥3	all	64 %	11	12	14	6	7	8

Note: *Based on annual CALMET meteorological dataset for 2003. # Upper 75th confidence limit = upper estimate of mean at 75 % confidence. **Upper 99th confidence limit = upper estimate of mean at 99 % confidence.

Table 4: Summary of estimated background annual particulate.

Location in Mataura	PM_{10} (annual) µg/m^3	$PM_{2.5}$ (annual) µg/m^3
	Mean	Mean
Township	12	7
Hill top areas	10	4

The results in Table 3 are likely to be applicable to the assessment of cumulative impacts of PM_{10} and $PM_{2.5}$ that is discharged from the CFBs and background levels for receptors on raised terrain to the east of the site. These hilltop receptors are likely to be downwind of the CFBs during relatively windy conditions, as such the background concentrations in Table 3 for days of moderate to strong wind are likely to apply, whereas elevated levels due to cold still days in Mataura township are not likely to be applied.

The results in Table 3 were also used to estimate realistic annual average PM_{10} and $PM_{2.5}$ concentrations when also utilising the site specific meteorological data set (as used for the dispersion modelling assessment).

The year of met-data was used to confirm the frequency of occurrence throughout the year of the daily weather categories specified in Table 3. These frequencies were used to calculate annual average background concentrations of PM_{10} and $PM_{2.5}$ by summing weighted background concentrations in Table 3 in accordance to the frequency of their associated daily averaged weather conditions. This would provide a realistic (albeit conservative) estimate of the annual average PM_{10} and $PM_{2.5}$ concentrations that are likely to occur in Mataura Township.

Based on the percentage of time that the meteorological conditions occur, the resultant annual average background concentration for Mataura township is 12 µg/m^3 and 7 µg/m^3 respectively for PM_{10} and $PM_{2.5}$ respectively. For annual average impacts on the hilltop area of Mataura, the estimated annual average concentrations for Mataura are likely to be too conservative and there the average of monitoring results from the Hillcrest monitoring site was instead used for this assessment. From Table 4 and Table 5 these annual average values are 10 µg/m^3 and 4 µg/m^3 respectively for PM_{10} and $PM_{2.5}$ respectively.

3.2 Coal fired Boiler Contributions

Incremental impacts of PM_{10} and $PM_{2.5}$ ambient concentrations due to CFB 1 emissions were estimated using the established background levels at the southern Alliance boundary monitoring site. Background concentrations and total cumulative measured PM_{10} concentrations are shown in Figure 4. Background concentrations were established as described in Section 3.1 with all values used (i.e., no exclusions for days when non CFB wind directions were less than 12 hours of the day). On occasions, the background only concentrations are higher than the measured concentrations. This is because there were periods during those days when the wind was blowing from the direction of the boiler stack the concentrations were lower than those observed when the wind was not blowing from the direction of the boiler. Ranked values are shown in Table 5.

Therefore, it is concluded that the background from the direction of the boiler is variable and can be lower than the background from other directions. This is more apparent for upper ranks compared to concentrations below approximately rank 20.

To determine the incremental impact of the CFB 1 emissions upon monitored cumulative concentrations requires the subtracting the 24-hour average background concentration from the measured cumulative 24-hour PM_{10} and concentrations for any one day. The analysis of the monitoring data revealed that this assumption was not valid for the days that recorded the higher ranked impacts. However, it is still considered valid to days of recorded 24-hour PM_{10} and $PM_{2.5}$ concentrations that were the 20th rank or lower.

From reviewing the data in Table 5, with the exception of the maximum measured concentration of 46 µg/m^3, the maximum increment the boiler contributes to 24-hour PM_{10} is 9 ug/m^3. For the maximum concentration of 46 µg/m^3, it is uncertain what the background is, but the boiler is most likely to have been the major contributor to this.

From reviewing the data in Table 5, with the exception of the maximum measured concentration of 33 µg/m³, the maximum increment the boiler contributes to 24-hour $PM_{2.5}$ is 6 ug/m³. For the maximum concentration of 33 µg/m³, it is uncertain what the background is, but the boiler is most likely to have been the major contributor to this.

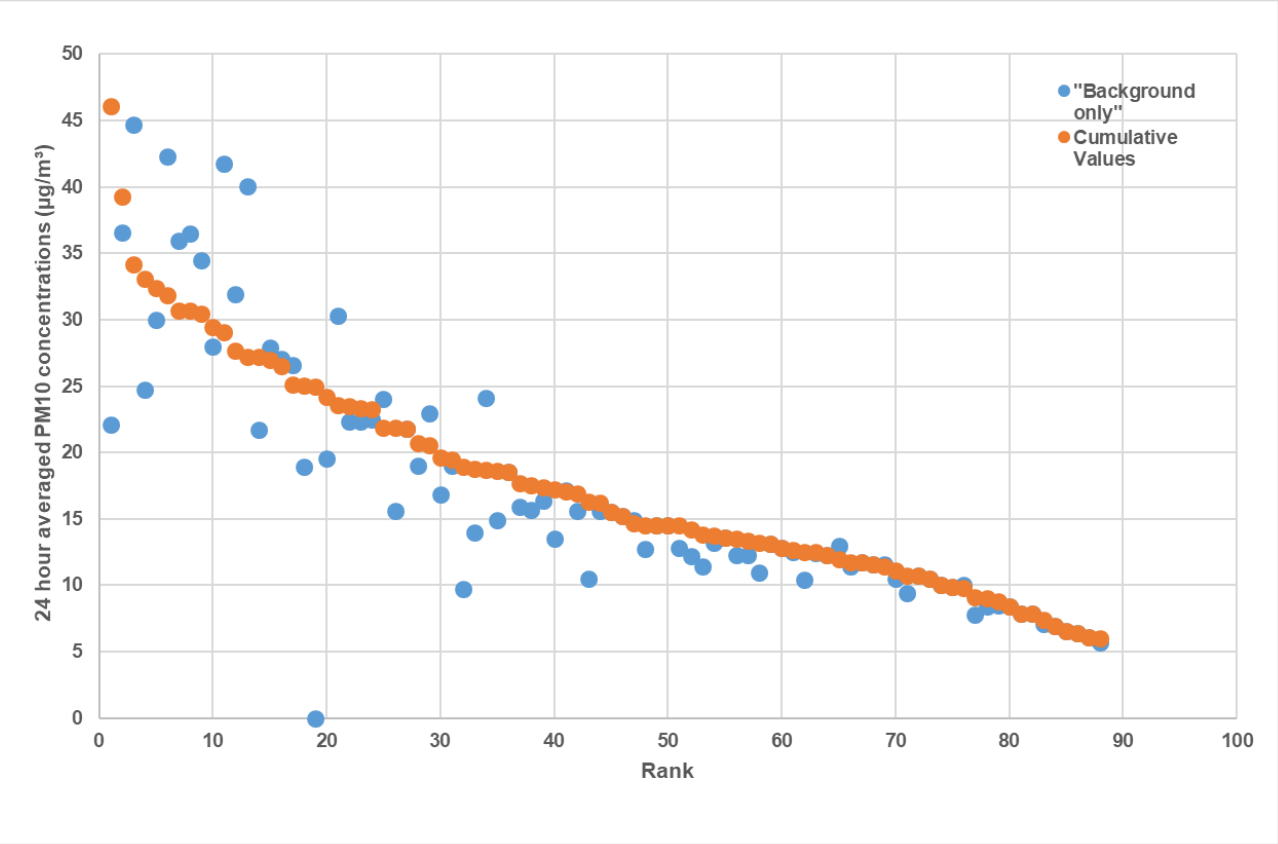


Figure 4: Measured PM_{10} concentrations by rank with background only contributions also shown.

3.3 $PM_{2.5}/PM_{10}$ Ratio

The measured cumulative concentration, boiler contributions and background concentrations were also reviewed to estimate the $PM_{2.5}/PM_{10}$ ratio. Background concentrations were established as described in Section 2.1. Boiler contributions were derived from subtracting the 24-hour average background concentration from the measured cumulative 24-hour PM_{10}. Their respective $PM_{2.5}/PM_{10}$ ratios are shown in Table 5.

A maximum ratio of 0.8 and an average ratio of 0.6 are observed for both cumulative and background concentrations. Particularly for those days when the boiler was upwind of the monitor for over 12 hours per day, the ratio for cumulative concentrations is in a range of 0.6 to 0.8 with an average ratio of 0.7. This is consistent with the average ratio of 0.7 that were calculated for the boiler contribution only. It confirms that using the maximum ratio of 0.8 is considered to be appropriate and conservative to estimate $PM_{2.5}$ effects from the boiler.

Table 5: Ranked PM_{10} and $PM_{2.5}$ concentrations.

Rank	Date	24-hour average PM_{10}			24-hour average $PM_{2.5}$			Hours from boiler	$PM_{2.5}$/ PM_{10} Ratio		
		Total	Back-ground only	Boiler only*	Total	Back-ground only	Boiler only*		Total	Back-ground only	Boiler only
1	Thursday 10/05/18	46.1	22		33	12		23	0.71	0.55	0.9
2	Tuesday 29/05/18	39.3	37		27	26		6	0.70	0.70	0.7
3	Monday 18/06/18	34.2	45		27	35		10	0.78	0.79	
4	Friday 11/05/18	33.1	25		24	18		8	0.73	0.72	0.8
5	Sunday 10/06/18	32.4	30		22	20		5	0.69	0.68	0.9
6	Friday 1/06/18	31.9	42		19	25		15	0.61	0.58	
7	Tuesday 19/06/18	30.7	36		23	27		7	0.75	0.76	
8	Monday 4/06/18	30.7	36		23	28		15	0.75	0.76	
9	Tuesday 15/05/18	30.4	34		22	25		11	0.72	0.73	
10	Monday 11/06/18	29.4	28		20	19		4	0.69	0.69	0.7
11	Saturday 2/06/18	29.0	42		23	33		15	0.79	0.79	
12	Saturday 16/06/18	27.7	32		21	24		17	0.77	0.76	
13	Friday 15/06/18	27.2	40		20	30		22	0.72	0.75	
14	Wednesday 13/06/18	27.2	22		17	13		9	0.61	0.58	0.7
15	Thursday 31/05/18	27.0	28		16	11		18	0.61	0.40	
16	Monday 28/05/18	26.5	27		18	19		2	0.69	0.69	
17	Friday 18/05/18	25.1	27		18	19		4	0.71	0.71	

Rank	Date	24-hour average PM_{10}			24-hour average $PM_{2.5}$			Hours from boiler	$PM_{2.5}$/ PM_{10} Ratio		
		Total	Back-ground only	Boiler only*	Total	Back-ground only	Boiler only*		Total	Back-ground only	Boiler only
18	Thursday 14/06/18	25.0	19		16	11		15	0.66	0.56	1.0
19	Wednesday 30/05/18	25.0	0		17	0		24	0.69		0.7
20	Wednesday 9/05/18	24.2	20	5	14	10	4	6	0.57	0.51	0.8
21	Sunday 3/06/18	23.6	30	-7	18	23	-5	18	0.77	0.77	
22	Friday 25/05/18	23.5	22	1	17	16	1	6	0.72	0.72	0.6
23	Friday 4/05/18	23.4	22	1	14	13	1	14	0.61	0.59	1.1
24	Wednesday 2/05/18	23.2	23	1	15	14	1	7	0.64	0.64	0.7
25	Wednesday 20/06/18	21.9	24	-2	17	19	-2	8	0.77	0.78	
26	Saturday 5/05/18	21.9	16	6	14	10	4	19	0.64	0.67	0.6
27	Tuesday 5/06/18	21.8	22	0	13	14	0	9	0.62	0.64	
28	Wednesday 16/05/18	20.7	19	2	14	13	1	9	0.69	0.71	0.5
29	Friday 8/06/18	20.6	23	-2	13	14	-1	13	0.61	0.60	
30	Thursday 21/06/18	19.6	17	3	10	10	0	2	0.53	0.61	
31	Saturday 12/05/18	19.5	19	1	11	11	0	6	0.56	0.57	0.3
32	Tuesday 1/05/18	18.9	10	9	12	6	6	10	0.66	0.61	0.7
33	Saturday 30/06/18	18.8	14	5	14	9	4	21	0.72	0.67	0.9
34	Thursday 3/05/18	18.7	24	-5	11	15	-4	19	0.57	0.60	
35	Thursday 17/05/18	18.6	15	4	13	10	3	3	0.69	0.66	0.8

Rank	Date	24-hour average PM_{10}			24-hour average $PM_{2.5}$			Hours from boiler	$PM_{2.5}$/ PM_{10} Ratio		
		Total	Back-ground only	Boiler only*	Total	Back-ground only	Boiler only*		Total	Back-ground only	Boiler only
36	Wednesday 6/06/18	18.6	19	0	12	12	0	0	0.64	0.64	
37	Sunday 6/05/18	17.7	16	2	12	11	1	5	0.67	0.67	0.6
38	Wednesday 11/04/18	17.5	16	2	11	9	1	4	0.62	0.60	0.8
39	Sunday 1/07/18	17.4	16	1	14	13	1	6	0.78	0.78	0.7
40	Friday 13/04/18	17.2	14	4	10	8	3	3	0.61	0.56	0.8
41	Saturday 23/06/18	17.1	17	0	12	14	-1	23	0.72	0.80	
42	Friday 22/06/18	16.9	16	1	12	11	1	8	0.69	0.68	0.9
43	Thursday 26/04/18	16.3	10	6	7	5	2	6	0.45	0.50	0.4
44	Friday 29/06/18	16.2	16	1	11	11	1	5	0.71	0.70	0.9
45	Thursday 7/06/18	15.5	16	0	10	10	0	0	0.62	0.62	
46	Tuesday 10/04/18	15.2	15	0	9	9	0	0	0.62	0.62	
47	Sunday 17/06/18	14.6	15	0	11	11	0	11	0.75	0.74	
48	Monday 30/04/18	14.5	13	2	10	8	1	3	0.66	0.66	0.6
49	Tuesday 26/06/18	14.5	15	0	9	9	0	0	0.62	0.62	
50	Sunday 27/05/18	14.5	14	0	9	9	0	0	0.63	0.63	
51	Wednesday 25/04/18	14.5	13	2	9	8	1	11	0.60	0.63	0.4
52	Saturday 9/06/18	14.2	12	2	9	9	1	12	0.67	0.70	0.5
53	Saturday 14/04/18	13.8	11	2	8	6	2	7	0.59	0.54	0.8

Rank	Date	24-hour average PM_{10}			24-hour average $PM_{2.5}$			Hours from boiler	$PM_{2.5}$/ PM_{10} Ratio		
		Total	Back-ground only	Boiler only*	Total	Back-ground only	Boiler only*		Total	Back-ground only	Boiler only
54	Saturday 26/05/18	13.8	13	1	9	9	1	3	0.68	0.67	0.9
55	Thursday 19/04/18	13.5	14	0	9	9	0	0	0.63	0.63	
56	Saturday 7/04/18	13.5	12	1	7	6	1	5	0.55	0.52	0.8
57	Sunday 22/04/18	13.4	12	1	8	7	1	2	0.58	0.56	0.9
58	Sunday 24/06/18	13.2	11	2	9	8	2	8	0.69	0.69	0.7
59	Monday 2/07/18	13.1	13	0	9	9	0	0	0.66	0.66	
60	Thursday 28/06/18	12.8	13	0	9	9	0	0	0.67	0.67	
61	Thursday 12/04/18	12.6	13	0	7	7	0	5	0.54	0.53	1.9
62	Thursday 29/03/18	12.5	10	2	6	5	1	9	0.48	0.49	0.4
63	Thursday 24/05/18	12.5	12	0	9	9	0	4	0.68	0.70	
64	Wednesday 4/04/18	12.3	12	0	6	6	0	0	0.46	0.46	
65	Tuesday 22/05/18	11.9	13	-1	8	9	-2	9	0.63	0.71	
66	Wednesday 23/05/18	11.7	11	0	8	8	0	2	0.67	0.69	0.1
67	Friday 20/04/18	11.7	12	0	6	6	0	0	0.53	0.53	
68	Monday 9/04/18	11.6	12	0	7	7	0	0	0.59	0.59	
69	Sunday 8/04/18	11.4	12	0	7	7	0	8	0.58	0.61	
70	Wednesday 18/04/18	11.1	11	1	7	6	0	2	0.61	0.62	0.5
71	Monday 7/05/18	10.7	9	1	7	6	1	0	0.66	0.66	0.7

Rank	Date	24-hour average PM_{10}			24-hour average $PM_{2.5}$			Hours from boiler	$PM_{2.5}$/ PM_{10} Ratio		
		Total	Back-ground only	Boiler only*	Total	Back-ground only	Boiler only*		Total	Back-ground only	Boiler only
72	Saturday 21/04/18	10.7	11	0	6	6	0	0	0.56	0.56	
73	Wednesday 27/06/18	10.5	10	0	7	7	0	0	0.62	0.62	
74	Friday 6/04/18	10.0	10	0	5	5	0	0	0.49	0.49	
75	Tuesday 8/05/18	9.9	10	0	5	5	0	0	0.50	0.50	
76	Saturday 31/03/18	9.8	10	0	5	5	0	3	0.50	0.49	
77	Monday 21/05/18	9.1	8	1	6	5	1	2	0.64	0.64	0.6
78	Monday 16/04/18	9.0	8	1	4	4	0	8	0.45	0.47	0.2
79	Tuesday 17/04/18	8.8	9	0	5	5	0	5	0.52	0.56	
80	Tuesday 3/04/18	8.4	8	0	4	4	0	0	0.43	0.43	
81	Sunday 15/04/18	7.8	8	0	3	3	0	4	0.42	0.41	
82	Monday 25/06/18	7.8	8	0	5	5	0	0	0.65	0.65	
83	Friday 30/03/18	7.4	7	0	3	3	0	7	0.41	0.39	1.0
84	Saturday 19/05/18	7.0	7	0	4	4	0	0	0.60	0.60	
85	Sunday 20/05/18	6.6	7	0	4	4	0	1	0.58	0.58	0.5
86	Sunday 29/04/18	6.4	6	0	4	4	0	0	0.63	0.63	
87	Tuesday 12/06/18	6.1	6	0	2	2	0	0	0.35	0.35	
88	Monday 2/04/18	6.0	6	0	3	2	0	11	0.44	0.44	0.4

Notes: *Boiler only = total – background concentrations.

APPENDIX E

Nitrogen Oxide Conversion Rate Regime

1.0 INTRODUCTION

One of the important primary pollutants from combustion activities is NO_X. NO_X refers to the sum of the two most common oxides of nitrogen, namely nitric oxide (NO) and nitrogen dioxide (NO_2). The contaminant of concern for potential human health effects is NO_2. However, the relative proportions of NO and NO_2 in a discharge plume change from their original amounts with distance downstream. This Appendix describes a method for diagnosing NO_2 from the total NO_X, as a post-processing step, to provide modelled ground-level concentrations (GLCs) of NO_2.

2.0 METHOD

The modelled NO_X has been post-processed using a method described by Janssen et al. (1988), which gives the ratio of NO_2 to NO_X as a function of distance from the source. The function was derived empirically from measurements of NO, NO_2 and ozone (O_3) in stack plumes of Dutch power plants over a period of 10 years. Janssen et al. (1988) found that NO to NO_2 oxidation in power plant plumes could be described approximately by the relationship given in Equation 1.

$$[NO_2]/[NO_X] = A(1-\exp(-\alpha x)) \qquad \text{Equation 1}$$

In Equation 1, $[NO_2]$ and $[NO_X]$ are the volume mixing ratios, or concentrations (as NO_2), of NO_2 and NO_X. The non-dimensional parameter, *A*, is referred to as the 'ozone' parameter, and α is the 'wind' parameter. The downwind distance is denoted by *x*.

Encapsulated in *A* is the oxidation of NO to NO_2 in the presence of O_3 and the photolysis of NO_2 by sunlight (to re-form NO). The wind parameter,α, also depends on $[O_3]$, and it implicitly converts reaction rates to a downwind distance scale, using the wind speed at the plume height. If *x* is in km, α is in units of 1/km.

The Janssen et al. method has been used for NO_X plumes from the proposed generator because chemical equilibrium will not have been reached close to the site. Alternative methods such as the ozone-limiting method would assume that oxidation from NO to NO_2 was complete, and would over-estimate the NO_2 near to the source. Also, the availability of O_3 would be reduced, due to the time required for atmospheric mixing processes to replace O_3 consumed by the oxidation reaction.

Janssen et al. (1988) placed no lower limit on the downwind distance, and Equation (1) gives zero $[NO_2]$ at the source (where *x*=0). This is not realistic, as measurements of $[NO_2]/[NO_X]$ in gas turbine power station stacks in New Zealand indicate the fraction may be up to 20 %, and measurements of $[NO_2]/[NO_X]$ in boilers indicate the fraction may be up to 10 %. For the boiler, NO_2 is conservatively assumed to comprise approximately 10 % of total NO_X at the discharge point. Then, a reasonable variation of Equation 1 is that given in Equation 2.

$$[NO_2]/[NO_X] = 0.1 + 0.8A(1 - exp(-\alpha x)) \qquad \text{Equation 2}$$

The values of *A* and α depend on ambient ozone levels, incoming solar radiation and wind speed. These empirical relationships, originally developed in the Netherlands, are shown in Table 1, Table 2 and Table 3. It has been assumed that the relationships also apply in New Zealand. The following section describes the use of ambient measurements to determine values of *A* and α suitable for the proposed site. These have been used in the main body of the report to post-process modelled NO_X to provide estimates of NO_2 ground-level concentrations around the plant.

Table 1: Values for *A* and α in winter (solar radiation up to 400 W/m²).

Ozone background concentration	Wind speed at plume height < 5 m/s	Wind speed at plume height 5 m/s to 15 m/s	Wind speed at plume height > 15 m/s
120 – 200 ppb			
60 – 120 ppb			
40 – 60 ppb			
30 – 40 ppb	A = 0.87; α = 0.07	A = 0.87; α = 0.07	A = 0.87; α = 0.15
20 – 30 ppb	A = 0.83; α = 0.07	A = 0.83; α = 0.07	A = 0.83; α = 0.10
10 – 20 ppb	A = 0.74; α = 0.07	A = 0.74; α = 0.07	A = 0.74; α = 0.07
0 – 10 ppb	A = 0.49; α = 0.05	A = 0.49; α = 0.05	A = 0.49; α = 0.05

Table 2: Values for *A* and α in spring or autumn (solar radiation up to 1200 W/m²).

Ozone background concentration	Wind speed at plume height < 5 m/s	Wind speed at plume height 5 m/s to 15 m/s	Wind speed at plume height > 15 m/s
120 – 200 ppb			
60 – 120 ppb			
40 – 60 ppb	A = 0.85; α = 0.10	A = 0.85; α = 0.15	A = 0.85; α = 0.30
30 – 40 ppb	A = 0.80; α = 0.10	A = 0.80; α = 0.10	A = 0.80; α = 0.25
20 – 30 ppb	A = 0.74; α = 0.10	A = 0.74; α = 0.10	A = 0.74; α = 0.15
10 – 20 ppb	A = 0.635; α = 0.10	A = 0.635; α = 0.10	A = 0.635; α = 0.10
0 – 10 ppb			

Table 3: Values for *A* and α in summer (solar radiation up to 1800 W/m²).

Ozone background concentration	Wind speed at plume height < 5 m/s	Wind speed at plume height 5 m/s to 15 m/s	Wind speed at plume height > 15 m/s
120 – 200 ppb	A = 0.93; α = 0.40	A = 0.93; α = 0.65	A = 0.93; α = 0.80
60 – 120 ppb	A = 0.88; α = 0.20	A = 0.88; α = 0.35	A = 0.88; α = 0.45
40 – 60 ppb	A = 0.81; α = 0.15	A = 0.81; α = 0.25	A = 0.81; α = 0.35
30 – 40 ppb	A = 0.74; α = 0.10	A = 0.74; α = 0.15	A = 0.74; α = 0.25
20 – 30 ppb	A = 0.67; α = 0.10	A = 0.67; α = 0.10	A = 0.67; α = 0.10
10 – 20 ppb			
0 – 10 ppb			

3.0 DETERMINATION OF THE OZONE AND WIND PARAMETERS

As described above, the ozone and wind parameters, *A* and α, depend on ambient ozone, wind speed and solar radiation. They are determined from measurements presented in the following sections.

Ambient Ozone Concentrations

Baseline surface O_3 concentrations in New Zealand have been monitored at Baring Head, near Wellington, since 1991. Figure 1 shows hourly ozone concentrations at that site in 2008 - 2010, under baseline conditions (wind direction from the sea, direction between 150° and 210°, and speed greater than 5 m/s). There is a marked seasonal cycle, with minimum values of 10 - 20 ppb during the summer (days 335 to 365, and days 1 to 59) and maximum values of 25 - 35 ppb in the winter (days 152 to 243). Spring and autumn values are about 20 - 30 ppb. Under baseline conditions there is a relatively narrow range of ozone concentrations; the southerly winds are from the ocean, where the ozone destruction processes are slow.

Based on the ambient O_3 data, concentrations of 20 ppb in summer, 30 ppb in spring and autumn, and 35 ppb in winter have been used to look up parameter values in Table 1, Table 2 and Table 3.

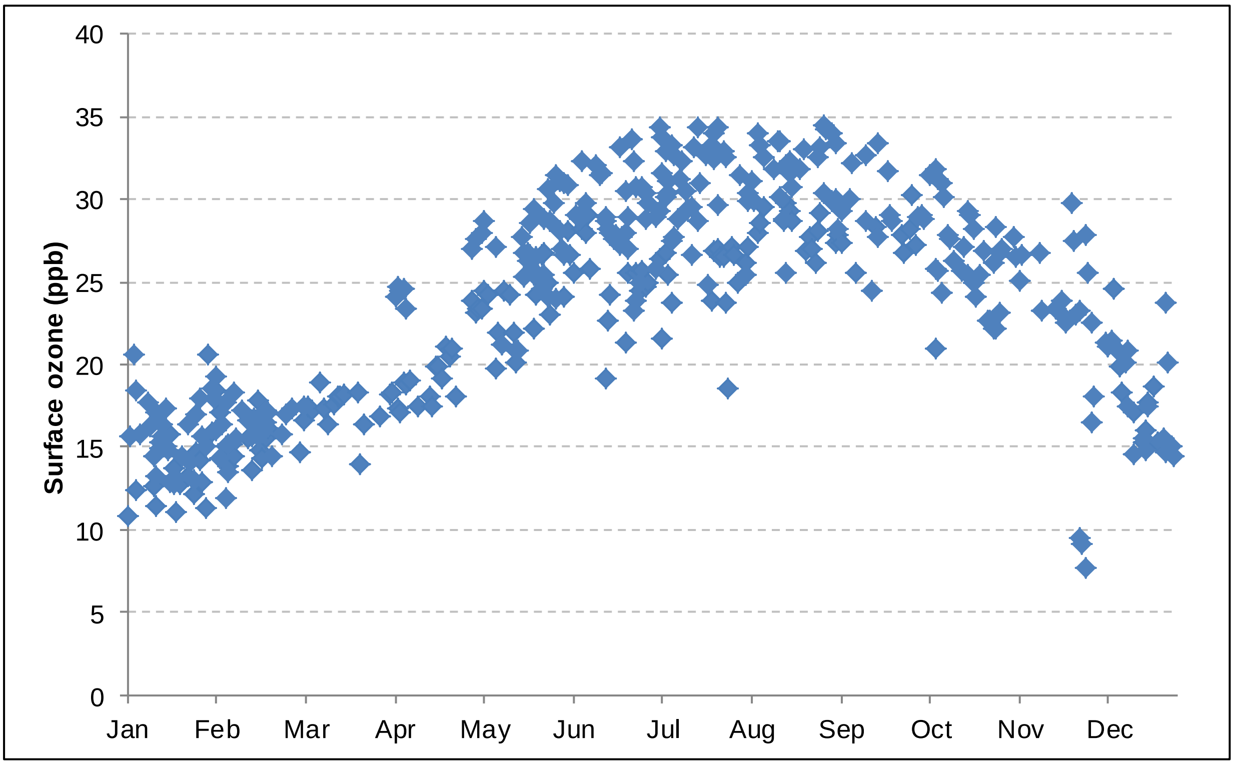


Figure 1: Daily average of surface ozone at Baring Head for 1 Jan 2008 to 1 Jan 2011 (NIWA).

Solar Radiation Data

Table 1, Table 2 and Table 3 provide seasonally-varying parameter values under incoming solar radiation rates of 400 W/m^2, 1200 W/m^2 and 1800 W/m^2 respectively. The ultraviolet solar radiation alters the chemical equilibrium between NO and NO_2 by dissociation of NO_2 molecules to re-form NO, and (through sensible heating at the surface) affects atmospheric mixing and dispersion. Parameters *A* and α have been used based on solar radiation levels experienced in Darfield, approximately 1.5 km to the west-southwest of the site's Area 2.

Figure 2 shows the maximum solar radiation rate at Darfield Electronic Weather Station (EWS) for each day from January 2007 to December 2010 (data publicly available and obtained from the National Climate Database and supplied by NIWA). This is expected to be conservative for the site. The solar flux rates show a variation over the year, from about 1,200 W/m^2 in summer to about 400 W/m^2 in winter.

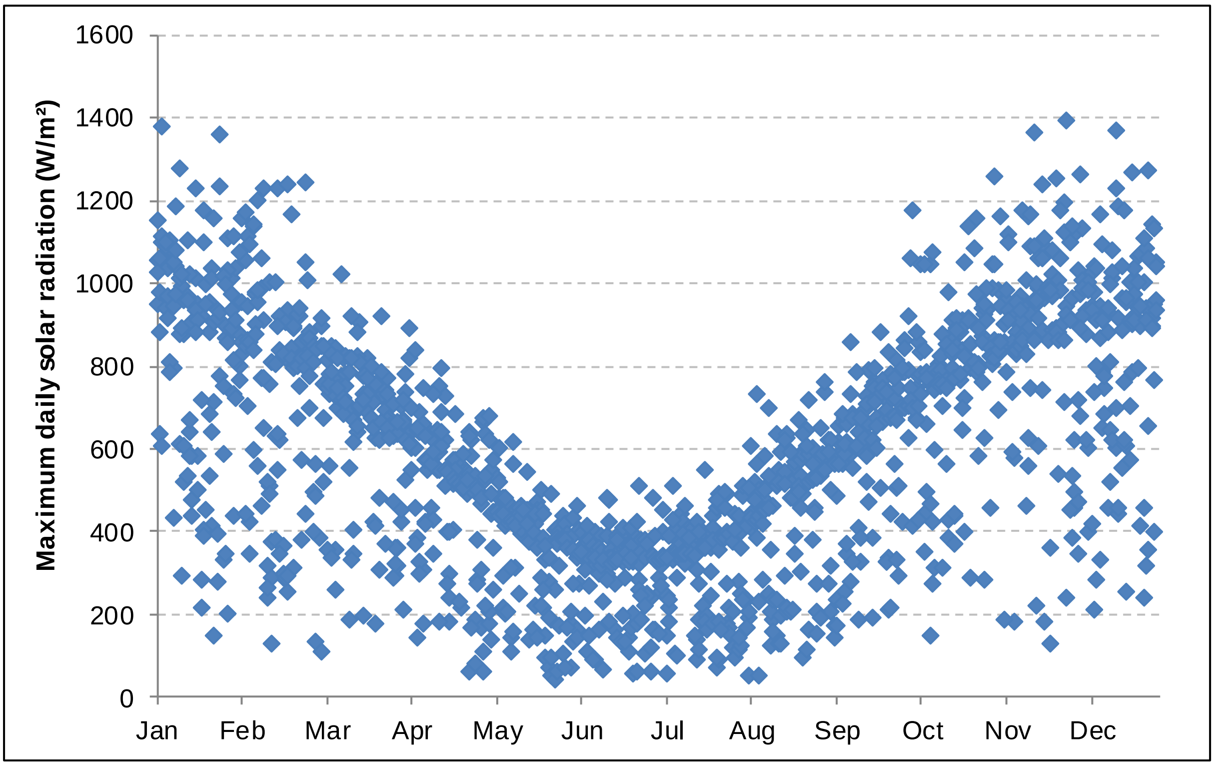


Figure 2: Maximum daily solar radiation at Darfield EWS for January 2007 to December 2010.

4.0 CONCLUSION

Suitable values of *A* and α have been selected from Table 1, Table 2 and Table 3, based on observed incoming solar radiation in Darfield and baseline O_3. These are shown in Table 4.

Table 4: Values of parameters *A* and α from the Janssen et al. method.

Season	O_3 (ppb)	Solar radiation (W/m^2)	Ozone parameter (*A*)	Wind parameter (α, 1/km)	Table number
Summer	20	1,200	0.635	0.1	Table 2
Autumn/Spring	30	700	0.83	0.07 – 0.1	Table 1
Winter	35	400	0.87	0.07 – 0.15	Table 1

For a conservative prediction of NO_2, the highest value of *A* and the highest value of α in Table 4 have been used in the dispersion modelling. These are 0.87 and 0.15, respectively. The ratio of $[NO_2]$ to $[NO_X]$ is then given in Equation 3:

$$[NO_2]/[NO_X] = 0.1 + 0.696(1 - exp(-0.15x)) \quad \text{Equation 3}$$

5.0 REFERENCES

Janssen LHJM, Van Wakeren JHA, Van Duren H and Elshout AJ 1988. A Classification of NO Oxidation Rates in Power Plant Plumes Based on Atmospheric Conditions. *Atmospheric Environment.* 22, No 1, 1988, pp 43-53.

NIWA 2013. Baring Head Atmospheric Ozone data. Sylvia Nichol, Gordon Brailsford, and Mike Harvey. http://www.niwa.co.nz/atmosphere/our-data/trace-gases. Accessed Aug 2013.

APPENDIX F

CALMET Modelling Set Up

1.0 INTRODUCTION

CALMET meteorological fields were generated for use with the CALPUFF model using a multi-stage process. This involved the use of hourly upper-air profiles from the prognostic model, TAPM, the setup from which is described in Section 3.0 below. This is considered by Golder to be preferable to using only the 12-hourly measurements above Invercargill as the radiosonde profiles are only measured every 12 hours.

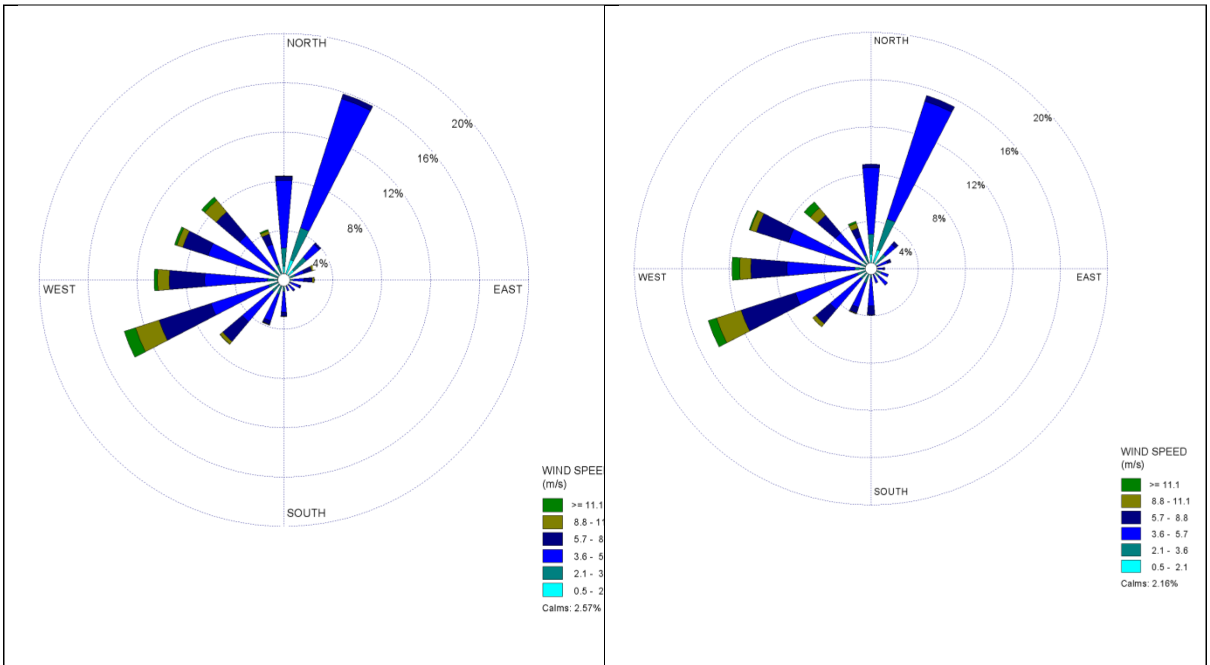
The multi-stage process is described in detail by Gimson *et al.* (2010). TAPM was run over New Zealand on a set of nested grids, with the highest resolution over Southland. Vertical profiles were extracted from its three-dimensional, hourly outputs, coinciding with several surface-based monitoring sites, with an extra profile location away from surface sites. The configuration of TAPM used here and a discussion of its performance are contained in Section 3.0 of this Appendix. An 'initial' CALMET run was based on available surface data and the single TAPM sounding, in which profiles above the surface sites were calculated by CALMET. The CALMET and TAPM site-based vertical profiles were blended so as to produce a gradual change from the CALMET profiles near the surface to the TAPM profiles aloft, thereby generating new profiles. This was done to avoid sudden changes in wind patterns, which can result in an unrealistic "bulls-eye" effect in the resulting wind fields. The new profiles were then treated as observations in an 'intermediate' CALMET run. The initial and intermediate CALMET runs cover the same area as TAPM's 3-km grid (the finest), but on a 1-km grid.

A 'final' CALMET run was then carried out at 50 m horizontal resolution. This was done over a sub-region containing the town of Mataura and the surrounding hills. The 'final' CALMET run used the 'intermediate' run for an initial estimate of the meteorological fields, as none of the surface sites are in the 50 m domain (the closest monitoring sites are in Edendale and Gore).

The following sections of this Appendix discuss the choice of year to model (Section 2.0), and describe the configurations of TAPM (Section 3.0) and CALMET (Section 4.0).

2.0 AVAILABLE METEOROLOGICAL DATA AND MODEL YEAR SELECTION

Meteorological modelling was carried out for a full year, coinciding with the availability of monitoring data from the Edendale. The Edendale data were available for the periods 25 September 2003 to 25 August 2004 and 29 March 2006 to 5 June 2006. The wind patterns for these periods are shown as wind roses in Figure 1. Wind roses for Invercargill Airport AWS site from 2000 to 2005 have been examined (see Figure 2). There is little variation between years; it can be assumed that the Edendale data sets are obtained in typical years and may be used for the dispersion modelling. Therefore, the full-year modelling period includes the 11-month period in 2003/2004 during which there were observations available from Edendale.



2003/2004 period 2005/2006 period

Figure 1: Edendale wind roses.

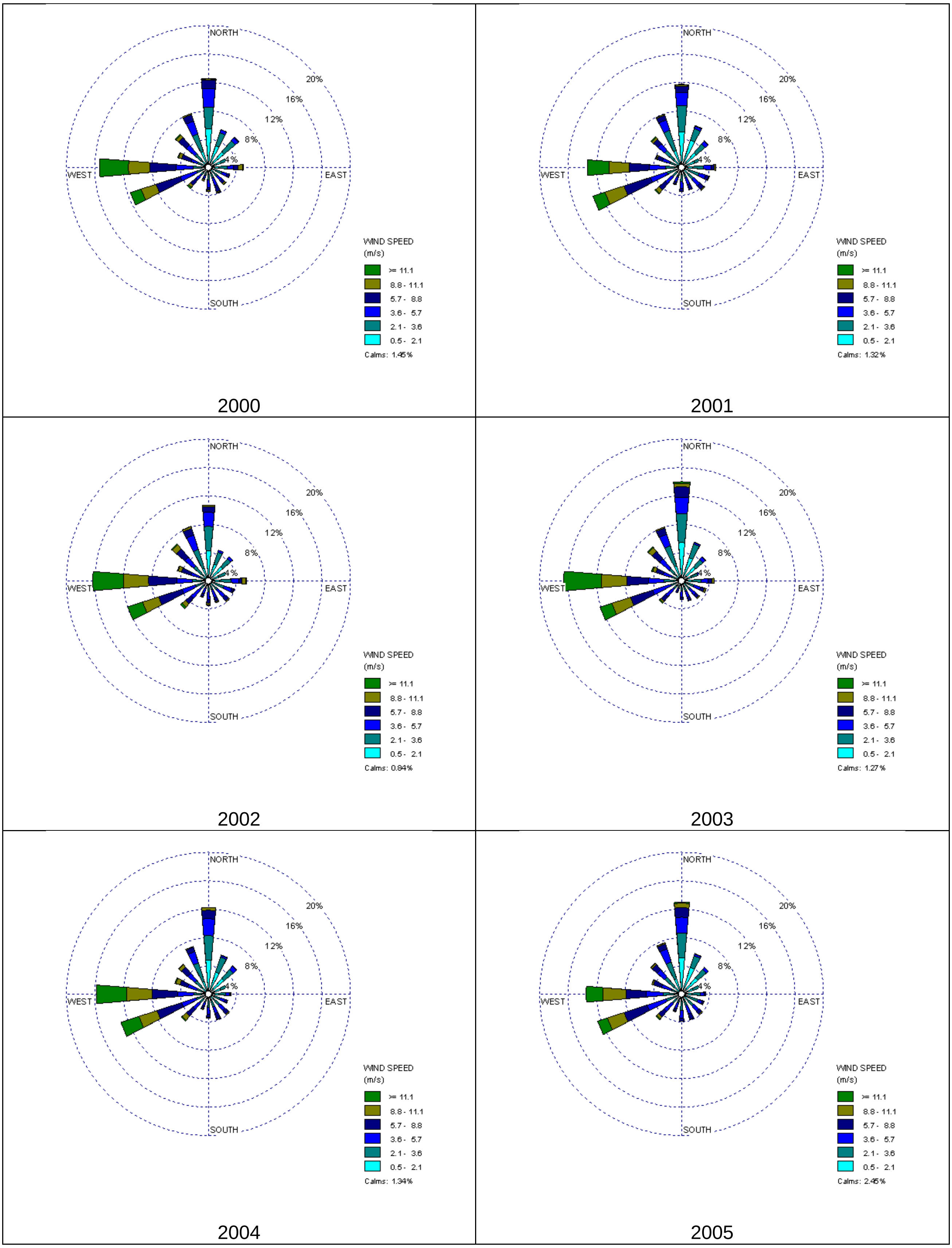


Figure 2: Invercargill Airport AWS wind roses: years 2000 to 2005.

3.0 TAPM MODELLING

3.1 Model Configuration

The TAPM model run was set up as described in Table 1. The model domain is centred using latitude/longitude coordinates, and projected onto a rectangular grid system. In this case, we have used the New Zealand Map Grid (NZMG). TAPM employs a one-way grid nesting. Each grid has the same centre, and the same number of points, so the higher resolution grids cover successively smaller areas. The vertical levels 'telescope' up from the surface, with lower levels closer together and the gap between them increasing with height. The monthly soil-moisture content was increased from its default setting (0.15 each month), to account for an annual cycle with wetter winters. TAPM's pollution-dispersion modules were not used for this project. All other parameters take default values.

Table 1: TAPM configuration parameters.

Parameter	Value
Start and end dates	24 August 2003 to 26 August 2004
Grid centre (Lat/Long)	46º 12.5' S 168º 48' E
Grid centre (NZMG)	(2185795, 5436123) (m)
No. of grids; no. of grid points in the horizontal	3; 32 x 36
Horizontal grid-cell spacing	30km, 10km, 3km
No. of grid levels in the vertical	25; from 10m to 8000m
Monthly deep-soil moisture (monthly values, January to December)	0.2, 0.2, 0.2, 0.2, 0.27, 0.35, 0.35, 0.35, 0.27, 0.2, 0.2, 0.2

3.2 Model Performance

TAPM results were used as a substitute for the upper-air data over Invercargill for the CALMET model. This was done so that hourly, rather than 12-hourly, data were available, and at locations nearer to the region of interest. For this approach to be viable, TAPM needs to perform well, particularly at upper levels. In regions of complex terrain, TAPM will not resolve the terrain well, and its performance as measured against surface-based data is not expected to be as good as at upper levels.

The performance of TAPM has been evaluated with commonly used statistical measures, such as the index of agreement (IOA) and other skill scores (Willmott, 1982). The IOA varies between 0 for no agreement, and 1 for an exact match. It is considered a better measure than the correlation coefficient. Values of the IOA at several hourly surface sites, and at several levels in the 12-hourly Invercargill profiles are shown in Table 2. Data from 925 mb (respectively 850 mb, 700 mb) were compared with results from the 750 m (respectively 1500 m, 3000 m) level. The IOA was calculated for wind-velocity components U and V, temperature (T) and relative humidity (RH).

Table 2: Index of agreement between model and observations.

Site	Altitude	IOA for U	IOA for V	IOA for T	IOA for RH
Tiwai Point	10 m	0.92	0.79	0.87	0.72
Lumsden	10 m	0.85	0.69	0.89	0.71
Gore	10 m	Not available	Not available	0.92	0.76
Edendale	10 m	0.88	0.82	0.92	Not available
Invercargill	10 m	0.86	0.81	0.91	0.77
Invercargill	925 mb	Not available	Not available	0.95	Not available
Invercargill	850 mb	0.93	0.91	0.95	Not available
Invercargill	700 mb	0.94	0.93	0.97	Not available

All IOAs are quite high (at least 0.69), indicating that TAPM performs well. With increasing height, the model performance improves, with all IOAs 925 mb and higher being above 0.9.

The statistical model evaluation has shown that TAPM performs well at upper levels over Invercargill, and we can therefore use the model as an hourly substitute for the 12-hourly Invercargill data, and use extracted profiles at other locations in the CALMET runs.

4.0 CALMET MODELLING

The following information provides details of the user input parameters for generating the CALMET three-dimensional meteorological data set. The start and end times for the CALMET run are shown in Table 3.

Table 3: Run control parameters.

Parameter	Value
Starting date/time	25/8/2003 00:00:00
Finish date/time	25/8/2004 23:00:00
UTC time zone	UTC+1200 (which is NZST)

The initial and intermediate CALMET runs were done on a 90 km by 105 km domain, which includes the terrain around Mataura that may influence the local meteorology. A grid spacing of 1 km was chosen to allow the region to be modelled using currently available computational resources. The final CALMET runs were done on a 3.5 km by 4.5 km domain at 50 m resolution, centred on Mataura, with much more terrain detail. The map projection and grid control parameters are shown in Table 4.

Table 4: CALMET map projection and grid control parameters (columns are merged for parameters that are the same in all runs).

Parameter	Initial/Intermediate	Final
Geodetic datum	WGS-84	
Projection origin	46.37S, 168.53E	
NZMG origin	5417 km northing; 2166 km easting	
Domain SW corner (NZMG)	(2141 km, 5384 km)	(2189.6 km, 5346.2 km)
Grid spacing	1 km	50 m
Number of Cells	NX = 90; NY = 105	NX = 70; NY = 90
Cell face heights (m)	0, 20, 50, 90, 130, 200, 300, 450, 650, 950, 1400, 2000, 2896	

Surface and upper-air wind and temperature data are blended by the model, as are surface wind data and parameterised terrain effects. Parameter choices are made to determine the weighting of the different data components. These are shown in Table 5. They vary between runs, as the runs have different purposes, or are carried out at different terrain resolution.

Table 5: CALMET wind field options and parameters.

Parameter	Value
Vertical extrapolation of surface wind observations (initial)	Extrapolation using similarity theory
Vertical extrapolation of surface wind observations (intermediate and final)	No extrapolation, as profile blending has been done
Layer dependent biases (initial)	-1, -0.9, -0.8, -0.7, -0.6, -0.4, -0.2, 0.0, 0.0, 0.0, 0.0, 0.0
Layer dependent biases (intermediate and final)	-1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1
Site maximum radius of influence parameters (initial and intermediate)	RMAX1 = 5 km RMAX2 = 5 km RMAX3 = 100 km
Distance from site of equal weighting of initial wind field and observations	R1 = 2.5 km R2 = 2.5 km
Radius of influence of terrain features (initial and intermediate)	TERRAD = 30 km
Radius of influence of terrain features (final)	TERRAD = 2 km

Default settings were used for other mixing height, terrain-effect, temperature radius of influence, cloud and precipitation parameters. The surface meteorological stations and their locations are shown in Table 6. Data from these were used in all CALMET runs. In the intermediate and final CALMET runs, these were also the locations of blended upper-air profiles. No precipitation stations were used.

Table 6: Surface meteorological stations and locations of extracted TAPM upper-air profiles.

Name	Source	NZMG X (km)	NZMG Y (km)	Time zone	Anem. ht. (m)
Edendale	Fonterra	2185.158	5424.800	-12	10
Invercargill Aero AWS	CliDB (11104)	2150.833	5410.791	-12	10
Tiwai Point AWS	CliDB (5823)	2155.490	5392.351	-12	10
Gore AWS	CliDB (5778)	2192.000	5447.000	-12	10
Lumsden AWS	CliDB (5496)	2155.945	5485.770	-12	10

5.0 REFERENCES

Gimson N, Chilton R, and Xie S 2010. *Meteorological Datasets for the Auckland Region – User Guide*. Report prepared by Golder Associates (NZ) Limited for Auckland Regional Council. Auckland Regional Council Technical Report 2010/022.

Willmott 1982. “Some comments on the evaluation of model performance”. Bulletin of the American Meteorological Society 63: 1309-1313.

APPENDIX G

CALPUFF Modelling Set Up

Introduction

As mentioned in the main text, CALPUFF version 7.2.0 was run from for the months of August 2003 to August 2004 (inclusive). Most standard options were used, including the PRIME building-wake algorithm and the 'pdf' formulation for dispersion under convective conditions. Concentrations of PM_{10}, $PM_{2.5}$, NO_X, and SO_2 were calculated by the model on regular sampling grids centred on the Alliance Mataura meat processing site and hide plant. The CALPUFF model domain is shown in Figure 1.

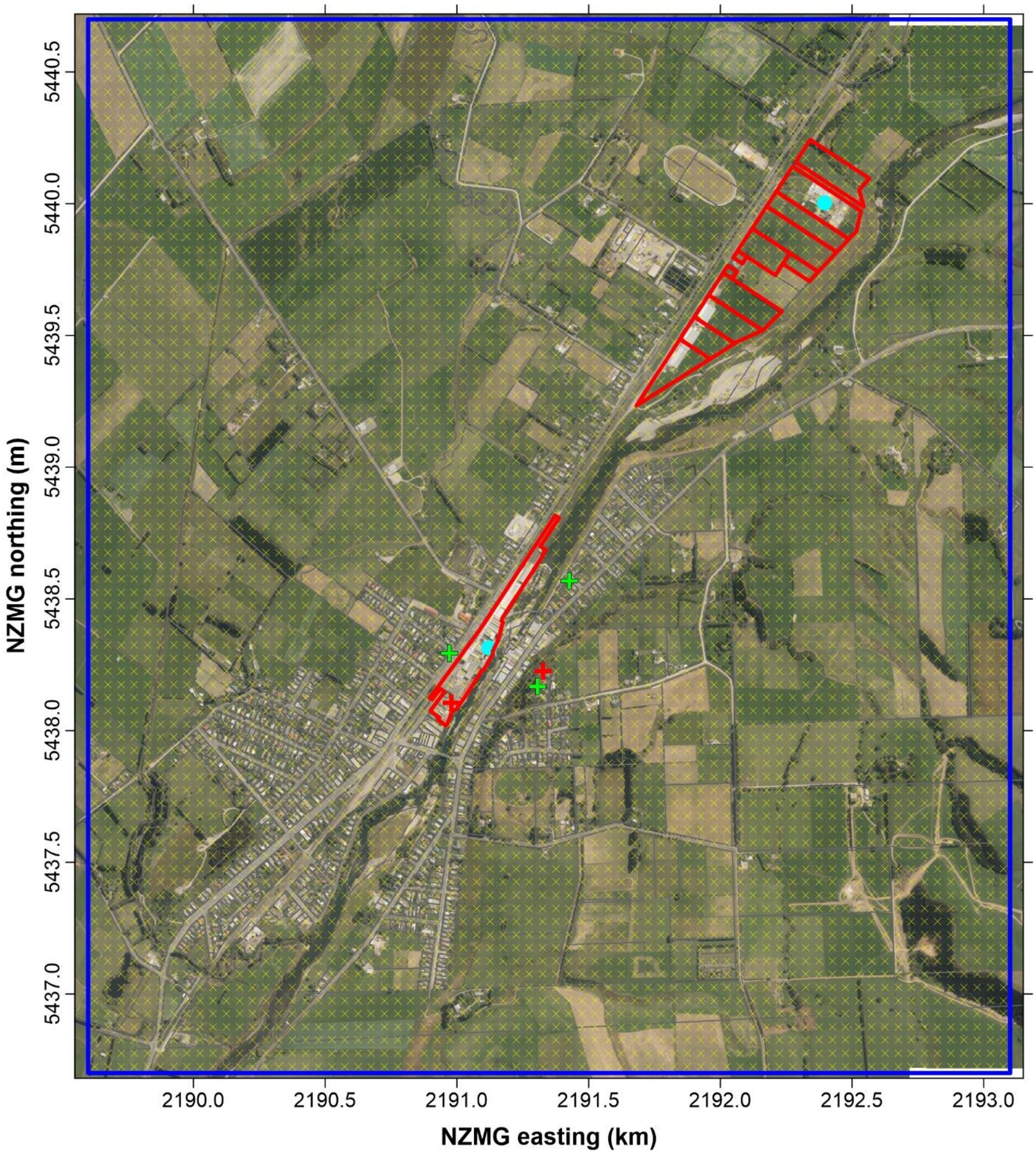


Figure 1: CALPUFF model domain. Sampling grids locations marked as yellow crosses, sensitive receptor locations marked as green crosses, monitoring sites marked as red crosses, the site boundary marked in red.

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		01:00	25 August 2003
End date/time		22:00	24 August 2004
Base time zone	XBTZ	-12 (NZST)	
Time step	NSECDT	3600 s	

Table 2: Pollutant specifications.

Parameter		Value	
Number of chemical species	NSPEC	5	
Number of emitted species	NSE	5	
Species; modelled; emitted; deposited?		PM_{10} NO_x $PM_{2.5}$ SO_2 NO_2	Yes; Yes; No Yes; Yes; No Yes; Yes; No Yes; Yes; No Yes; Yes; No
Chemical mechanism	MCHEM	0 (No chemistry)	
Dry deposition	MDRY	0 (No dry deposition)	
Wet deposition	MWET	0 (No wet deposition)	

Table 3: Technical options.

Parameter		Value
Dispersion coefficient calculation	MDISP	2 use micrometeorological variables
Back-up calculation	MDISP2	3 PG for rural; MP for urban
PDF for dispersion under convective conditions	MPDF	1 (On)
Building downwash	MBDW	2 PRIME algorithm
Check parameters for regulatory settings		No (they are USEPA-specific)
Minimum σv over land (default 0.5 m/s)		0.5 m/s

Table 4: Map projection (the parameters match those of CALMET).

Parameter	Value
Map projection	Tangential Transverse Mercator (TTM)
Datum region	WGS-84
Projection origin	46.37 S, 168.53 E
False origin *(NZTM coordinates)*	(2166, 5417) km

Table 5: Grid control.

Parameter		Value
SW corner of grid cell (1,1)		2189.6 km, 5436.2 km (NZMD)
Grid dimensions	NX x NY; DGRIDKM	70 x 90 grid cells at spacing 0.05 km
Vertical grid, number of layers		12
Cell-face heights for vertical grid (m)		0, 20, 50, 90, 130, 200, 300, 450, 650, 950, 1400, 2000, 2896

Table 6: Grid control (subset of CALMET grid points used by CALPUFF).

Parameter	Value
CALPUFF computational grid range E-W	1 to 70 out of NX=70
CALPUFF computational grid range S-N	11 to 90 out of NY=90
Use of gridded receptors?	NO

Table 7: Discrete receptors.

Type	NZTM Easting (m)	NZTM Northing (m)	Ground Elev. (m)*
Monitoring Site 1	2191327	5438225	80.35
Monitoring Site 2	2190978	5438105	55.66
House 1	2191305.53	5438167.48	82.17
House 2	2191425.76	5438567.7	56.99
House 3	2190970.65	5438293.93	56.04

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

Stack Source Parameters

Table 8: Stack discharge parameters.

Point source ID	Description	NZMD Easting (m)	NZMD Northing (m)	Stack height (m)	Base elevation (m)	Stack diameter (m)	Efflux velocity (m/s)	Temp. (K)
SRC_1	Hide Store 40 % MCR	2192395	5440002	20	58.31	0.6	2.3	523
SRC_3	Main Stack at 64 % MCR	2191122	5438314	30	57	2	2.8	503

Table 9: Emission parameters.

Point source ID	PM_{10} (kg/hr)	$PM_{2.5}$ (kg/hr)	NO_X (kg/hr)	SO_2 (kg/hr)
SRC_1[#]	0.21	0.17	0.16	0.47
SRC_3*	2.5	2	1.9	5.5

Notes: [#] emission rate for 40% MCR condition. *emission rate for 64 % MCR condition.

Building Parameters

```
'P'
'METERS'  1.00000000
'UTMY'  0.0000
9
'BLD_1'  1        55.39  'Boiler house SW'
   4        18.00
        2191107.85     5438300.21
        2191111.36     5438305.62
        2191124.35     5438297.19
        2191120.83     5438291.78
'BLD_2'  1        55.34  'Boiler House NE'
   4         6.00
        2191111.37     5438305.77
        2191117.07     5438314.54
        2191130.07     5438306.10
        2191124.38     5438297.32
'BLD_3'  1        57.22  'Building 3 - SW of Boiler House'
   4         9.00
        2191085.78     5438245.29
        2191104.73     5438275.60
        2191120.00     5438266.06
        2191101.05     5438235.74
'BLD_4'  1        57.00  'North Group - 1'
   4        27.00
        2191153.19     5438486.47
        2191186.57     5438537.87
        2191204.00     5438526.55
        2191170.62     5438475.15
'BLD_5'  1        57.00  'North Group - 2'
   4        35.00
        2191168.77     5438470.89
        2191202.84     5438523.37
        2191219.99     5438512.23
        2191185.92     5438459.75
'BLD_6'  1        57.00  'North Group - 3'
   4        23.00
        2191114.83     5438425.70
        2191153.75     5438485.63
        2191171.51     5438474.09
        2191132.59     5438414.16
'BLD_7'  1        57.00  'North Group - 4'
   4        24.00
        2191136.45     5438418.82
        2191168.37     5438469.90
        2191186.26     5438458.72
        2191154.34     5438407.64
'BLD_8'  1        58.37  'Hide Store N'
   6         6.00
        2192384.24     5440025.56
        2192398.74     5440047.78
        2192412.30     5440039.11
        2192416.40     5440045.89
        2192430.58     5440037.22
        2192411.83     5440007.27
'BLD_9'  1        57.94  'Hide Store E'
   8         8.00
        2192427.75     5440032.02
        2192454.23     5440015.15
        2192433.58     5439983.15
        2192440.20     5439978.27
        2192434.68     5439970.39
        2192393.38     5439997.66
        2192398.59     5440005.85
        2192407.25     5439999.86
2
'SRC_1'        58.31      20.00      2192395.44      5440002.58
'SRC_3'        57.00      30.00      2191122.39      5438314.03
```

Figure 2: Building parameter (BPIP) input file.

APPENDIX H

Cumulative Modelling Assessment Results

Table 1: Peak 24-hr PM_{10} GLCs due to CFBs predicted at Alliance southern boundary.

Rank	Modelled GLC (µg/m³)[(1)]	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit [(2)]	99th Upper Limit [(3)]	Mean	75th Upper Limit	99th Upper Limit	
1	12	11	12	14	23	24	26	**50**
2	12	11	12	14	23	24	26	**50**
3	11	11	12	14	22	23	25	**50**
4	10	11	12	14	21	22	24	**50**
5	10	11	12	14	21	22	24	**50**

Notes: [(1)] Modelling results under daily weather category D (average wind speed >3 m/s). [(2)] 75th upper limit = upper estimated mean background at 75 % confidence. [(3)] 99th upper limit = upper estimated mean background at 99 % confidence.

Table 2: Peak 24-hr $PM_{2.5}$ GLCs due to CFBs predicted at Alliance southern boundary.

Rank	Modelled GLC (µg/m³)[(1)]	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit [(2)]	99th Upper Limit [(3)]	Mean	75th Upper Limit	99th Upper Limit	
1	10	6	7	8	16	17	18	**25**
2	9	6	7	8	15	16	17	**25**
3	9	6	7	8	15	16	17	**25**
4	8	6	7	8	14	15	16	**25**
5	8	6	7	8	14	15	16	**25**

Notes: [(1)] Modelling results under daily weather category D (average wind speed >3 m/s). [(2)] 75th upper limit = upper estimated mean background at 75 % confidence. [(3)] 99th upper limit = upper estimated mean background at 99 % confidence.

Table 3: $PM_{2.5}$ GLCs due to CFBs predicted at Alliance southern boundary during peak background levels.

Rank	Modelled GLC (µg/m³)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit (2)	99th Upper Limit (3)	Mean	75th Upper Limit	99th Upper Limit	
1	2	17	21	28	19	23	30	**25**
2	1	17	21	28	18	22	29	**25**
3	1.4	17	21	28	18	22	29	**25**
4	1.0	17	21	28	18	22	29	**25**
5	0.9	17	21	28	18	22	29	**25**

Notes: (1) Modelling results under daily weather category A (average wind speed <2 m/s and average temperature <5 ºC). (2) 75th upper limit = upper estimated mean background at 75 % confidence. (3) 99th upper limit = upper estimated mean background at 99 % confidence.

Table 4: Peak PM_{10} GLCs due to CFBs predicted at the MIL.

Averaging period	Location	Modelled GLC (µg/m³)*	Background (µg/m³)#	Cumulative GLC (µg/m³)	Assessment criterion (µg/m³)	Modelled Weather condition*
24-hour	200 m southeast of CFB 2	30	14#	44	**50**	D
Annual	250 m east of CFB 2	3	12	15	**20**	-

Notes: * Weather condition D: daily averaged wind speed ≥3 m/s. # Using 99th upper limit 24-hour background concentration = upper estimated mean background at 99 % confidence.

Table 5: Peak $PM_{2.5}$ GLCs due to CFBs predicted at the MIL.

Averaging period	Location	Modelled GLC (µg/m³)	Background 99th Limit (µg/m³)	Cumulative GLC (µg/m³)	Assessment criterion (µg/m³)	Modelled Weather condition*
24-hour	200 m southeast of CFB 2	24	8	32	**25**	D
Annual	250 m east of CFB 2	2	7	9	**10**	-

Notes: * Weather condition D: daily averaged wind speed ≥3 m/s. # Using 99th upper limit 24-hour background concentration = upper estimated mean background at 99 % confidence.

Table 6: Peak 24-hr PM_{10} GLCs due to CFBs predicted at House #1.

Rank	Modelled GLC (µg/m³)(1)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit (2)	99th Upper Limit(3)	Mean	75th Upper Limit	99th Upper Limit	
1	28	11	12	14	39	40	42	**50**
2	20	11	12	14	31	32	34	**50**
3	19	11	12	14	30	31	33	**50**
4	19	11	12	14	30	31	33	**50**
5	18	11	12	14	29	30	32	**50**

Notes: (1) Modelling results under daily weather category D (average wind speed >3 m/s). (2) 75th upper limit = upper estimated mean background at 75 % confidence. (3) 99th upper limit = upper estimated mean background at 99 % confidence.

Table 7: Peak 24-hr $PM_{2.5}$ GLCs due to CFBs predicted at House #1.

Rank	Modelled GLC (µg/m³)(1)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³) 75th Upper Limit (2)
		Mean	75th Upper Limit (2)	99th Upper Limit (3)	Mean	75th Upper Limit	99th Upper Limit	
1	23	6	7	8	29	30	31	**25**
2	16	6	7	8	22	23	24	**25**
3	15	6	7	8	21	22	23	**25**
4	15	6	7	8	21	22	23	**25**
5	14	6	7	8	20	21	22	**25**

Notes: (1) modelling results under daily weather category D (average wind speed >3 m/s); (2) 75th upper limit = upper estimated mean background at 75 % confidence; (3) 99th upper limit = upper estimated mean background at 99 % confidence.

Table 8: PM_{10} GLCs due to CFBs predicted at House#1 during peak background levels.

Rank	Modelled GLC (µg/m³)(1)	Background GLC (µg/m³) (1)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit (2)	99th Upper Limit(3)	Mean	75th Upper Limit	99th Upper Limit	
1	3.0	24	29	38	27	32	41	**50**
2	1.0	24	29	38	25	30	39	**50**
3	0.6	24	29	38	25	30	39	**50**
4	0.1	24	29	38	24	29	38	**50**
5	< 0.1	24	29	38	24	29	38	**50**

Notes: (1) modelling results and background concentrations are for daily weather Category A (average wind speed <2 m/s and temperature <5 ºC); (2) 75th upper limit = upper estimated mean background at 75 % confidence; (3) 99th upper limit = upper estimated mean background at 99 % confidence.

Table 9: $PM_{2.5}$ GLCs due to CFBs predicted at House#1 during peak background levels.

Rank	Modelled GLC (µg/m³)(1)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit (2)	99th Upper Limit (3)	Mean	75th Upper Limit	99th Upper Limit	
1	2	17	21	28	19	23	30	**25**
2	0.8	17	21	28	18	22	29	**25**
3	0.5	17	21	28	17	21	28	**25**
4	0.1	17	21	28	17	21	28	**25**
5	< 0.1	17	21	28	17	21	28	**25**

Notes: (1) modelling results and background concentrations are for daily weather Category A (average wind speed <2 m/s and temperature <5 ºC). (2) 75th upper limit = upper estimated mean background at 75 % confidence. (3) 99th upper limit = upper estimated mean background at 99 % confidence.

Table 10: Peak 24-hr PM_{10} GLCs due to CFBs predicted at House #2.

Rank	Modelled GLC (µg/m³)(1)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit (2)	99th Upper Limit(3)	Mean	75th Upper Limit	99th Upper Limit	
1	16	11	12	14	27	28	30	**50**
2	16	11	12	14	27	28	30	**50**
3	13	11	12	14	24	25	27	**50**
4	13	11	12	14	24	25	27	**50**
5	13	11	12	14	24	25	27	**50**

Notes: (1) Modelling results under daily weather category D (average wind speed >3 m/s). (2) 75th upper limit = upper estimated mean background at 75 % confidence. (3) 99th upper limit = upper estimated mean background at 99 % confidence.

Table 11: Peak 24-hr $PM_{2.5}$ GLCs due to CFBs predicted at House #2.

Rank	Modelled GLC (µg/m³)(1)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit (2)	99th Upper Limit (3)	Mean	75th Upper Limit	99th Upper Limit	
1	13	6	7	8	19	20	21	**25**
2	12	6	7	8	18	19	20	**25**
3	11	6	7	8	17	18	19	**25**
4	11	6	7	8	17	18	19	**25**
5	10	6	7	8	16	17	18	**25**

Notes: (1) Modelling results under daily weather category D (average wind speed >3 m/s). (2) 75th upper limit = upper estimated mean background at 75 % confidence. (3) 99th upper limit = upper estimated mean background at 99 % confidence.

Table 12: Peak 24-hr PM_{10} GLCs due to CFBs predicted at House #3.

Rank	Modelled GLC (µg/m³)(1)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit (2)	99th Upper Limit (3)	Mean	75th Upper Limit	99th Upper Limit	
1	17	11	12	14	28	29	31	**50**
2	14	11	12	14	25	26	28	**50**
3	14	11	12	14	25	26	28	**50**
4	14	11	12	14	25	26	28	**50**
5	13	11	12	14	24	25	27	**50**

Notes: (1) Modelling results under daily weather category D (average wind speed >3 m/s). (2) 75th upper limit = upper estimated mean background at 75 % confidence. (3) 99th upper limit = upper estimated mean background at 99 % confidence.

Table 13: Peak 24-hr $PM_{2.5}$ GLCs due to CFBs predicted at House #3.

Rank	Modelled GLC (µg/m³)[(1)]	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit [(2)]	99th Upper Limit [(3)]	Mean	75th Upper Limit	99th Upper Limit	
1	13	6	7	8	19	20	21	**25**
2	11	6	7	8	17	18	19	**25**
3	11	6	7	8	17	18	19	**25**
4	11	6	7	8	17	18	19	**25**
5	11	6	7	8	17	18	19	**25**

Notes: [(1)] Modelling results under daily weather category D (average wind speed >3 m/s). [(2)] 75th upper limit = upper estimated mean background at 75 % confidence. [(3)] 99th upper limit = upper estimated mean background at 99 % confidence.

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B

APPENDIX B

Golder Associates (NZ)

Limited Air Quality Effects of Energy Plant Emissions

August 2020

REPORT

Air Quality Effects of Energy Plant Emissions

Alliance Mataura

Submitted to:

Alliance Group Limited

PO Box 1410, Invercargill

Submitted by:

Golder Associates (NZ) Limited

Level 1, 214 Durham Street, Christchurch 8011

+64 3 377 5696

1793285-7403-008-R-Rev4

August 2020

Distribution List

Doyle Richardson | Alliance Group Limited

Executive Summary

This report presents an assessment of cumulative air quality impacts associated with emissions associated with two future options for supplying thermal energy to the main processing site owned and operated by Alliance Group Ltd, Mataura, Southland (Alliance).

The first option involves the operation of the existing 9.4 megawatt (MW) coal fired boiler (CFB) with the addition of a baghouse filter and operating at a maximum energy output of 6.4 MW (68 % MCR) and operation of the existing 923 kilowatt (kW) CFB 3 at the Alliance hide salting plant. The second option involves the operation of a new 8 MW biomass fired boiler (BFB) at 100 % MCR along with the existing 923 kW CFB.

The assessment was based on dispersion modelling of the boilers' discharges to air and direct ambient monitoring of respirable particulate at several locations within Mataura. The assessment indicates that sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) air quality impacts associated with either energy supply option are likely to cause a less than minor cumulative air quality effects.

The ambient air quality effects of PM_{10} from the main site CFB 2 and BFB were assessed for an in-stack concentration of 50 mg/Nm^3 (corrected to 12 vol % CO_2 or 7 % O_2 and dry basis).

The PM_{10} and associated $PM_{2.5}$ emissions (estimated at 100 % of the PM_{10}) that were established for the two energy plant options when operating at their respective MCRs are predicted to cause low increases in the surrounding 24-hour and annual average concentrations of ambient PM_{10} and $PM_{2.5}$ within Mataura. From the analysis of ambient monitoring data, background sources of ambient particulate appear to significantly degrade the air quality within Mataura township during autumn and winter months and particularly on cold still days. During such days the energy plant is predicted to have a very minor contribution to the cumulative ambient levels within Mataura.

Therefore, the conclusion from this assessment is that the key air pollutants (i.e., SO_2, NO_2 and PM_{10}) that would be discharged from the proposed energy plant options, comply with relevant national air quality standards and guidelines at off-site locations where people are likely to be exposed. The cumulative 24-hour $PM_{2.5}$ effects are likely to exceed the WHO guideline limit during autumn and winter months and particularly on cold still days. However, this is primarily caused by the existing degraded background air quality in Mataura. The proposed energy plant options will significantly reduce the amount of particulate discharged by Alliance from the site are expected to have a very minor contribution to the cumulative ambient level of $PM_{2.5}$.

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1.0 INTRODUCTION

Alliance Group Limited (Alliance) operates a meat processing and hide processing plant at Mataura, Southland. The main plant (meat processing) is located at the centre of Mataura, approximately 12 km to the southwest of Gore township, as shown in Figure 1. The hide processing plant is sited approximately 2 km north of the main site.

Alliance holds an existing resource consent (Environment Southland Consent No. AUTH-20158002) that authorises air discharges from the site, which expires on 15 December 2020. The existing permit covers the discharges from the following coal fired boilers (CFBs) at its main site and hide salting site:

- A 9,400 kilowatt (kW) rated Babcock and Wilcox spreader stoker boiler (CFB 2);
- A 3,800 kW rated back up spreader stoker boiler to CFB 1;
- A 923 kW rated Boag spreader stoker boiler (CFB 3) at the hide salting plant; and
- A 160 kW rated CFB boiler at the main site (for office heating - currently unused).

Golder Associates (Golder) previously prepared an assessment of air quality effects resulting from air contaminants discharged from the two main CFBs operated at the Alliance Mataura site (Golder 2020). This assumed the CFB 2 operating at 64 % of its maximum rated capacity (MCR) (with no baghouse) and CFB 3 operating at 40 % MCR.

For the above operating scenario, Golder (2020) reported the predicted ambient air contaminant concentration increases due to the CFB emissions to air, their cumulative effects with existing background air quality and mitigation options. The air contaminant impacts assessed by Golder (2020) included respirable particulate matter (PM_{10} and $PM_{2.5}$), sulfur dioxide (SO_2) and nitrogen dioxide (NO_2).

Golder (2020) concluded that the existing control measures of the CFBs did not represent the Best Practical Option (BPO) for minimising respirable particulate effects. The report recommended the installation of a more effective end-of-pipe treatment of existing CFB 1 and CFB 2 combined exhaust discharge, or the replacement of this energy plant with an alternative modern heating plant, which has lower particulate emissions.

Alliance now proposes to reduce the discharge of PM_{10} and $PM_{2.5}$ from the existing CFB 2 by either installing a new bag house filter, or at some stage in the future, replacing the existing CFB 2 with a new 8 megawatt (MW) biomass fired boiler (BFB).

This report[1] has been prepared to assess the air quality effects of options recommended by Golder (2020). This includes allowances for:

- the operation of the existing CFB 2 (and with back up from CFB 1) at a maximum output rate of 6.4 MW (68 % MCR) with a full baghouse filter and the 923 kW lignite CFB as it currently operates at the hide salting site.
- the operation of a new 8 MW biomass fired boiler (BFB) at the main site (replacing CFB 1 and CFB 2) and the existing 923 kW lignite CFB at the hide salting site.

The ambient particulate monitoring from Golder (2020) report is utilised for this assessment. This also enabled the background ambient particulate levels to be established within Mataura. These data combined with modelled incremental impacts from energy plant were used to evaluate the extent of cumulative air quality effects in urban and other areas surrounding the Alliance site.

[1] Your attention is drawn to the document "Report Limitations" in Appendix A.

2.0 ASSESSMENT SCOPE

The scope of the air quality assessment presented in this report includes the cumulative ambient air quality concentrations due to emissions from two potential energy supply options and existing background air quality. The specific air contaminants considered include common air pollutants (i.e., PM_{10}, $PM_{2.5}$, SO_2 and NO_2). The potential air quality effects of emissions of carbon monoxide, metals and organic compounds associated with solids fuel combustion are expected to have a less than minor, or negligible potential to cause any adverse effects and are not considered further in this report.

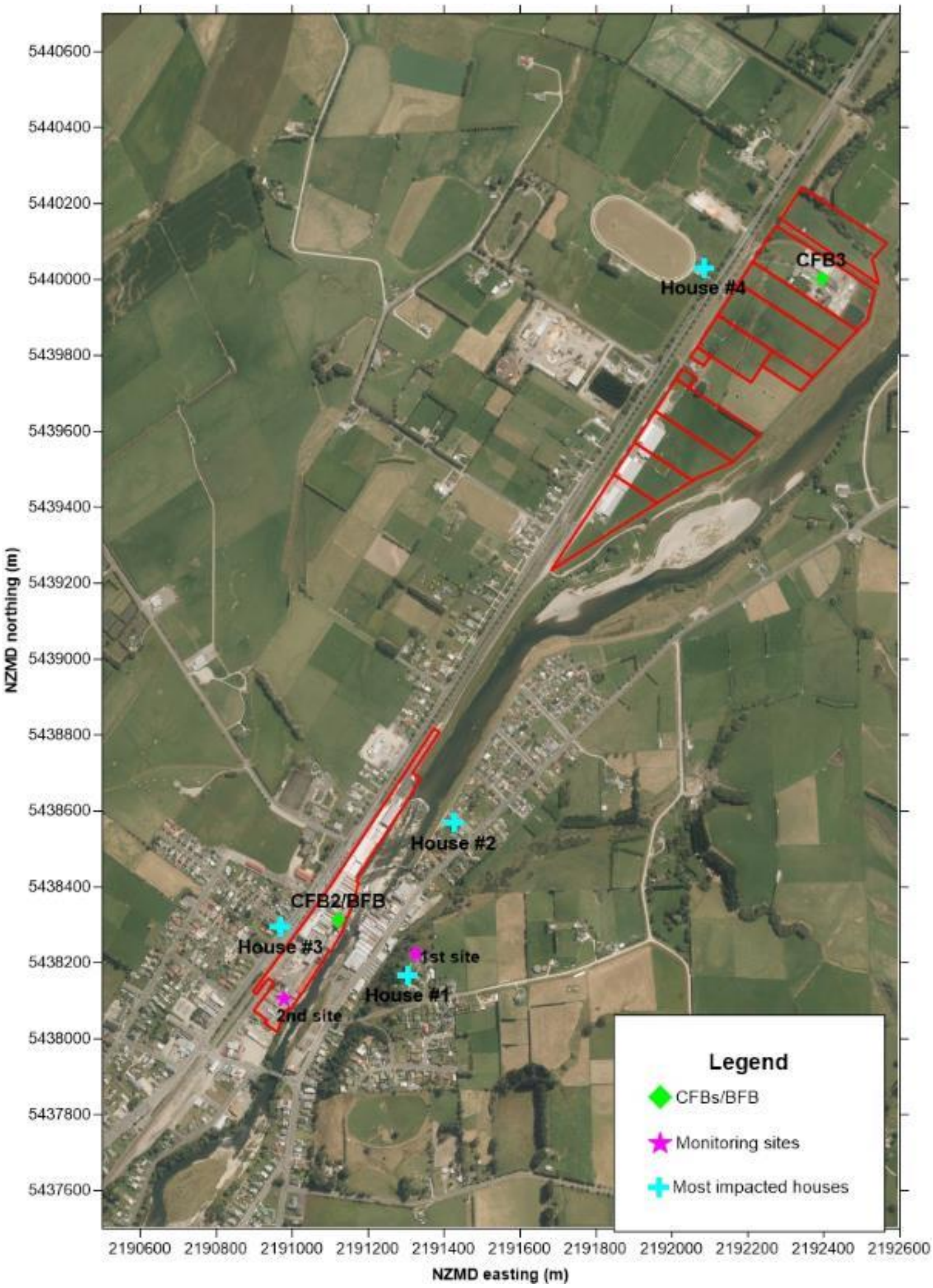

Figure 1: Alliance Mataura site and surrounds.

3.0 SITE AND BOILER INFORMATION

3.1 General

The Alliance Mataura processes approximately 1,000 head of cattle per day during the peak season. The hide salting plant and its energy plant (CFB 3) are situated at the northern extent of the site and 2 km from the main process plant and CFB 2 (locations shown in Figure 1).

The peak processing season typically occurs from November to July, and shoulder season from August to October.

3.2 Energy Plant

The site CFBs are currently fired on a lignite coal that is supplied from the Newvale coal mine.

CFB 2 operates up to 24 hours a day and seven days per week in peak season, and 14 hours per day and five days per week during shoulder seasons. Alliance commissioned a report by DETA Consulting (2020) which confirmed the maximum theoretic peak energy demand from CFB 2 to be 6.4 MW (i.e., 68 % MCR). CFB 2 typically operates up to 50 % of its maximum continuous capacity rating (MCR).

CFB 2 has a 30 m high stack with an efflux diameter of 2 m, whereas CFB 3 has a 20 m high stack with a discharge diameter of 0.6 m.

The small hide plants' CFB 3 operates up to 35 hours per week over three days in peak season. Coal usage records indicate a maximum and average weekly usage of 7 tonnes and 2 tonnes respectively. This infers a maximum hourly coal combustion rate of 200 kg/hr (as received) and maximum operating rate of 40 % MCR.

Alliance propose to either install a baghouse filter on CFB 2 and continue to operate up to 68 % MCR, or replace this with an 8 MW biomass fired boiler (BFB).

It is expected that the new BFB would operate up to 100 % MCR with an efficiency of approximately 75 %. It is proposed to have a stack height of 29 m. To achieve a nominal efflux velocity of 15 m/s, an efflux diameter of 0.76 m was established via stoichiometric calculations.

The BFB's stack efflux diameter of 0.76 m for achieving a 15 m/s efflux velocity at 100 % MCR (8 MW steam output), should be reviewed once the supplier confirms the boiler's thermal efficiency and normal stack oxygen level at this operating rate.

Note, the BFB option would have a significantly higher efflux velocity than the existing CFB 2 discharge.

3.3 Stack Height Assessment

Golder has undertaken some preliminary assessments to assess the benefits of stack heights for a new BFB which are greater than 29 m above ground level. This indicated no significant further reductions in ground level air quality effects, due to stack heights above 29 m.

The results of stoichiometric calculations for the CFB or BFB exhaust air flow are summarised in Appendix B.

3.4 Steam Generation (CFB 2)

Records of steam generation rates for the 2018-2019 processing season were accessed from the Alliance Mataura SCADA system. This includes over thirty thousand 15-minute records of steam production rate (Tonnes/hr) and gauge pressure (Bar).

The analysis of hourly varying steam generation for peak processing days (occurring in mid-June 2018), which had the highest peak hourly steam demand (kg/hr) and the highest daily steam demand (tonnes/day) are presented in Figure 2 and Figure 3.

Table 1 provides a summary of the daily average %MCR output rates from CFB 2, which indicates a maximum daily average output of 53 % MCR. The 2018-2019 peak hourly steam rate of 8,692 kg/hr equates to 64 % MCR. (NB: at 100 % MCR, CFB 2 produces 13,600 kg/hr at 10 Bar) Note, 68 % MCR is considered the current operational maximum.

Finally, Figure 4 shows the cumulative distribution of CFB 2 operating rates for the full year, which shows that the 50th percentile steam output rate (accounting for shut-downs throughout the year) is 29 % MCR.

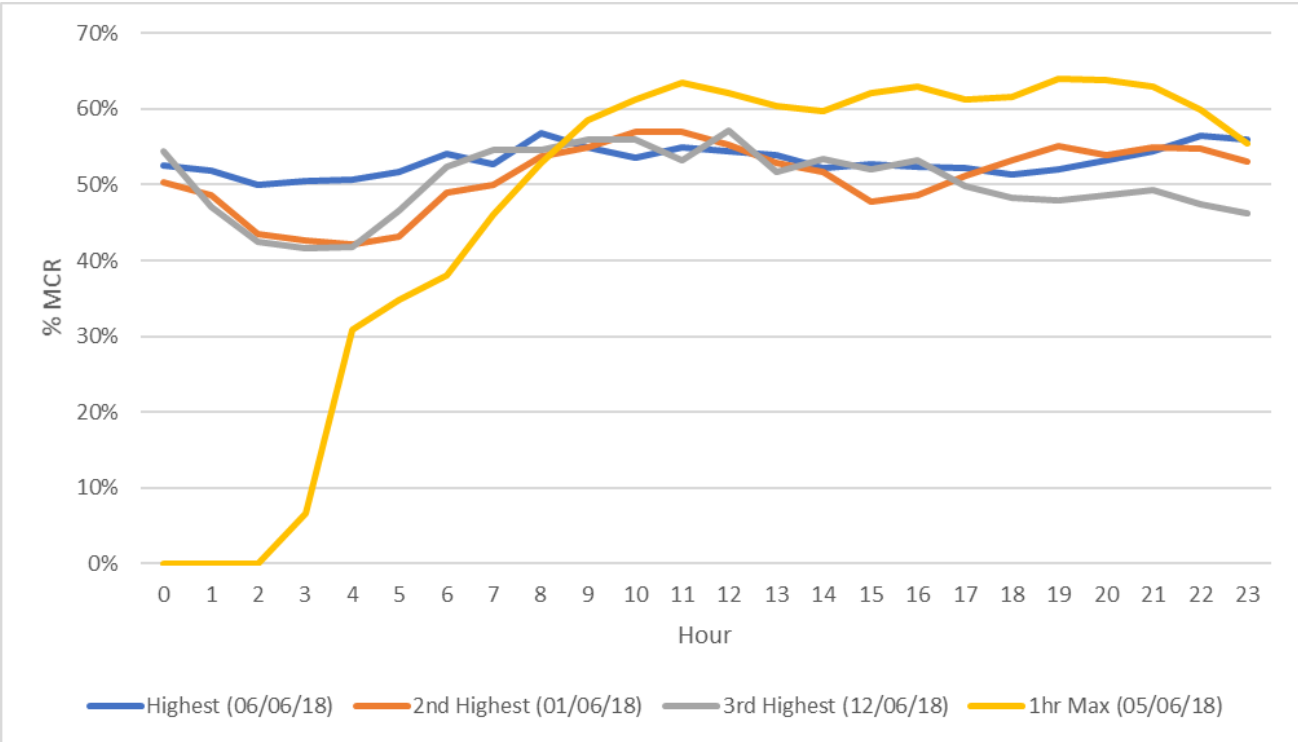

Figure 2: Hourly varying CFB 2 steam output for peak processing days (1, 5, 6 and 12 June 2018).

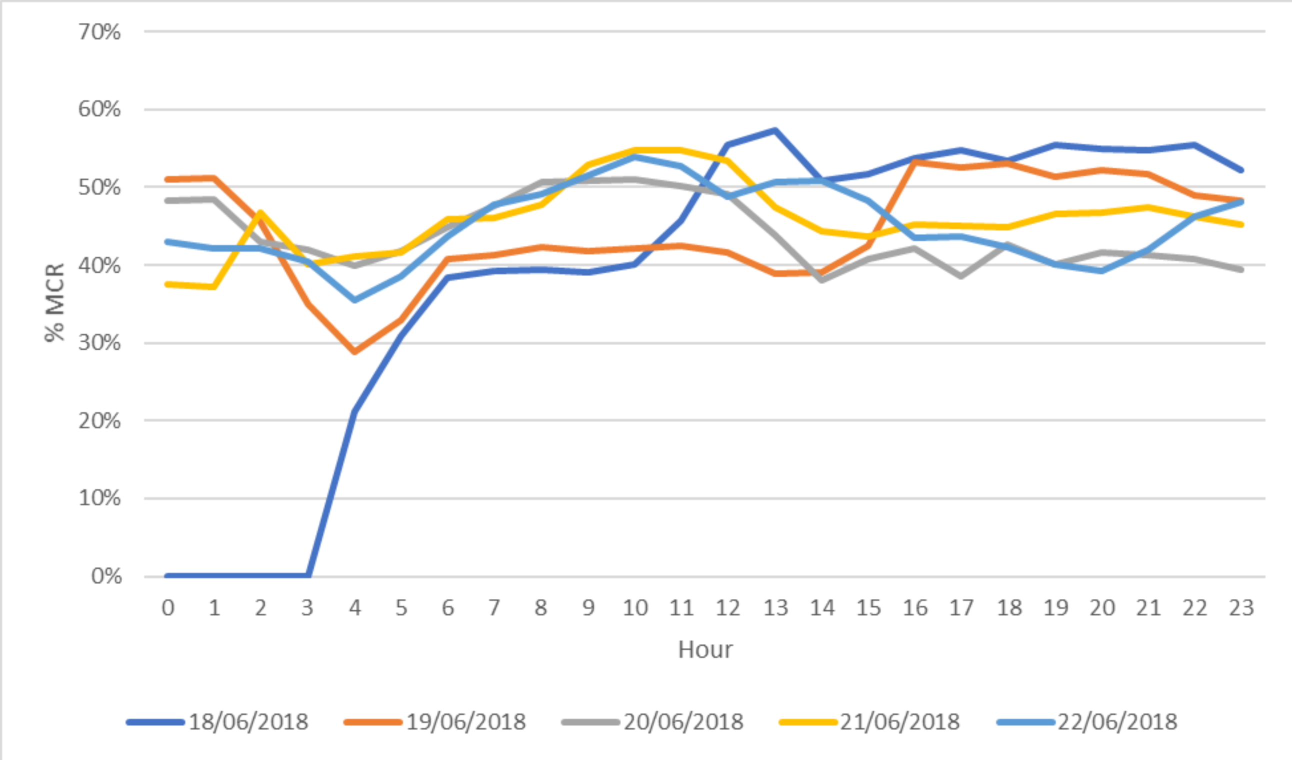

Figure 3: Hourly varying CFB 2 steam output for peak processing week (18 to 22 June 2018).

Table 1: Summary of daily average %MCR for CFB 2 for peak processing days.

Date	Maximum 1-hour average %MCR	24-hour average %MCR	Maximum 1-hour steam production rate (kg/hr)	Daily steam output (tonnes)
06/06/2018	57 %	53 %	7,730	174
01/06/2018	57 %	51 %	7,762	167
12/06/2018	57 %	50 %	7,780	164
05/06/2018	64 %	47 %	8,692	154
18/06/2018	57 %	39 %	7,804	128
19/06/2018	53 %	45 %	7,236	145
20/06/2018	51 %	44 %	6,934	144
21/06/2018	55 %	46 %	7,455	150
22/06/2018	54 %	45 %	7,343	148

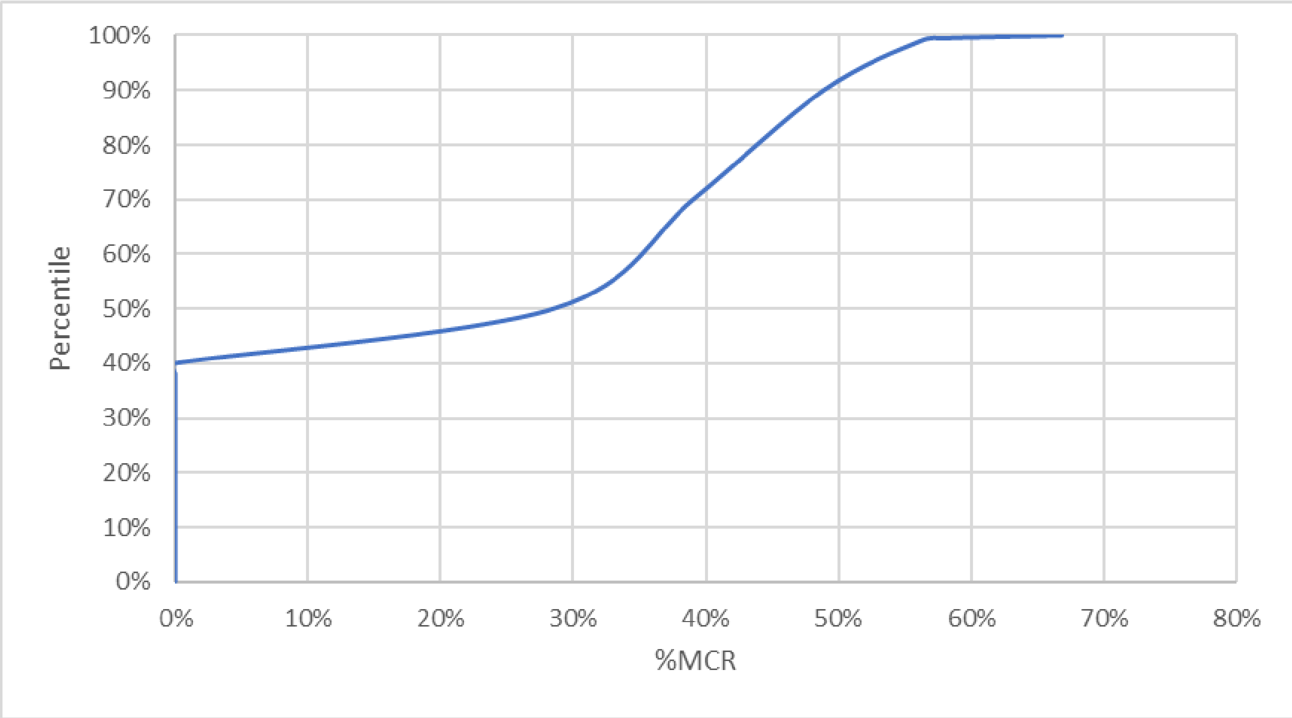

Figure 4: Cumulative distribution of CFB 2 steam output (June 2018 to June 2019).

4.0 NATURE OF AIR DISCHARGES

4.1 General

The energy plants produce hot exhaust air streams containing combustion products and particulates. The latter arise from fly ash, un-combusted carbon fines/soot and from the condensation of organic volatiles within the exhaust air stream.

The main portion of the exhaust flow consists of nitrogen (N_2) and residual oxygen (O_2) from the combustion air. The primary products of combustion include carbon dioxide (CO_2), sulfur dioxide (SO_2), carbon monoxide (CO), water (H_2O) and nitrogen oxides (NO_x). The latter is discharged as NO (nitrogen oxide, approximately 90 %), NO_2 (nitrogen dioxide, approximately 10 %) and some trace levels of nitrous oxide (N_2O).

There is also a range of products of incomplete combustion (PICs) that mainly consist of volatile organic compounds (VOCs, including trace levels of methane), metals and dioxin like compounds. For the BFB option, the extent of metals, PaHs and dioxin/furan compounds within the exhaust air is relatively low compared to the trace levels that are contained within CFB exhaust air. Furthermore, BFBs produce minimal SO_2 emissions.

The condensation of semi-volatile VOCs within the boiler stack and un-burnt carbon particulates (soot) are a key source of fine respirable particulate ($PM_{2.5}$), whereas PM_{10} and larger suspended particulates are derived from these sources as well as larger fractions of fine fly ash and coal fines. VOCs also include trace levels of polyaromatic hydrocarbons (PaHs) and dioxins/furan compounds.

The primary air pollutant impacts that were assessed included SO_2, PM_{10}, $PM_{2.5}$ and NO_2. Ambient impacts of CO and other trace pollutants would be less than minor, or negligible for either energy plant option. Therefore, these have not been included within the assessment scope.

4.2 Coal Analysis

Newvale lignite is used to fire CFBs at the Alliance Mataura site. Test results for this coal's composition and energy content for the period of June 2016 to February 2018 are summarised in Table 2.

Table 2: Newvale coal properties.

Property	Value	Source
Moisture	40.0 %	Average of testing from June 2016 to February 2018.
Ash	3.6 %	Average of testing from June 2016 to February 2018.
Volatile	30.3 %	Average of testing from June 2016 to February 2018.
Fixed Carbon	26.1 %	Average of testing from June 2016 to February 2018.
Gross Calorific Value (as received basis)	15.0 MJ/kg	Average of testing from June 2016 to February 2018.
Hydrogen (dry basis)	4.8 %	CRANZ 1978.
Oxygen (dry basis)	24.6 %	CRANZ 1978.
Nitrogen (dry basis)	0.6 %	CRANZ 1978.
Sulfur (as received basis)	Min 0.38 % Average 0.4 % Max 0.43 %	Testing from June 2016 to February 2018.

4.3 Biomass Analysis

The proposed BFB is capable of being fired on woodchips, or the blend of woodchips and dewatered DAF solids that is produced via a dissolved air flotation (DAF) tank, which is used to treat the site's wastewater. The typical fuel properties of the woodchips, DAF solids and the woodchip/solids blend (75:25) are presented in Table 3. The property data for woodchips and DAF solids are based on:

- BFB request for proposal (RFP) provided by Alliance;
- DAF solids analysis report provided by Alliance;
- Confirmation from the boiler supplier.

Table 3: Biomass properties.

Property	100 % wood	100 % DAF solids	75 % wood, 25 % DAF solids
Moisture (as received basis)	40 %	50 %	43 %
Ash (as received basis)	1 %	1.6 %	1.3 %
Net Calorific Value (as received basis)	11.5 MJ/kg	11.5 MJ/kg	11.5 MJ/kg
Carbon (dry ash free basis)	53 %	71 %	58 %
Hydrogen (dry ash free basis)	6 %	10.3 %	7 %
Oxygen (dry ash free basis)	40.7 %	13.8 %	34 %
Nitrogen (dry ash free basis)	0.3 %	4.4 %	1.3 %
Sulfur (dry ash free basis)	0 %	0.5 %	0.13 %

4.4 Exhaust Flow and Fuel Burning Rates

The CFB and BFB combustion exhaust flow rates (actual and normalised to standard atmospheric pressure and temperature) for each boiler and fuel burning rates were calculated using stoichiometric equations using properties in Table 3 and nominal value of exhaust oxygen content (7.0 vol. % dry for the BFB).

A summary of the stoichiometry calculations is provided in Appendix B. The calculated exhaust discharge parameters for each energy plant option are summarised in Table 4.

The efflux velocity associated with woodchip combustion at 100 % MCR of 15 m/s (Table 4) was used for predicting the air quality impacts for the BFB operation. This is slightly lower than the efflux velocity when firing on a 75:25 blend of wood chips and dewatered DAF solids.

Table 4 highlights the low efflux velocity for the CFB option due to its larger stack diameter and lower maximum output rating of 6.4 MW versus 8 MW for a new BFB energy plant.

Table 4: Stack discharge parameters.

Parameter	CFB 2 (B&W)*	CFB 3 (Boag)	New BFB[#]
	68 % MCR	40 % MCR	100 % MCR
Maximum steam output (kW)	6400	923	8000
Stack height (m) a.g.l	30	20	29
Stack diameter (m)	2.0	0.6	0.76
Efflux velocity (m/s)	2.9	2.3	15
Stack oxygen (vol. % dry)	8	5	7
Efflux temperature (°C)	230	250	170
Assumed efficiency (%)	65	50	75
Fuel burning rate (tonne/hour) *as-received*	2.47	0.2	3.34

Notes: [#] Data relates to combustion of wood chips only. * CFB 2 output allows for infrequent small contributions to total output from the smaller back up CFB 1.

4.5 Contaminant Emission Rates

4.5.1 Coal fired boilers (CFBs)

4.5.1.1 Particulates

With a baghouse filter, the CFB 2's in-stack PM_{10} concentration is expected to achieve an upper limit of 50 mg/Nm^3 (corrected to 12 vol.% CO_2 and dry basis) for its full range steam outputs. Accordingly, a PM_{10} mass emission rate of 0.21 g/s was calculated for operation at 68 % MCR (based on a 65 % combustion efficiency). It is also reasonable to assume that all PM_{10} will be within the $PM_{2.5}$ size fraction for a discharge concentration of 50 mg/Nm^3 (corrected to 12 vol.% CO_2 and dry basis).

The same PM_{10} and $PM_{2.5}$ emission rates for CFB 3 used in the Golder (2020) report was also assumed for this assessment. These are based on CFB 2 stack testing. The PM_{10} mass emission rate of 0.21 g/s was based on maximum in-stack PM_{10} concentration of 640 mg/Nm^3 (corrected to 12 vol.% CO_2 and dry basis) for CFB 2 when operating at 40 % MCR. The $PM_{2.5}$ mass emission rate is assessed to be 0.16 g/s assuming $PM_{2.5}$ is comprised of 80 % of PM_{10}.

A summary of the maximum PM emission rates from the CFBs are as follows:

- CFB 2: PM_{10}: 0.21 g/s, $PM_{2.5}$: 0.21 g/s (68 % MCR);
- CFB 3: PM_{10}: 0.21 g/s, $PM_{2.5}$: 0.17 g/s (40 % MCR).

4.5.1.2 Nitrogen Oxides

The total NO_x emissions from the combustion of coal were calculated using United States Environmental Protection Agency (USEPA) "AP42" emission factors for boilers burning lignite coal (USEPA 1998b, Table 1.7-1). For spreader stoker boilers the emission factor for NO_x formation is 2.9 kg of NO_x per tonne of coal burned and the coal usage is unchanged from that presented in Golder (2020).

Based on the above NO_x emission factor and maximum coal burning rates listed in Table 4 then the following NO_x emissions (as NO_2 mass equivalents) versus operating rate are calculated:

- CFB 2: 1.9 g/s (68 % MCR);
- CFB 3: 0.16 g/s (40 % MCR).

Typically, 90 % of oxides of nitrogen (NO_x) mass discharged from a CFB occur in the form of nitrogen monoxide (NO). The remainder of the NO_x discharge (approximately 10 %), is in the form of nitrogen dioxide (NO_2), with trace levels of nitrates (NO_3) – the latter minor fraction form secondary particulate but are sufficiently minor to exclude from further consideration in this assessment.

Once discharged, NO undergoes oxidation within the atmosphere to form NO_2. The proportion of NO to NO_2 conversion post discharge is calculated based on typical background ozone concentrations and distance from the discharge point (to simulate time). The methodology used to calculate the NO conversion rate is documented in Appendix C.

4.5.1.3 Sulfur Dioxide

Test results for coal sulfur content from June 2016 to February 2018 show the as-received sulfur contents that range from 0.38 wt.% to 0.43 wt.% with an average of 0.4 wt.%. These values are consistent with other published coal sulfur values for New Vale coal (CANZ 2010).

The existing consent condition specified the maximum sulfur content of the coal blend to be 0.6 wt.% (as received). However, for this assessment, a coal sulphur content of 0.45 wt. % is assumed for calculating maximum hourly averaged SO_2 emission rates. This allows for 5 % retention of sulfur within the ash.

The maximum SO_2 emission rates for each CFB are assumed as follows:

- CFB 2: peak rate of 5.86 g/s (68 % MCR);
- CFB 3: peak rate of 0.47 g/s (40 % MCR).

4.5.2 Biomass fired boiler (BFB)

The discharge rate of each contaminant was calculated for firing with both 100 % wood chips and 75:25 blend of woodchips and DAF solids. The higher emission rate for each contaminant was used in the modelling assessment and presented in below.

4.5.2.1 Particulates

When burning 100 % woodchips or a blend (75 % wood and 25 % DAF solids), the emission rate of PM_{10} was based on an exhaust concentration of 50 mg/Nm³ (corrected to 7 % O_2 dry basis). The blend resulted in a higher calculated dry flow rate of 4.5 Nm³/s (corrected to 7 % O_2) compared to 100 % wood chip combustion. The associated PM_{10} mass emission rate is 0.23 g/s. The emission rate of $PM_{2.5}$ will effectively equate to this value.

4.5.2.2 Nitrogen Oxides

NO_x emissions from biomass combustion are based on a discharge concentration upper limit of 3000 mg/m³ (corrected to 7 % O_2 dry STP flow) when firing with the wood/DAF solids blend. The associated maximum NO_x mass emission rate of 13.6 g/s. This is based on all the organic nitrogen within the DAF solids forming NO_x.

Firing with 100 % woodchips results in a much lower NO_x discharge concentration, as wood contains a low nitrogen content.

The same NO to NO_2 conversion rate discussed in Section 4.5.1.2 has been used.

4.5.2.3 Sulfur Dioxide

The blend has an estimated sulphur content of 0.13 % by weight (dry ash free basis) and associated SO_2 mass emission rate of 1.31 g/s when assuming no ash retention.

4.5.3 Summary of emission rates

A summary of the maximum contaminant emission rates for all energy plant is provided in Table 5.

Table 5: Contaminant emission rates from boilers assumed for the assessment.

Contaminants	Emission rate (g/s)		
	CFB 2 (B&W)	CFB 3 (Boag)	New BFB
	68 % MCR	40 % MCR	100 % MCR
SO_2	5.9	0.47	1.31
NO_x	2.0	0.16	13.6
PM_{10}	0.21	0.21	0.23
$PM_{2.5}$	0.21	0.17*	0.23

Notes: * Based on assumption of $PM_{2.5}$:PM_{10} ratio of 0.8 (See Appendix D).

5.0 RECEIVING ENVIRONMENT

5.1 General

Mataura is an urban area in Southland with a population of 1,629 people and 672 households, according to 2018 census information (Statistics New Zealand 2018). Mataura is predominantly residential with commercial and industrial areas. The main source of air pollution in Mataura is from home heating using coal and wood, industrial emissions also contribute to air pollution.

The site is located near the centre of the township and is surrounded by predominantly residential dwellings in all directions, except for directly due north of the plant. The nearest residential dwellings are 110 m to the west, 200 m to the south and 300 m north-east of the main coal-fired boiler (CFB 2). Houses are also located on elevated terrain 210 m east of CFB 2/BFB.

There are commercial properties and buildings located adjacent to the main Alliance processing site on the eastern side of the Mataura River and these are 50 m or more from CFB 2/BFB.

The smaller CFB 3 is located 2 km north of the main CFB 2/BFB and is surrounded by rural land. The nearest residential dwelling is approximately 300 m west of CFB 3.

There are recreational and public facilities surrounding the site include a golf club, school, and various community halls – these are located further away than the nearby residential dwellings and are less sensitive to air contaminant emissions from the site's boilers

5.2 Wind Patterns

The site wind patterns are significantly influenced by the raised terrain running along the eastern side of the Mataura River. As such, southerly and northerly wind conditions tend to align with a north north-east to south southwest bearing and cold air drainage flows can be expected to move along this same bearing and towards the south southwest towards town. Wind roses from the Alliance Mataura ambient monitoring data (April to July 2018) and CALMET data set (2003) are shown in Figure 5. Note that the Mataura monitoring data in this figure only covers the 2018 autumn-winter months. This explains the absence of stronger winds shown for a full year in the CALMET data set. This aside the modelled CALMET wind pattern is consistent with that measured in 2018.

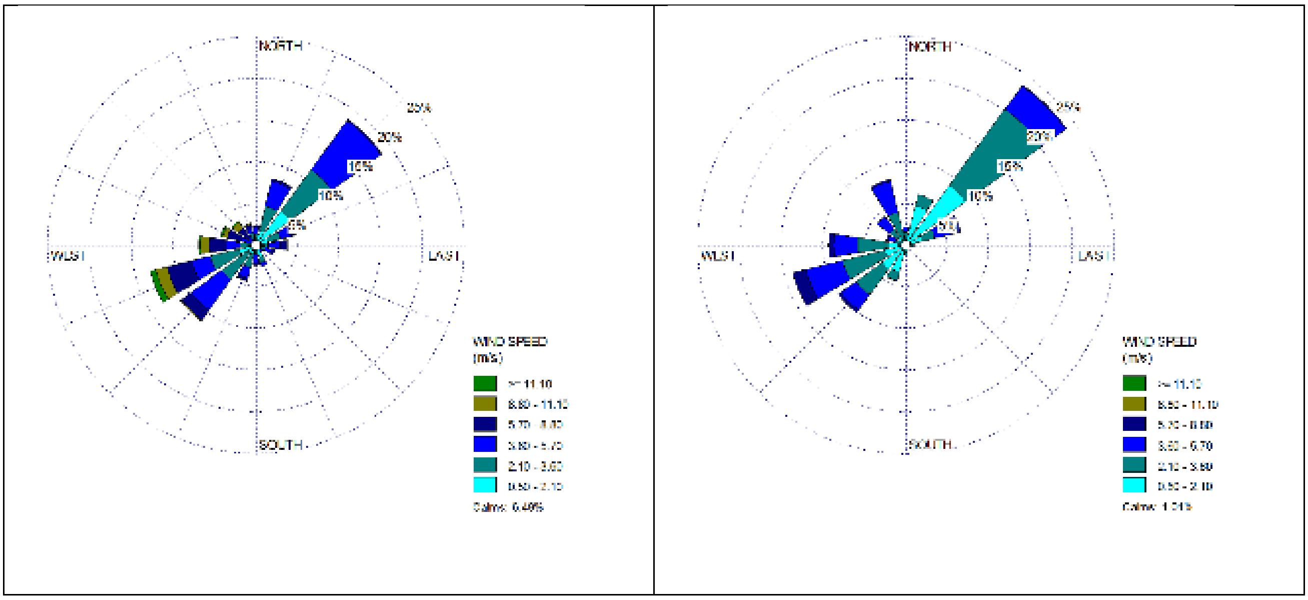

Figure 5: Wind roses: (left) CALMET, (right) ambient monitoring site.

5.3 Existing Ambient Air Quality

Historical ambient PM_{10} monitoring programmes by Environment Southland and Alliance have previously indicated the Mataura airshed is in compliance with the Ministry for the Environment's (MfE) National Environmental Standards (NES) for PM_{10}. However, ambient monitoring reported by Golder (2018) for the period of March to early July 2018 indicates that compliance with the current NES for ambient PM_{10} is not certain, This monitoring also indicates that compliance with proposed NES amendments (currently under consultation) for ambient $PM_{2.5}$ are also not certain. Further, residential home heating is the predominant source of ambient PM_{10} and $PM_{2.5}$ in Mataura during autumn and winter months.

5.3.1 Particulate

Ambient monitoring of PM_{10} and $PM_{2.5}$ was undertaken at two locations and reported by Golder (2018). The first being the elevated terrain immediately to the east of the CFB 2 stack (i.e., at Hillcrest Avenue). The second site was at the southern boundary of Alliance (see Figure 1). The monitoring reported by Golder (2018) is summarised in Appendix D.

A summary of the PM_{10} and $PM_{2.5}$ results are provided in Table 6 and Table 7, Figure 6 and Figure 7.

Table 6: PM_{10} percentiles (24-hour average) measured in Mataura during 2018.

Station	24-hour average PM_{10} concentration (µg/m^3)						NES
	10th percentile	25th percentile	50th percentile	75th percentile	95th percentile	Max	(µg/m^3)
Hillcrest Avenue*	5	7	11	12	15	19	50
Southern boundary#	8	12	16	23	32	46	50

Notes: * Measured from 8 February to 26 March 2018 (Golder 2020). # Measured from April – 4 July 2018 (Golder 2020).

Table 7: $PM_{2.5}$ percentiles (24-hour average) measured in Mataura during 2018.

Station	24-hour average $PM_{2.5}$ concentration (µg/m^3)						WHO
	10th percentile	25th percentile	50th percentile	75th percentile	95th percentile	Max	(µg/m^3)
Hillcrest Avenue	2	3	5	5	7	9	25
Southern boundary	4	7	10	15	23	33	25

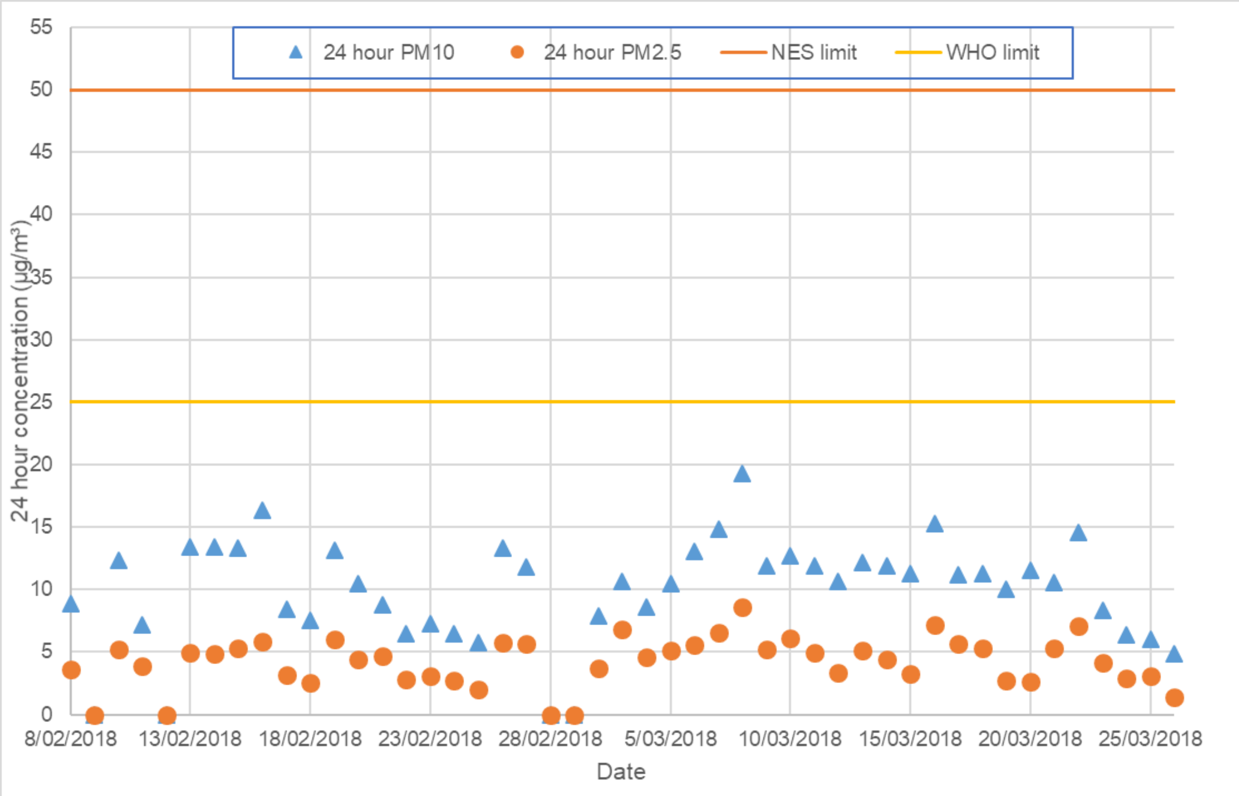

Figure 6: Hillcrest Avenue location: 24-hour average PM_{10} and $PM_{2.5}$ concentrations.

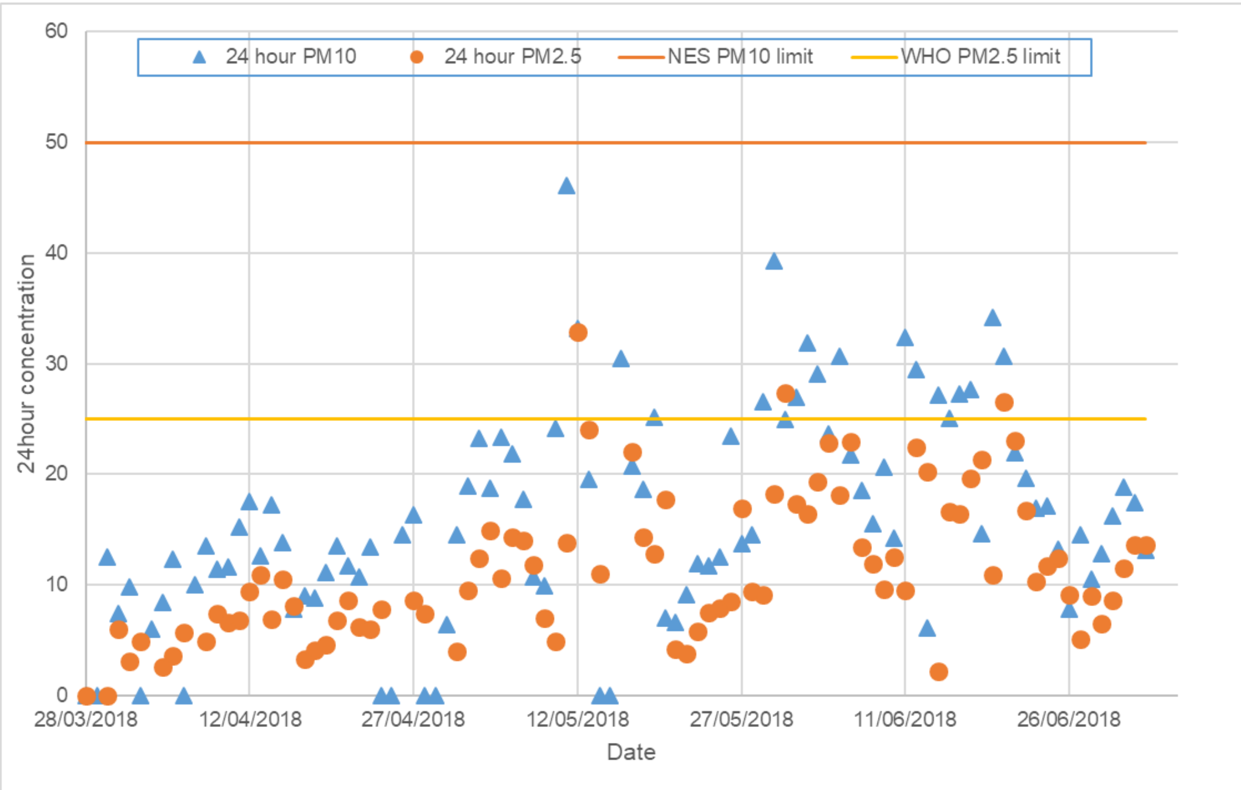

Figure 7: Alliance Southern boundary: 24-hour average PM_{10} and $PM_{2.5}$ concentrations.

5.3.2 Sulphur dioxide

Golder is not aware of recent SO_2 monitoring data that is representative of background for the main township of Mataura. Therefore, data available from Edendale has been reviewed. This monitoring is described in Golder 2013 and summarised in Table 8. Other South Island towns that have had a historical use of coal and where ambient monitoring has been completed include Timaru. The SO_2 monitoring (MfE 2003) in Timaru (1998 to 2001) can also provide an indication of ambient SO_2 concentrations in Mataura (see Table 9). Based on the data from these other South Island towns, background SO_2 concentrations are estimated to be 120 µg/m³, 30 µg/m³ and 5 µg/m³ for 1-hour, 24-hour and annual average, respectively.

Table 8: Summary of the Fonterra Edendale SO_2 monitoring results (Golder 2013).

Processing season	Max. 1-hour SO_2 conc. (µg/m³)	Max. 24-hour SO_2 conc. (µg/m³)	annual average SO_2 conc. (µg/m³)
2002	46	10	3
2003	35	10	2

Table 9: Summary of the Environment Canterbury Timaru SO_2 monitoring (MfE 2003).

Year	Max. 1-hour SO_2 conc. (µg/m³)	Max. 24-hour SO_2 conc. (µg/m³)
1998	92	27
1999	111	36
2000	165	31
2001	123	21

5.3.3 Nitrogen dioxide

Golder is also not aware of any available ambient NO_2 monitoring data in Mataura. In such cases, the Ministry for Environment (MfE 2016) recommends using default background air quality values developed by the New Zealand Transport Agency (NZTA 2014) for NO_2 by census area units (CAU). For Mataura, these values are 58 µg/m³, 38 µg/m³ and 13 µg/m³ for NO_2 (1-hour, 24-hour and annual average, respectively).

These default background values are expected to be conservatively representative for the location of the site and receiving environment.

5.3.4 Summary of the background air quality

The background SO_2 and NO_2 air quality values used for this assessment are provided in Table 10 and the assumed background PM concentrations are provided in Table 11. The values in these table are used in the assessment of cumulative effects provided in sections 8.0 and 9.0.

Table 10: Summary of SO_2 and NO_2 background air quality concentrations.

Contaminant	Averaging period	Background concentration (µg/m³)
SO_2	1-hour	120
	24-hour	30
	Annual	5
NO_2	1-hour	60
	24-hour	40
	Annual	13

Table 11: Summary of estimated background 24-hour particulate versus weather conditions.

Daily Weather Category**	Daily average wind speed (m/s)	Daily average temp.	Percentage of time conditions occur*	PM_{10} (24-hour) µg/m³			$PM_{2.5}$ (24-hour) µg/m³		
				Mean	Upper confidence level#		Mean	Upper confidence level#	
					75th	99th		75th	99th
A	<2	<5 °C	2 %	24	29	38	17	21	29
B	<2	≥5 °C	9 %	20	22	26	13	15	18
C	≥2 and <3	all	25 %	13	13	15	8	9	9
D	≥3	all	64 %	11	12	14	6	7	8

Notes: **Defined by Golder (2020) to assist with this analysis. *Based on annual CALMET meteorological dataset for 2003. # percentage of ambient concentrations are expected to be lower than this number during the weather category.

Table 12: Summary of estimated background annual average particulate.

Location in Mataura	PM_{10} (annual) µg/m³	$PM_{2.5}$ (annual) µg/m³
	Mean	Mean
Township	12	7
Hill top areas	10	4

6.0 ASSESSMENT METHODOLOGY

6.1 General

This assessment was undertaken using a standard air atmospheric dispersion modelling to predict ambient air quality (AAQ) ground level concentrations (GLCs) beyond the Alliance site boundary due to the discharges from the operation of CFB 2, or new BFB and CFB 3. The background contaminant levels in Section 5.0 were added to these increments to assess cumulative concentrations.

This modelling prediction of CFB 2/BFB ambient impacts was supplemented by the availability of ambient monitoring data for PM_{10} and $PM_{2.5}$. Background PM_{10} and $PM_{2.5}$ levels were established for various wind speeds, directions and ambient temperatures throughout the operational week-days and non-operational weekend periods.

6.2 Assessment Criteria

6.2.1 General

Relevant sources of air quality assessment criteria in order of highest priority are listed as follows:

- The ambient air quality standards contained in the NES;
- The Ambient Air Quality Guidelines (AAQG) (MfE/MoH 2002);
- The Regional Air Quality Plan for Southland (unless more stringent than above criteria);
- World Health Organization (WHO 2005);
- California reference levels (OEHAA 2012).

The MfE (MfE 2008) provides recommendations regarding the priority of the various sources of air quality criteria. The order of the air quality criteria reflects these recommendations. World Health Organisation guidelines and California reference levels (OEHAA 2012) should be used for criteria that is not covered by the higher priority sources (i.e., NES, AAQG, Regional Plans).

While the AAQGs are not mandatory, the NES are, and their requirements over-ride those of any regional plan except where such a plan imposes stricter requirements. The NES, AAQG and WHO are discussed below.

6.2.2 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 13 for each air contaminant.

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

- That is in an airshed; and
- That is in the open air; and
- Where people are likely to be exposed to the contaminant.

The exception is that if the discharge is authorised by a resource consent, then the standards do not apply to the site to which that consent applies.

Mataura is not gazetted as a polluted airshed under the NES.

Therefore, the key areas for this assessment in terms of NES compliance are the residential dwellings surrounding the Alliance Mataura site.

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.

6.2.3 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 13.

6.2.4 The Regional Air Quality Plan

There are no specific AAQ criteria that the Southland regional air quality plan specifies that require consideration for this assessment.

6.2.5 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 currently proposing to adopt these ambient guidelines as National Standards.

The WHO guideline for 24-hour SO_2 has not been adopted in New Zealand (either as national standard or guideline, or by any regional council). The current MfE guideline for 24-hour SO_2 is relevant for this assessment.

6.2.6 Summary of criteria

A summary of relevant MfE NES and other air quality criteria are presented in Table 13.

Table 13: Summary of standards and guidelines relevant to this application.

Contaminant	Guideline/standard (µg/m³)	Averaging period	Allowable exceedances per year	Source
SO_2	350	1-hour	9	NES
	570	1-hour	0	NES
	120	24-hour	0	MfE AAQG
	30	Annual	0	MfE AAQG
NO_2	200	1-hour	9	NES
	100	24-hour	0	MfE AAQG
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.

6.3 Atmospheric Dispersion Modelling

Dispersion modelling was carried out using CALPUFF, version 7.2.1. CALPUFF is used commonly throughout the world to model AAQ impacts of a variety of sources, including industrial ventilation outlets. Version 6 of the model is described by TRC (2011a). CALPUFF's dispersion modelling is driven by complex CALMET meteorological inputs and is a more appropriate system for modelling point source industrial discharges to air. The CALMET input files provide key information on the terrain and land use variations and hourly varying meteorology in three dimensions. These files are themselves created using a combination of data from prognostic weather model, TAPM version 4 and data from climate stations. The inputs and setup is described in Appendix F. In summary, the ambient effects modelling process requires the following order of modelling and inputs:

- TAPM weather modelling for one year for the Southland region but starting for approximately 1000 km by 1000 km grid;
- CALMET diagnostic meteorological modelling for the same years for the Mataura area using inputs from TAPM and local meteorological data and terrain and land use information. Nested CALMET modelling using finer resolution terrain and land use information;
- CALPUFF dispersion modelling of AAQ impacts due to the CFB discharges to air using CALMET meteorological inputs and CFB stack discharge parameters;
- Data sets outputted from CALPUFF providing ambient contaminant concentrations within the Mataura area for ground level and elevated receptors.

The complex terrain precludes the use of Gaussian models such as AERMOD for modelling ambient impacts from the CFB stacks.

6.3.1 Dispersion model configuration

Appendix E provides a summary of the CALPUFF input settings. It is noted that the PDF function for convective meteorological conditions was turned on for air dispersion modelling.

6.3.2 Emission rate assumptions

Normal maximum operating rates for all hours of the year were assumed for the air quality impact assessment of each energy supply option.

The use of fixed maximum emission rates overstates the actual long term and daily average AAQ impacts but provides realistic peak 1-hour predictions.

6.3.3 Meteorological modelling

The meteorological input files that were key inputs to CALPUFF were generated using its companion model, CALMET. This provides hourly, three-dimensional fields of meteorological parameters including as wind, temperature, humidity, isolation and rainfall. 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 a combination of local surface stations and outputs of the prognostic model TAPM (for an introduction to TAPM, see Hurley et al., 2005). The setup configuration of the CALMET modelling run is provided in Appendix F.

6.3.4 Building effects and elevated receptors

There are surrounding tall buildings on the Alliance site (but not off site) that could influence the dispersion of the plume discharged from CFB 2/BFB. Building heights and footprints were inputted to the CALPUFF configuration along with the local terrain heights and land use information available via the CALMET data files.

6.3.5 Nitrogen dioxide formation

The procedures for accounting for the transformation of NO_x emissions into ambient hourly and annual average NO_2 concentrations is provided in Appendix C**.**

7.0 AIR DISCHARGE MODELLING RESULTS

7.1 Introduction

This section of the report provides a summary of the dispersion modelling predictions for ground level concentrations (GLCs) of contaminants discharged from the proposed two operational scenarios. In Section 8.0 and Section 9.0, the results for each of the two operational scenarios are combined with estimated background ambient air contaminant concentrations to assess cumulative impacts.

Model predictions are made for the following:

- 9th highest (99.9th percentile) 1-hour average concentration (the probable maximum value);
- Maximum 24-hour average concentrations;
- Annual average concentrations.

Predicted GLCs are presented for the four most impacted off-site residential dwellings. The GLC contour plots are presented for the different averaging periods that are relevant to each contaminant's standard and guideline criteria. The GLC contour plots highlight the following:

- Site boundary - indicated by the red line;
- Location of the boiler stacks - marked with a light blue dot;
- Location of the most impacted residential dwelling (MIRD) - marked with a green cross;
- Location of the ambient monitoring sites - marked with a red cross.

7.2 Coal Fired Boiler #2 with Full Bag House

7.2.1 Particulate matter

7.2.1.1 Respirable Particulate - PM_{10}

Contour plots of the predicted maximum 24-hour average and annual average PM_{10} concentrations are provided in Figure 8 and Figure 9 respectively for the option of operating CFB 2 with a full bag house and alongside the smaller CFB 3.

The maximum off-site 24-hour average PM_{10} concentration of 18 µg/m³ occurs at the north-eastern boundary of the hide plant, on a small strip of land between two Alliance owned properties, where the highest off-site annual average PM_{10} concentration of 1 µg/m³ also occurs.

The residential dwelling (House #1) is predicted to be the most impacted receptor, with the highest increase in 24-hour average PM_{10} of 2.3 µg/m³ and annual average of 0.2 µg/m³ due to CFB 2 at 68 % MCR. The distant CFB 3 has an insignificant contribution.

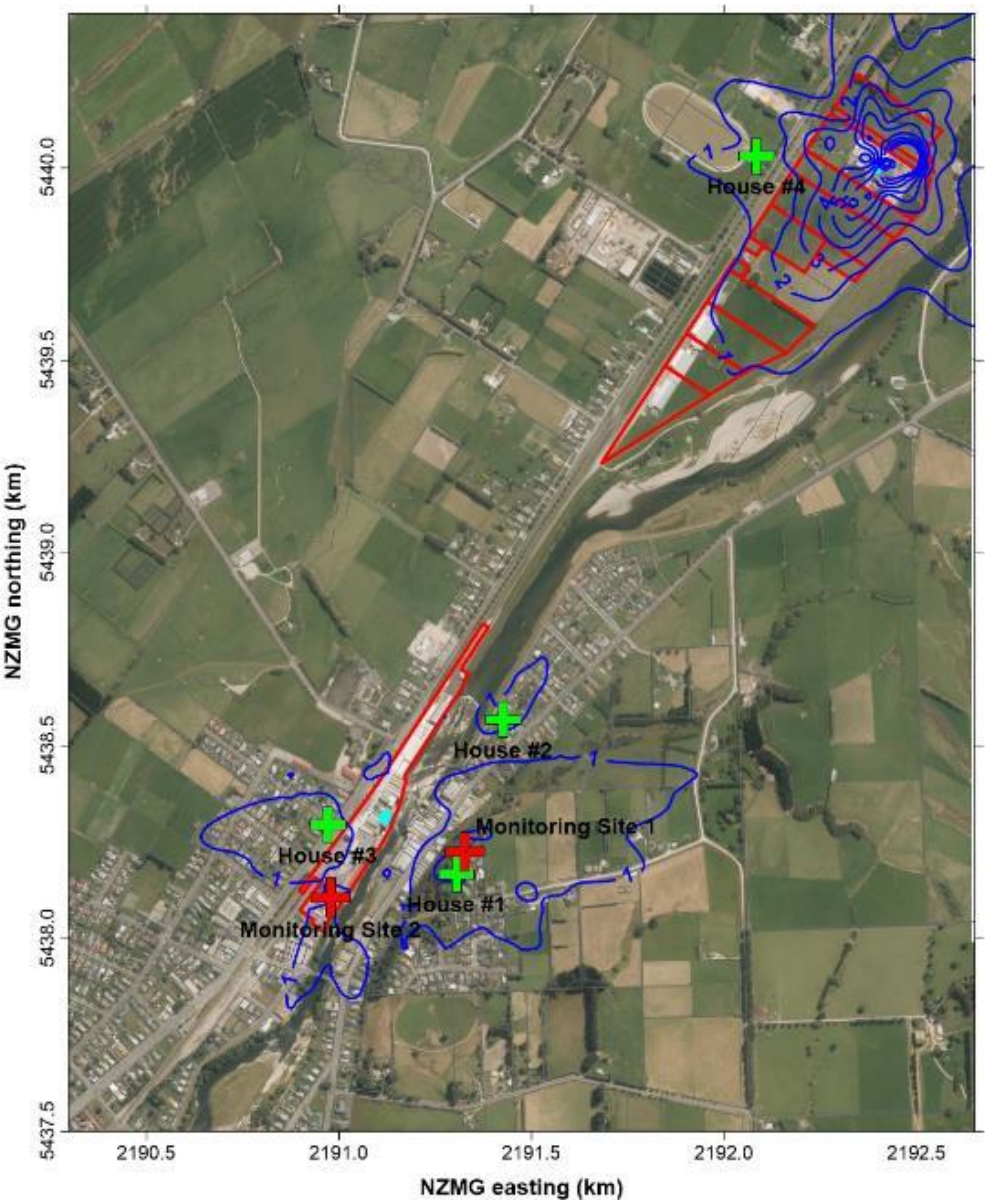

Figure 8: Predicted maximum 24-hour average PM_{10} ground level concentrations (µg/m^3), excluding background concentrations. CFB 2 at 68 % MCR, CFB 3 at 40 % MCR.

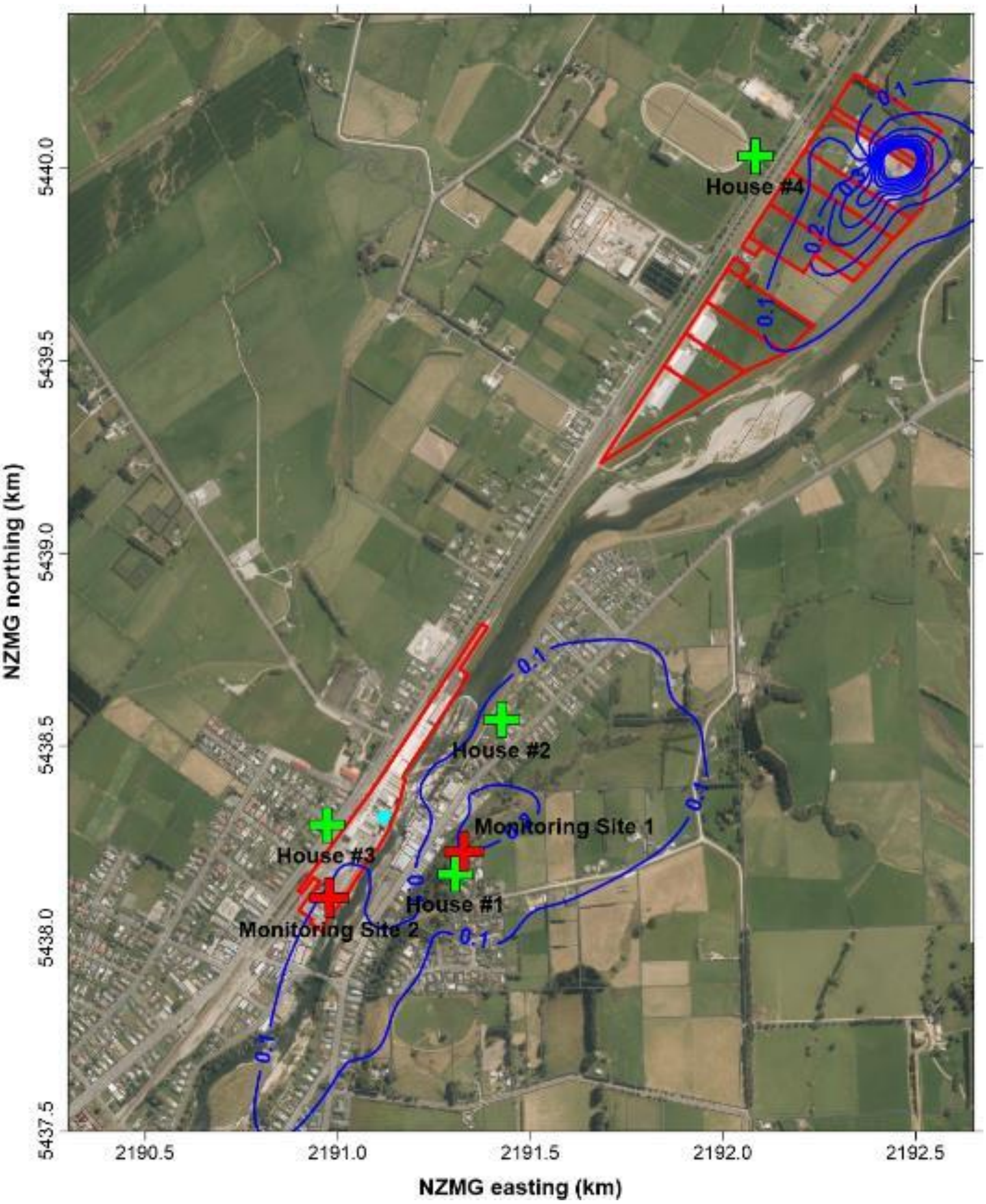

Figure 9: Predicted maximum annual average PM_{10} ground level concentrations ($\mu g/m^3$), excluding background concentrations. CFB 2 at 68 % MCR, CFB 3 at 40 % MCR.

7.2.1.2 Fine Particulate - $PM_{2.5}$

Contour plots of the predicted maximum 24-hour average and annual average $PM_{2.5}$ concentrations are provided in Figure 10 and, Figure 11.

The maximum off-site 24-hour average $PM_{2.5}$ concentration of 12 µg/m³ occurs at the north-eastern boundary of the hide plant, on a small strip of land between two Alliance owned properties, which is close to the location of the highest off-site annual average $PM_{2.5}$ concentration of 1 µg/m³.

The residential dwelling (House #1) is predicted to be the most impacted receptor, with the highest increase in 24-hour average $PM_{2.5}$ of 2.3 µg/m³ and annual average of 0.2 µg/m³ due to CFB 2 at 68 % MCR. The distant CFB 3 has an insignificant contribution.

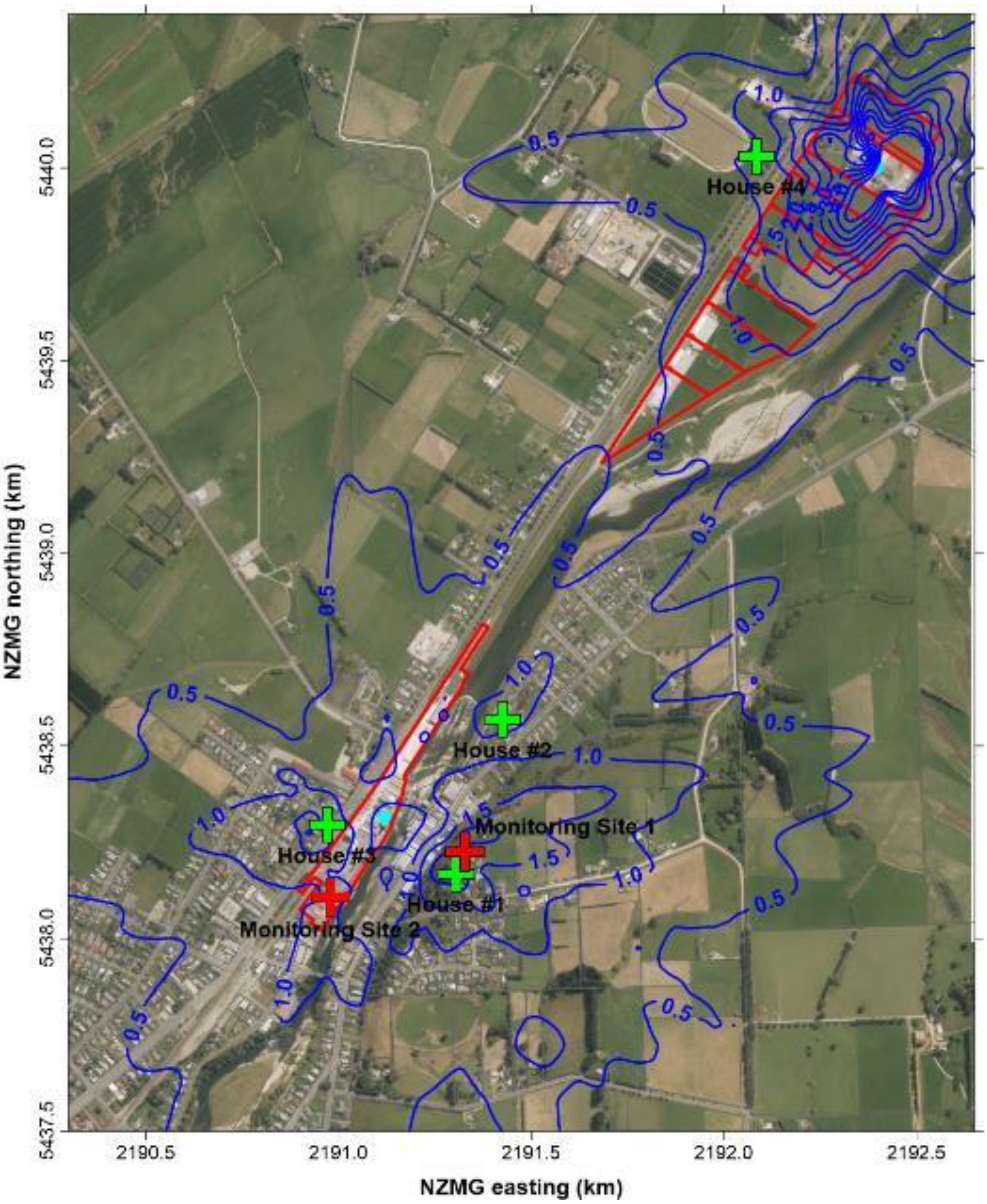

Figure 10: Predicted maximum 24-hour average $PM_{2.5}$ ground level concentrations (µg/m³), excluding background concentrations. CFB 2 at 68 % MCR, CFB 3 at 40 % MCR.

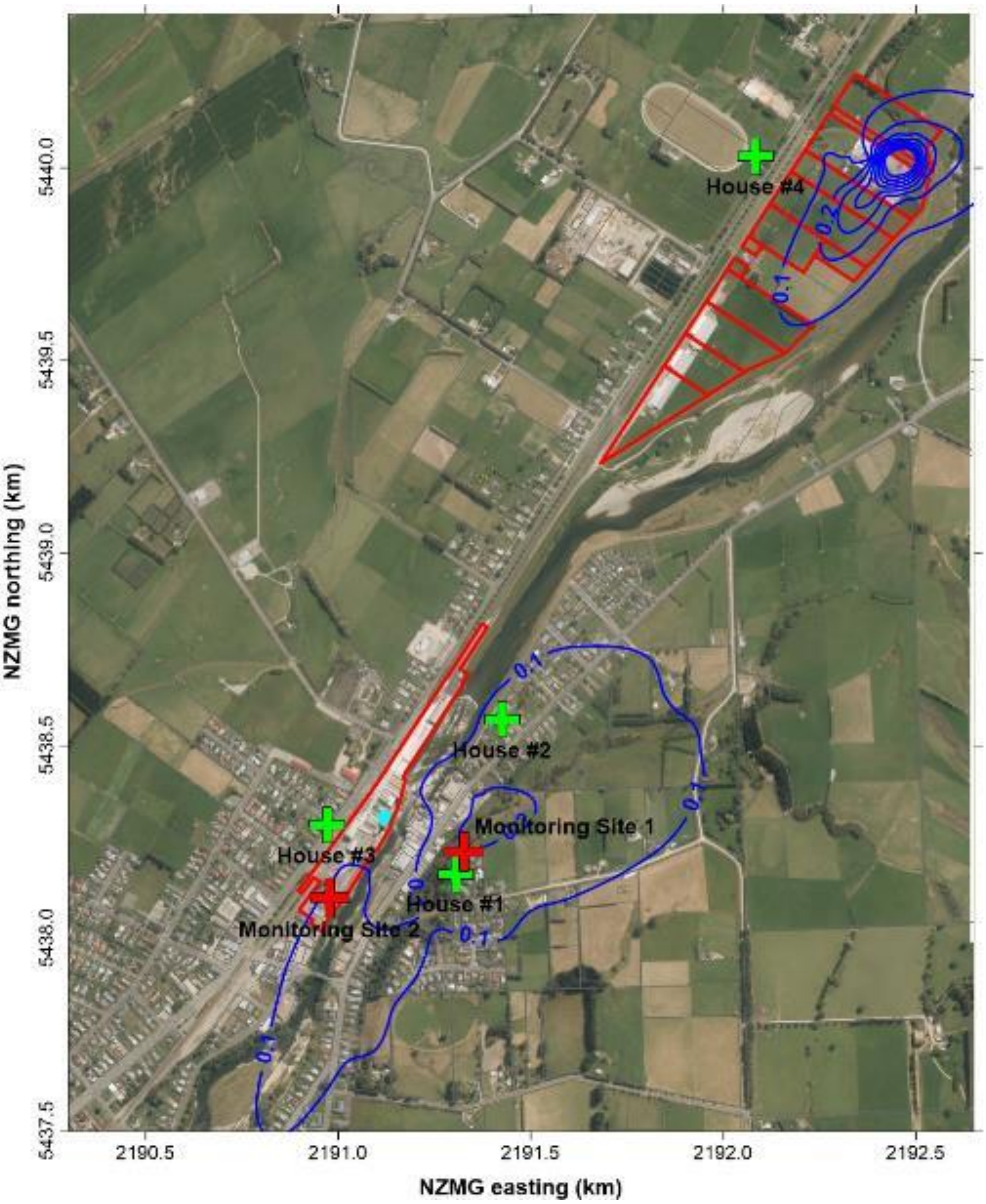

Figure 11: Predicted maximum annual average $PM_{2.5}$ ground level concentrations (μg/m^3), excluding background concentrations. CFB 2 at 68 % MCR, CFB 3 at 40 % MCR.

7.2.2 Nitrogen dioxide

Contour plots of the predicted 1-hour average (99.9th percentile value) and maximum modelled 24-hour average concentrations are provided in Figure 12 and Figure 13 respectively for the option of operating CFB 2 with a full bag house.

The highest 1-hour NO_2 impact of 20 µg/m^3 occurs 250 m north-east of CFB 3[2]. The maximum 24-hour average NO_2 impact of 4 µg/m^3 occurs at the same location.

Residential dwellings to the north-east and east of the CFB 2 (including House #2) are predicted to have a maximum increase in 1-hour average NO_2 of 7 µg/m^3 , while dwellings near House #1 have a maximum increase in 24-hour average of 3 µg/m^3 due to CFB 2 at 68 % MCR.

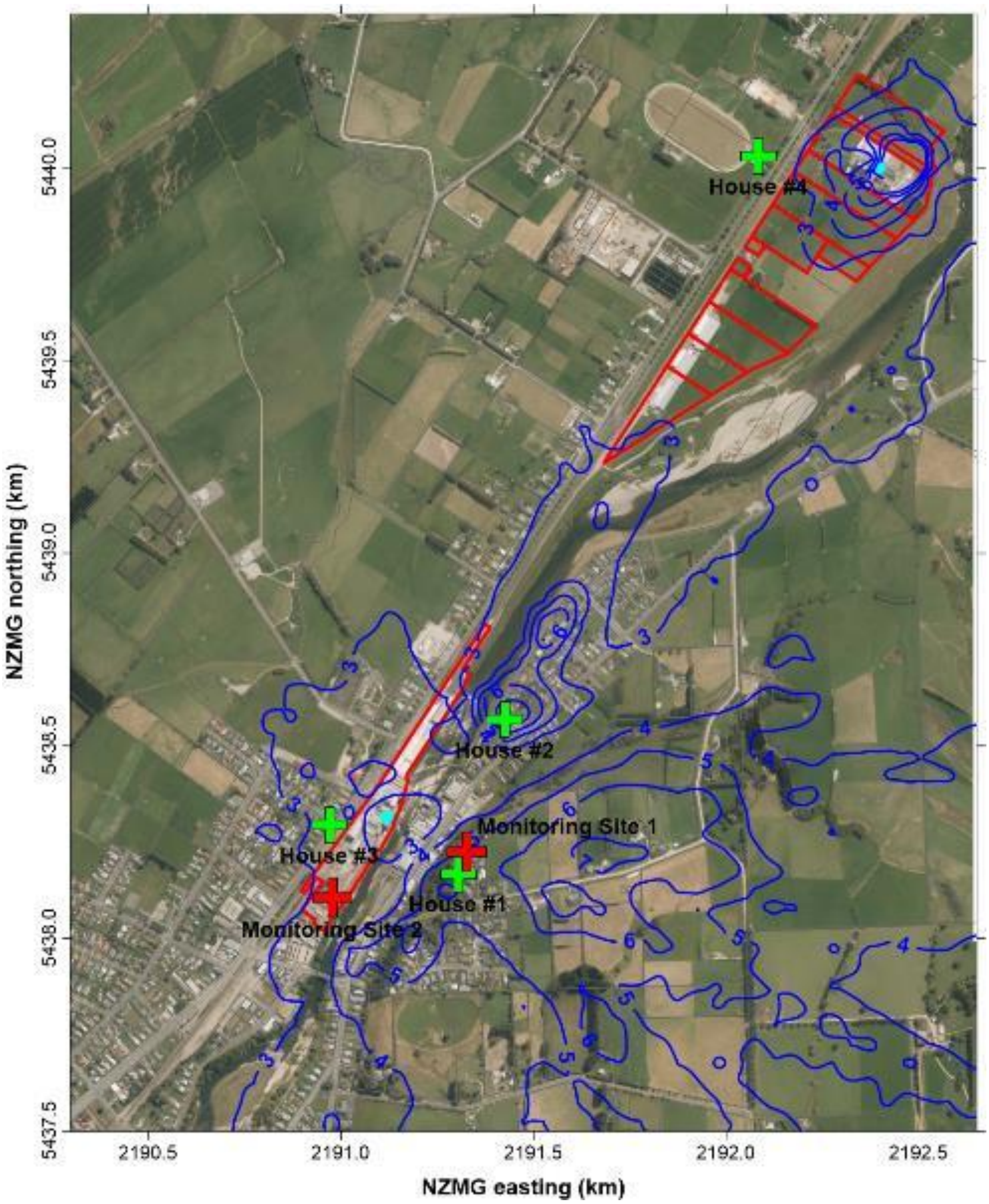

Figure 12: Predicted maximum 1-hour average NO_2 ground level concentrations (µg/m^3) (99.9th percentile value), excluding background concentrations. CFB 2 at 68 % MCR, CFB 3 at 40 % MCR.

[2] Note this is at a small area inside the 4 µg/m³ adjacent to the site boundary.

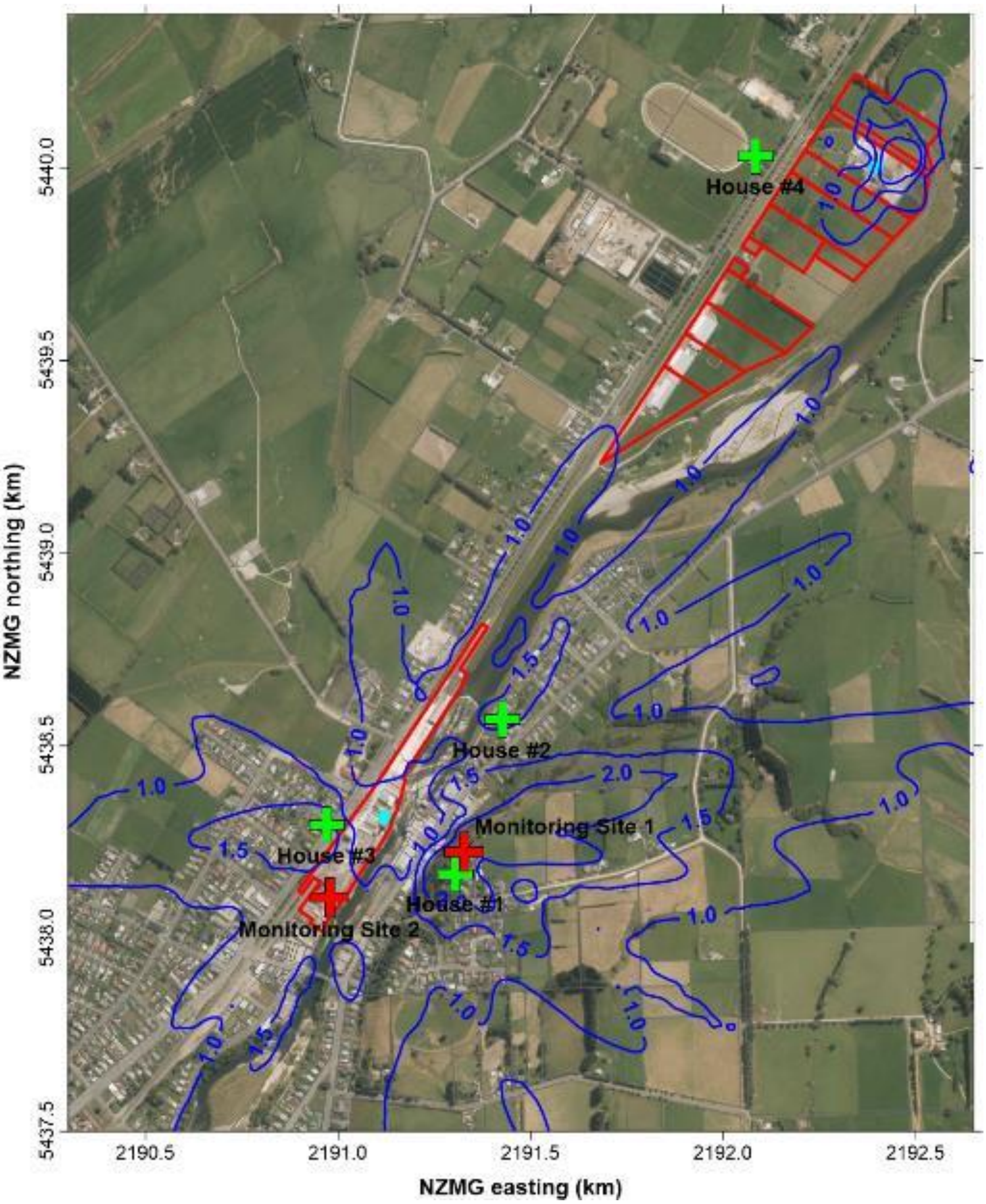

Figure 13: Predicted maximum 24-hour average NO_2 ground level concentrations (µg/m^3), excluding background concentrations. CFB 2 at 68 % MCR, CFB 3 at 40 % MCR.

7.2.3 Sulfur dioxide

Contour plots of the predicted 1-hour maximum (99.9th percentile modelled value), 24-hour average and annual average SO_2 concentrations are provided in Figure 14, Figure 15 and Figure 16, respectively for the option of operating CFB 2 with a full bag house.

The most impacted residential dwellings (House #1 and #2) are predicted to have a maximum increase in 1-hour average SO_2 of close to 125 µg/m³ due to CFB 2 at 68 % MCR. The highest 1-hour SO_2 impact of 180 µg/m³ occurs 85 m north-east of CFB 3. The maximum 24-hour average SO_2 impact of 67 µg/m³ occurs 200 m east of CFB 2, close to House #1. The same dwelling is close to the location of the highest predicted annual average SO_2 concentration of 5 µg/m³.

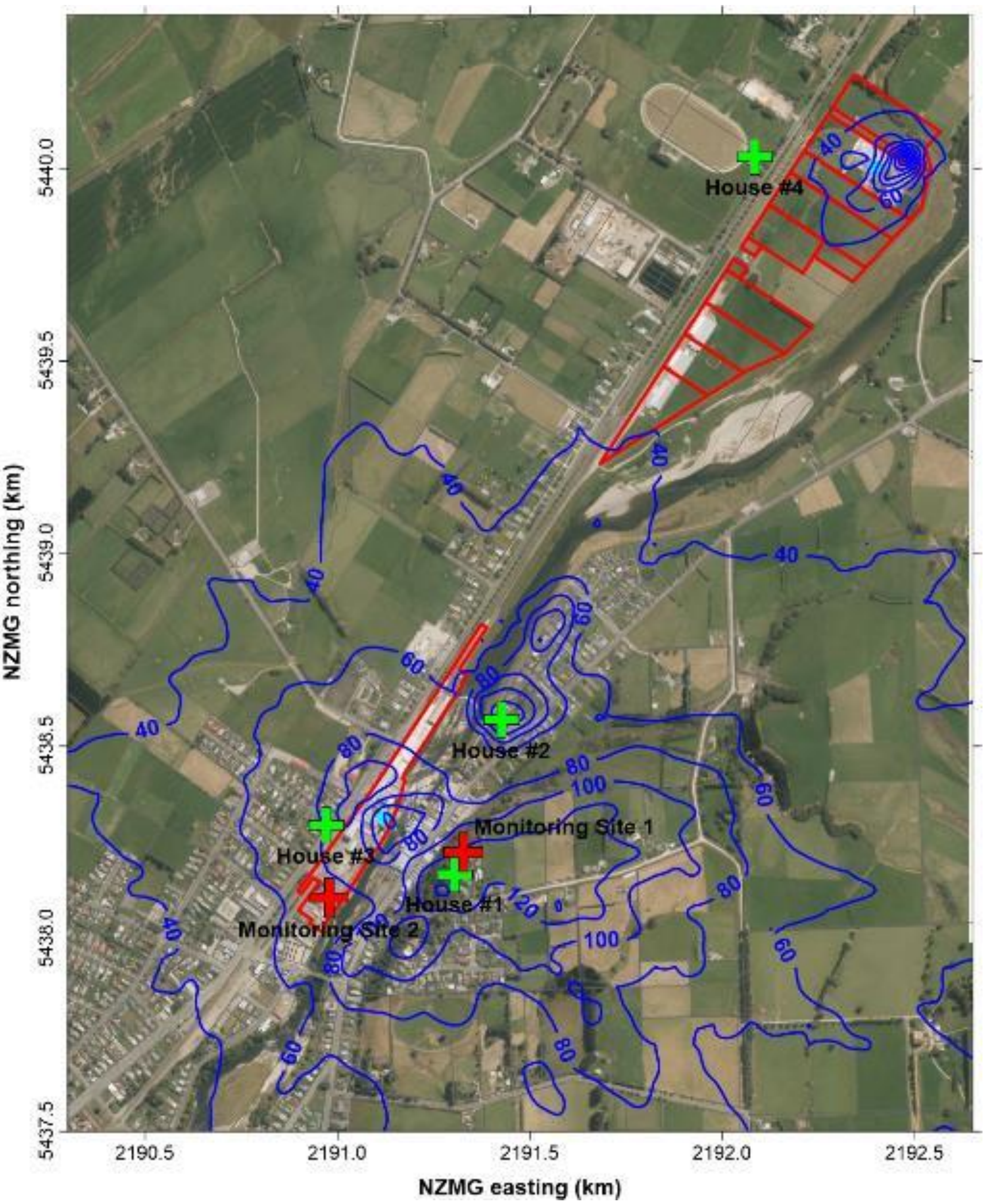

Figure 14: Predicted maximum 1-hour average SO_2 ground level concentrations (µg/m³) (modelled 99.9th percentile value), excluding background concentrations. CFB 2 at 68 % MCR, CFB 3 at 40 % MCR.

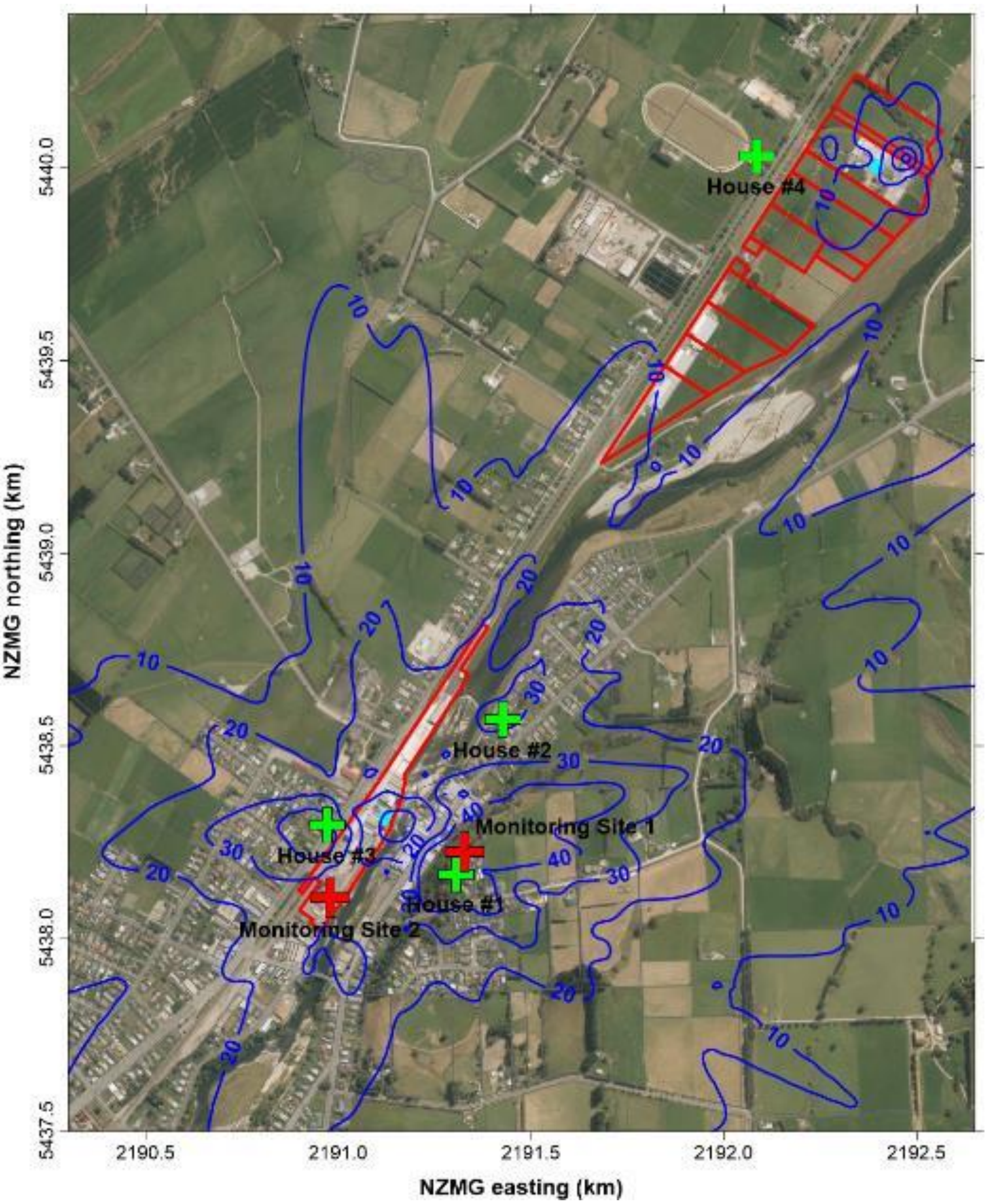

Figure 15: Predicted maximum 24-hour average SO_2 ground level concentrations($\mu g/m^3$), excluding background concentrations. CFB 2 at 68 % MCR, CFB 3 at 40 % MCR.

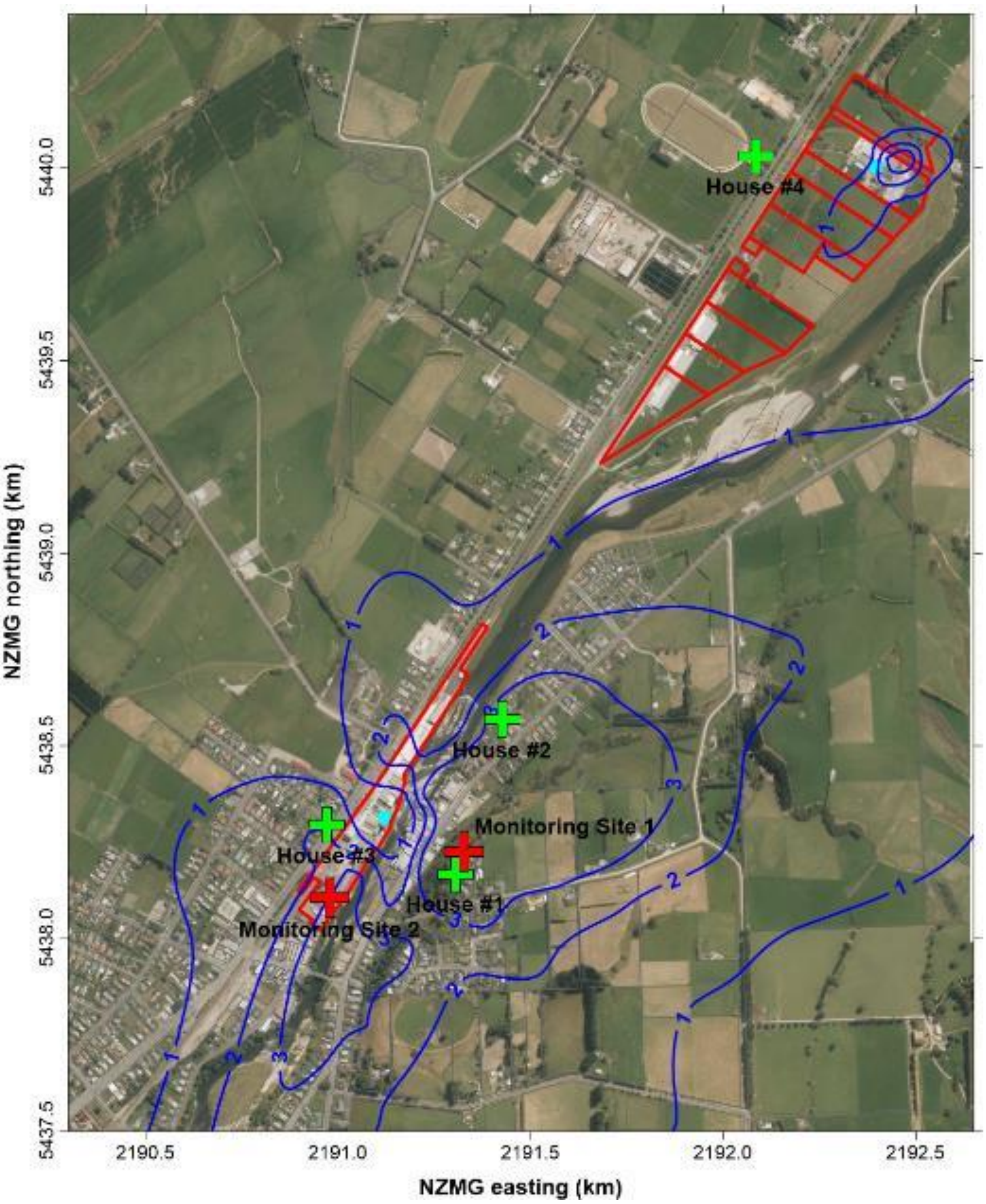

Figure 16: Predicted annual average SO_2 ground level concentrations ($\mu g/m^3$), excluding background concentrations. CFB 2 at 68 % MCR, CFB 3 at 40 % MCR.

7.3 Biomass Fired Boiler

7.3.1 Particulate matter

7.3.1.1 Respirable Particulate - PM_{10}

Contour plots of the predicted maximum 24-hour average and annual average PM_{10} concentrations modelled for the operation of BFB along with CFB 3 at the hide plant are provided in Figure 17 and Figure 18 respectively.

The maximum off-site 24-hour average PM_{10} concentration of 18 µg/m³ occurs at the north-eastern boundary of the hide plant, on a small strip of land between two Alliance owned properties. This is also close to the location where the highest off-site annual average PM_{10} concentration of 1 µg/m³ occurs.

The residential dwelling (House #1) is predicted to have the highest increase in 24-hour average PM_{10} (i.e., 2.3 µg/m³) due to BFB at 100 % MCR. The distant CFB 3 has an insignificant contribution to this dwelling. This dwelling is expected to have the maximum increase in annual average PM_{10} (i.e., 0.2 µg/m³).

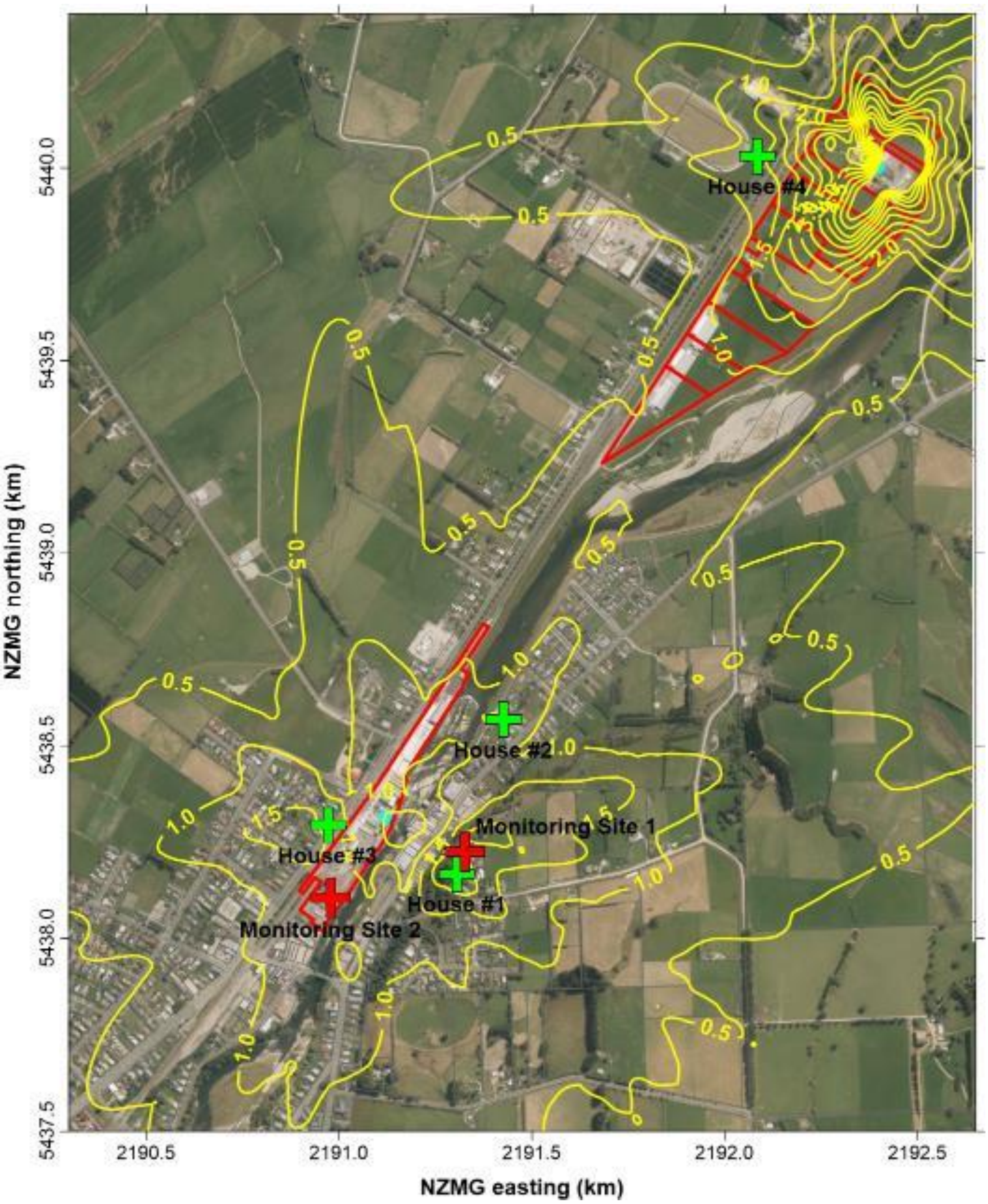

Figure 17: Predicted maximum 24-hour average PM_{10} ground level concentrations (µg/m³), excluding background concentrations. BFB at 100 % MCR, CFB 3 at 40 % MCR.

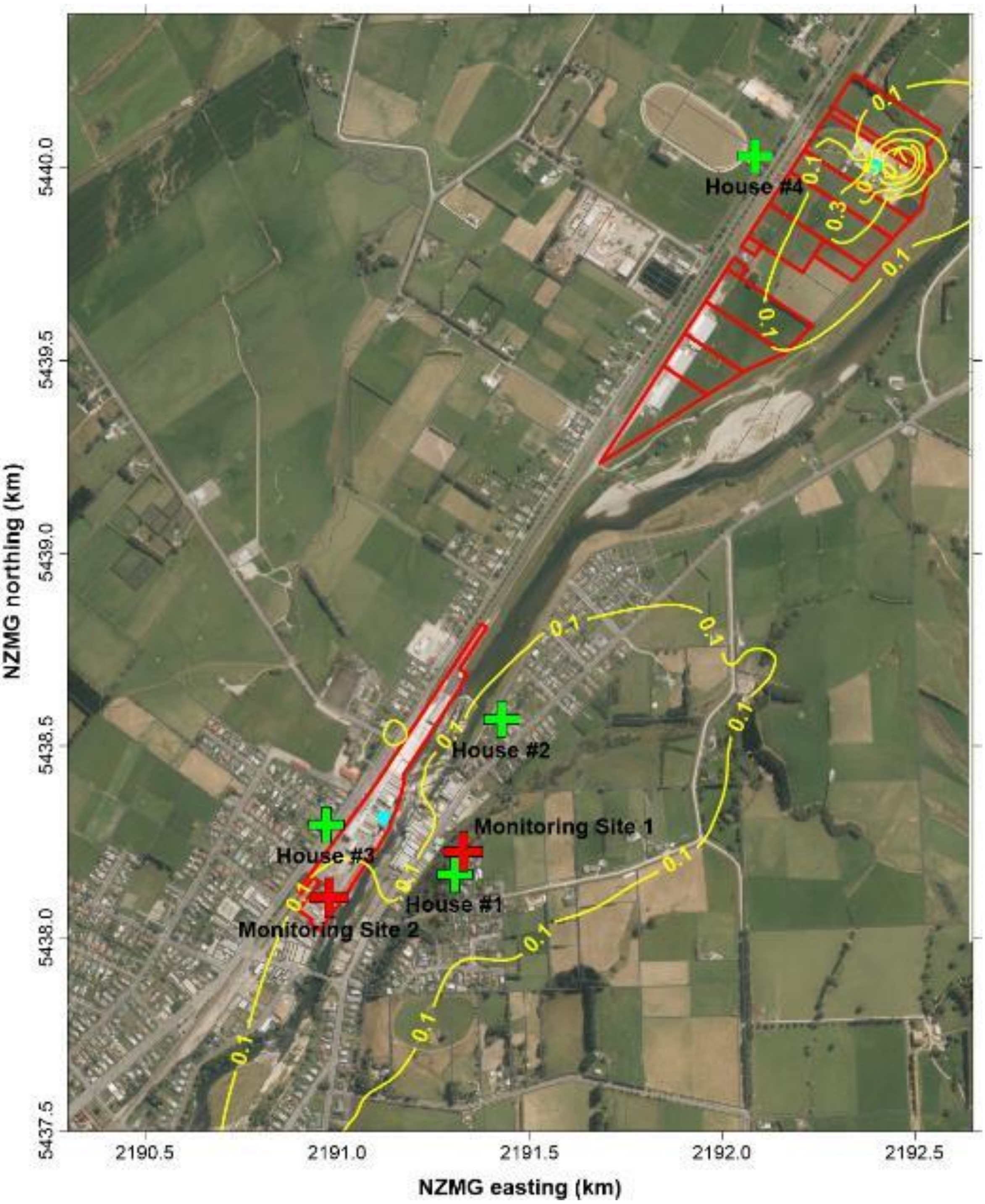

Figure 18: Predicted maximum annual average PM_{10} ground level concentrations ($\mu g/m^3$), excluding background concentrations. BFB at 100 % MCR, CFB 3 at 40 % MCR.

7.3.1.2 Fine Particulate - $PM_{2.5}$

Contour plots of the predicted maximum 24-hour average and annual average $PM_{2.5}$ concentrations modelled for the operation of BFB along with CFB 3 at the hide plant are shown in Figure 19 and Figure 20, respectively.

The highest off-site 24-hour $PM_{2.5}$ ground level concentration of 12 µg/m^3 occurs at the north-eastern boundary of the hide plant, on a small strip of land between two Alliance owned properties, which is close to the location where the highest off-site annual average $PM_{2.5}$ concentration of 1 µg/m^3 occurs.

The residential dwelling (House #1) is predicted to have the highest increase in 24-hour average $PM_{2.5}$ (i.e., 2.3 µg/m^3) due to BFB at 100 % MCR. The more distant CFB 3 has an insignificant contribution to this dwelling. This dwelling is also expected to have the maximum increase in annual average PM_{10} (i.e., 0.2 µg/m^3).

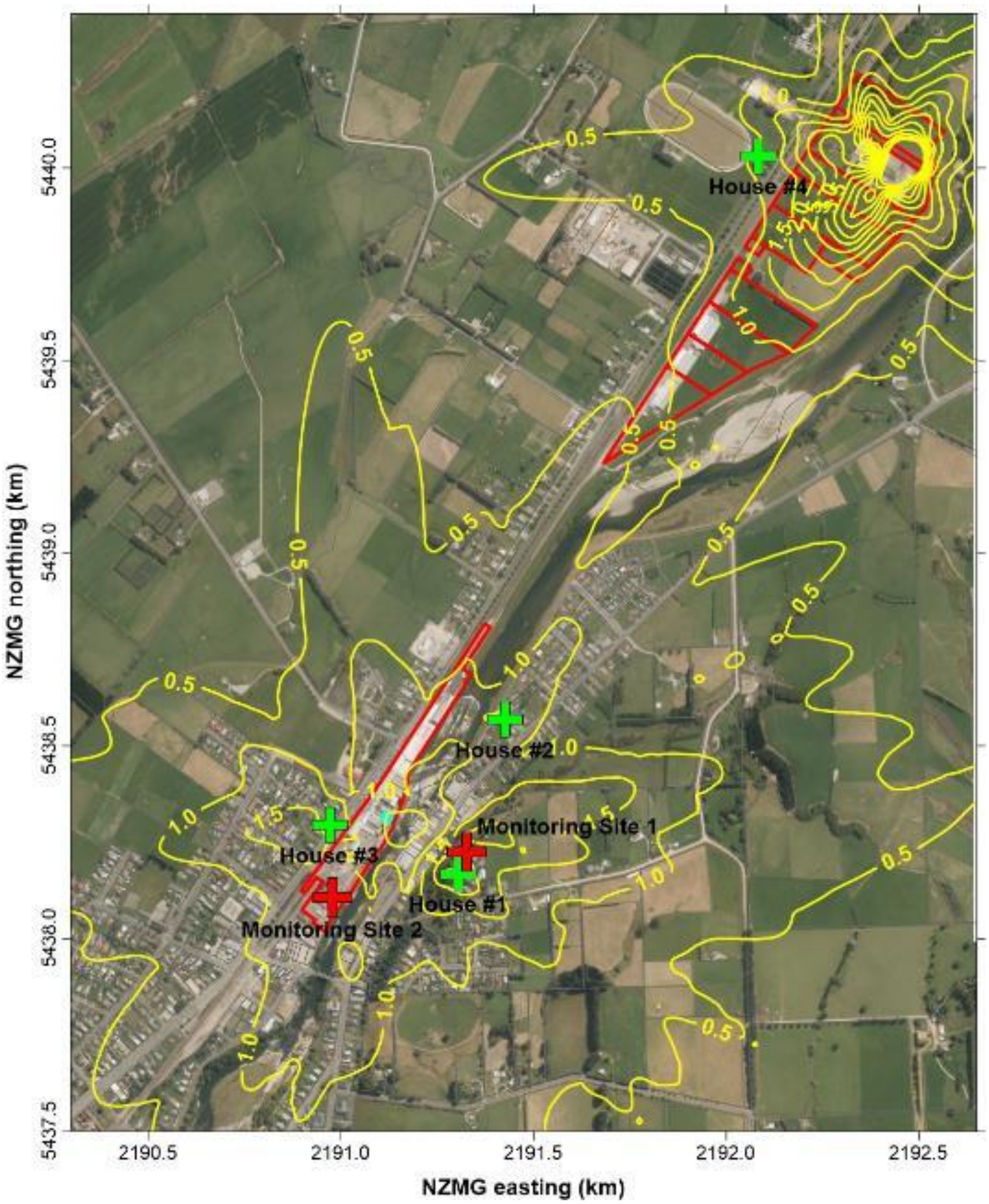

Figure 19: Predicted maximum 24-hour average $PM_{2.5}$ ground level concentrations (µg/m^3), excluding background concentrations. BFB at 100 % MCR, CFB 3 at 40 % MCR.

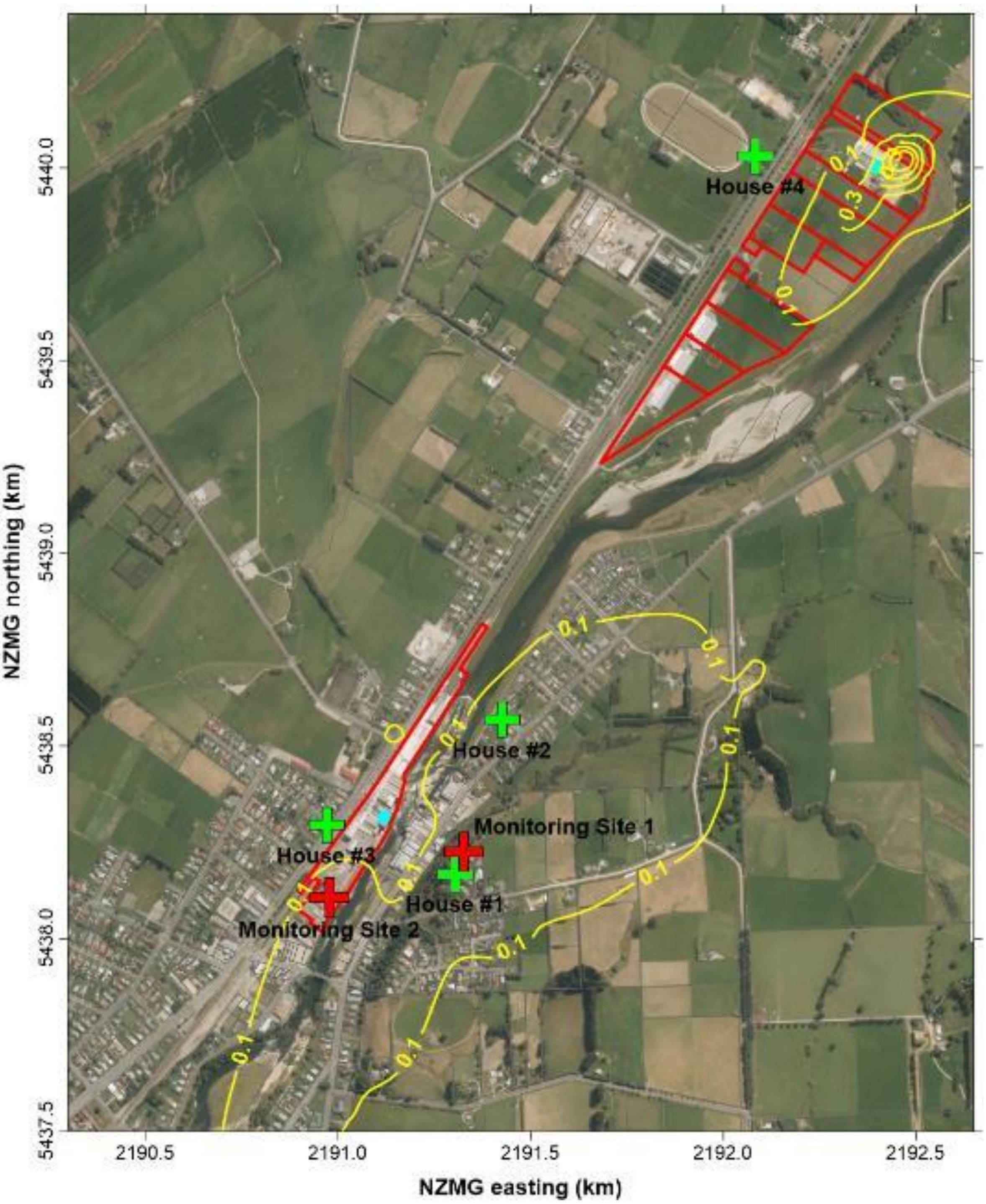

Figure 20: Predicted maximum annual average $PM_{2.5}$ ground level concentrations (µg/m^3), excluding background concentrations. BFB at 100 % MCR, CFB 3 at 40 % MCR.

7.3.2 Nitrogen dioxide

Contour plots of the predicted maximum 1-hour average (99.9th percentile modelled) and maximum modelled 24-hour average concentrations are provided in Figure 21 and Figure 22 respectively for the BFB option, when burning a blend of wood chips and DAF solids (worst case for NO_2 impacts).

The highest 1-hour NO_2 off-site impact of 58 µg/m^3 occurs at 550 m south-east of the BFB. Residential dwellings to the north-east and east of BFB (including House #2) are predicted to have a maximum increase in 1-hour average NO_2 of approximately 50 µg/m^3 due to BFB at 100 % MCR.

Residential dwelling (House #1) is close to the location where the maximum 24-hour NO_2 impact of 20 µg/m^3 is predicted (i.e., 250 m south-east of BFB).

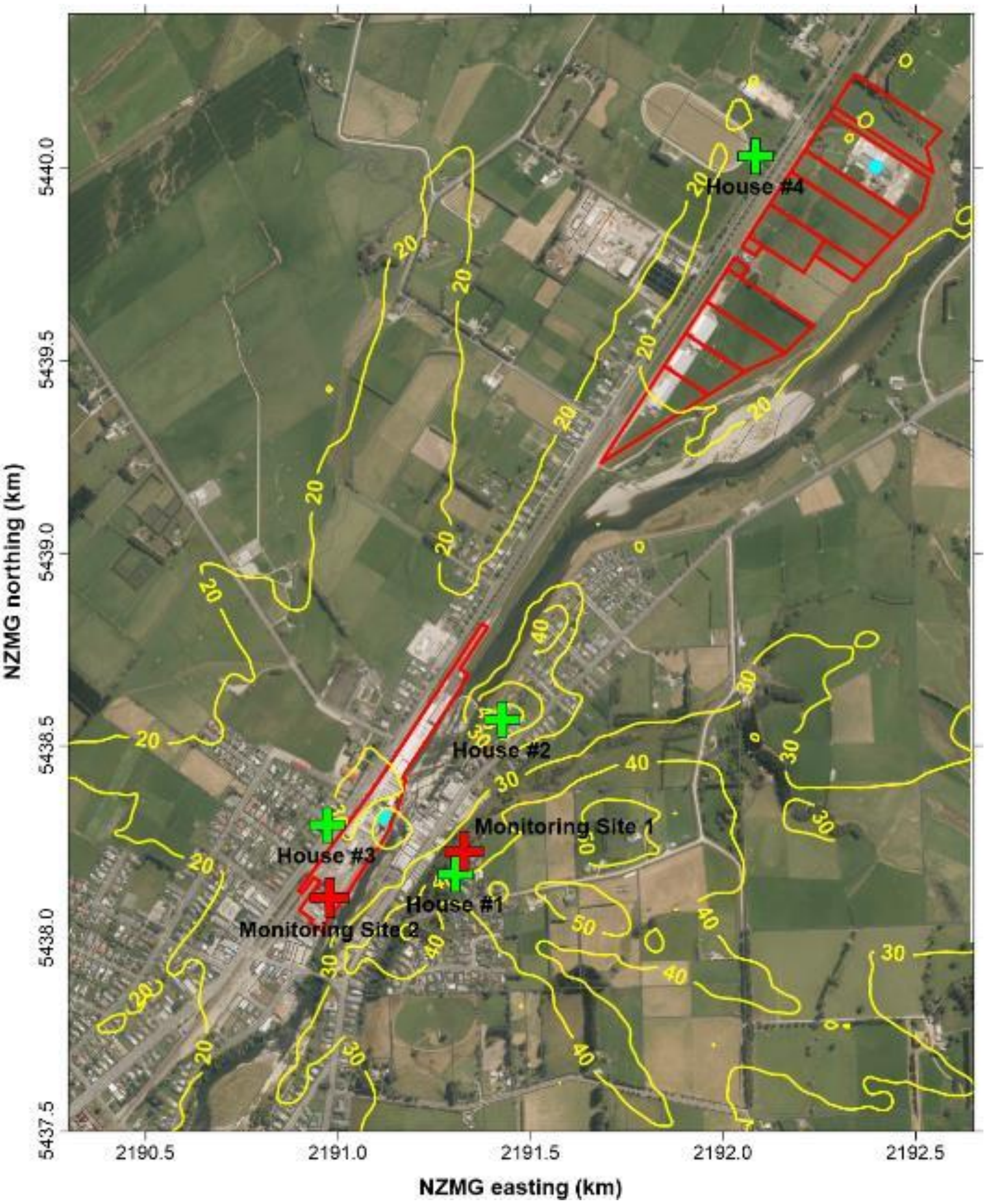

Figure 21: Predicted maximum 1-hour average NO_2 ground level concentrations (µg/m^3) (99.9th percentile value), excluding background concentrations. BFB at 100 % MCR, CFB 3 at 40 % MCR.

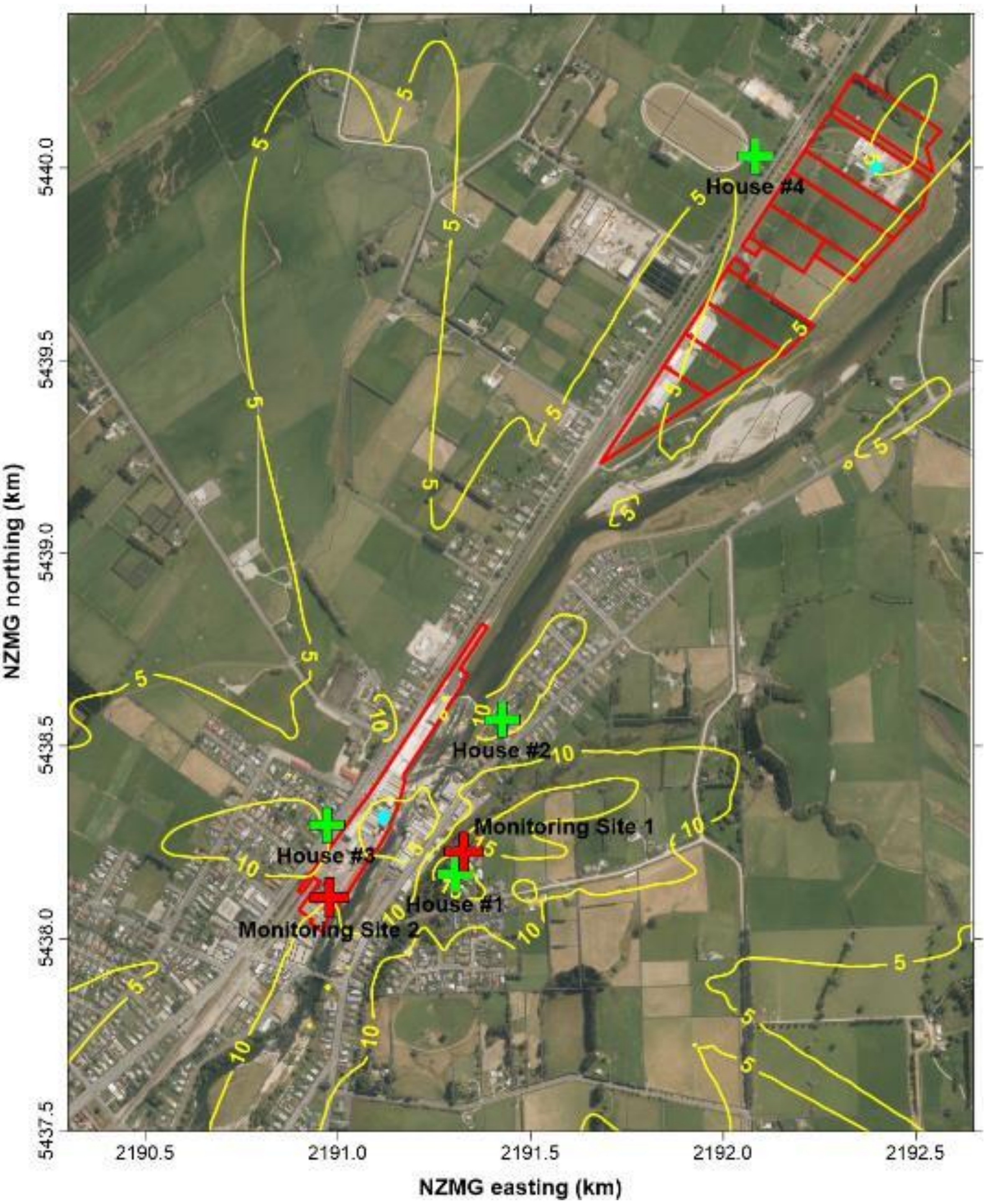

Figure 22: Predicted maximum 24-hour average NO_2 ground level concentrations ($\mu g/m^3$), excluding background concentrations. BFB at 100 % MCR, CFB 3 at 40 % MCR.

7.3.3 Sulfur dioxide

Contour plots of the predicted 1-hour maximum (99.9th percentile modelled value), 24-hour average and annual average SO_2 concentrations are provided in Figure 23, Figure 24 and Figure 25, respectively for the BFB option, when burning a blend of wood chips and DAF solids (worst case for SO_2 impacts).

The highest off-site 1-hour SO_2 impact of 174 µg/m³ occurs 85 m north-east of CFB 3, where the highest 24-hour SO_2 concentration of 40 µg/m³ and annual average of 3.5 µg/m³ occur.

Residential dwellings to the north-east and east of the BFB (House #2) are predicted to have a maximum increase in 1-hour average SO_2 of approximately 35 µg/m³ due to BFB at 100 % MCR. The maximum 24-hour average SO_2 impact of 14 µg/m³ occurs near House #1. The same dwelling is close to the location where the maximum annual average SO_2 impact of 1.1 µg/m³ is predicted.

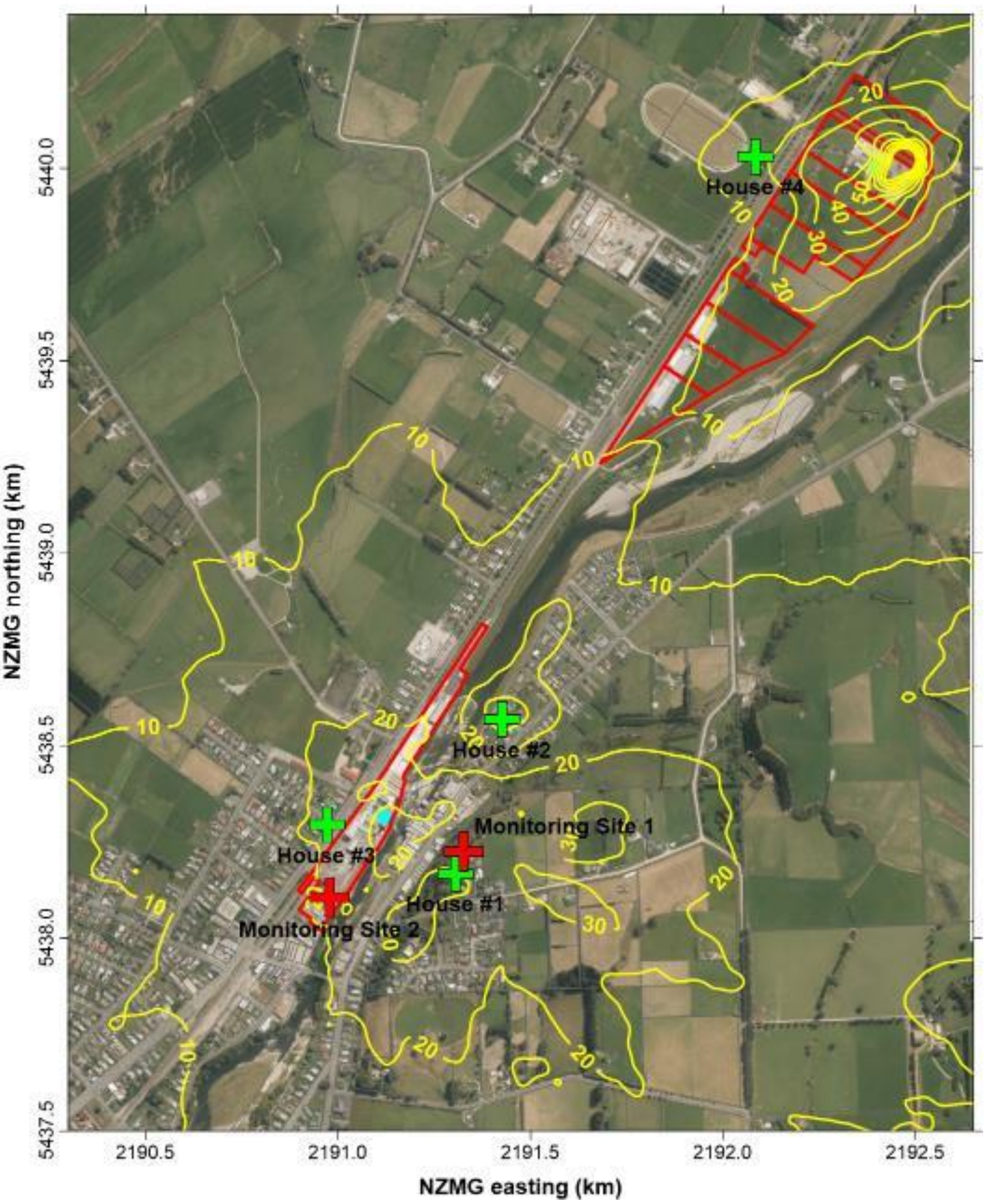

Figure 23: Predicted maximum 1-hour average SO_2 ground level concentrations (µg/m³) (modelled 99.9th percentile value), excluding background concentrations. BFB at 100 % MCR, CFB 3 at 40 % MCR.

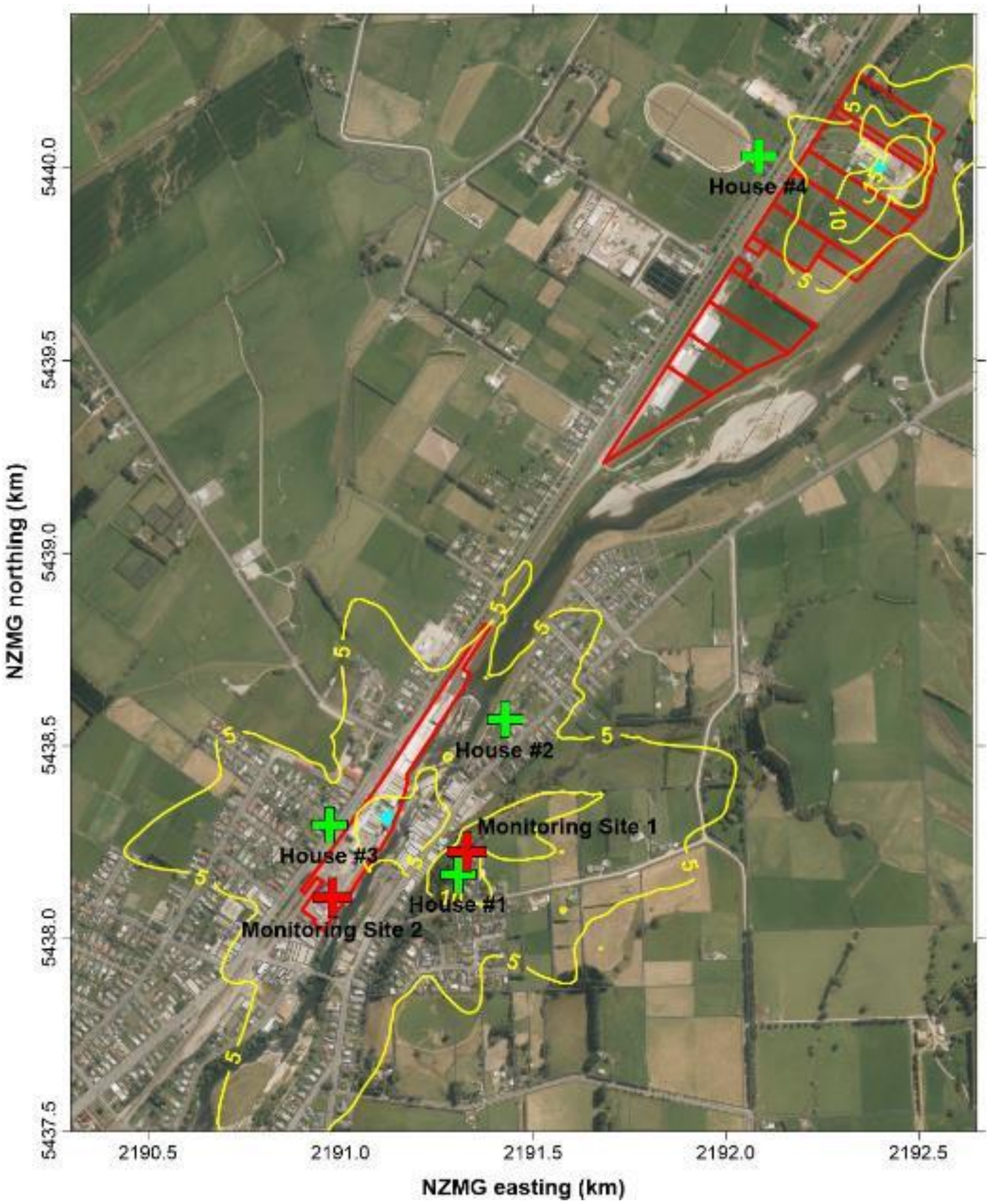

Figure 24: Predicted maximum 24-hour average SO_2 ground level concentrations($\mu g/m^3$), excluding background concentrations. BFB at 100 % MCR, CFB 3 at 40 % MCR.

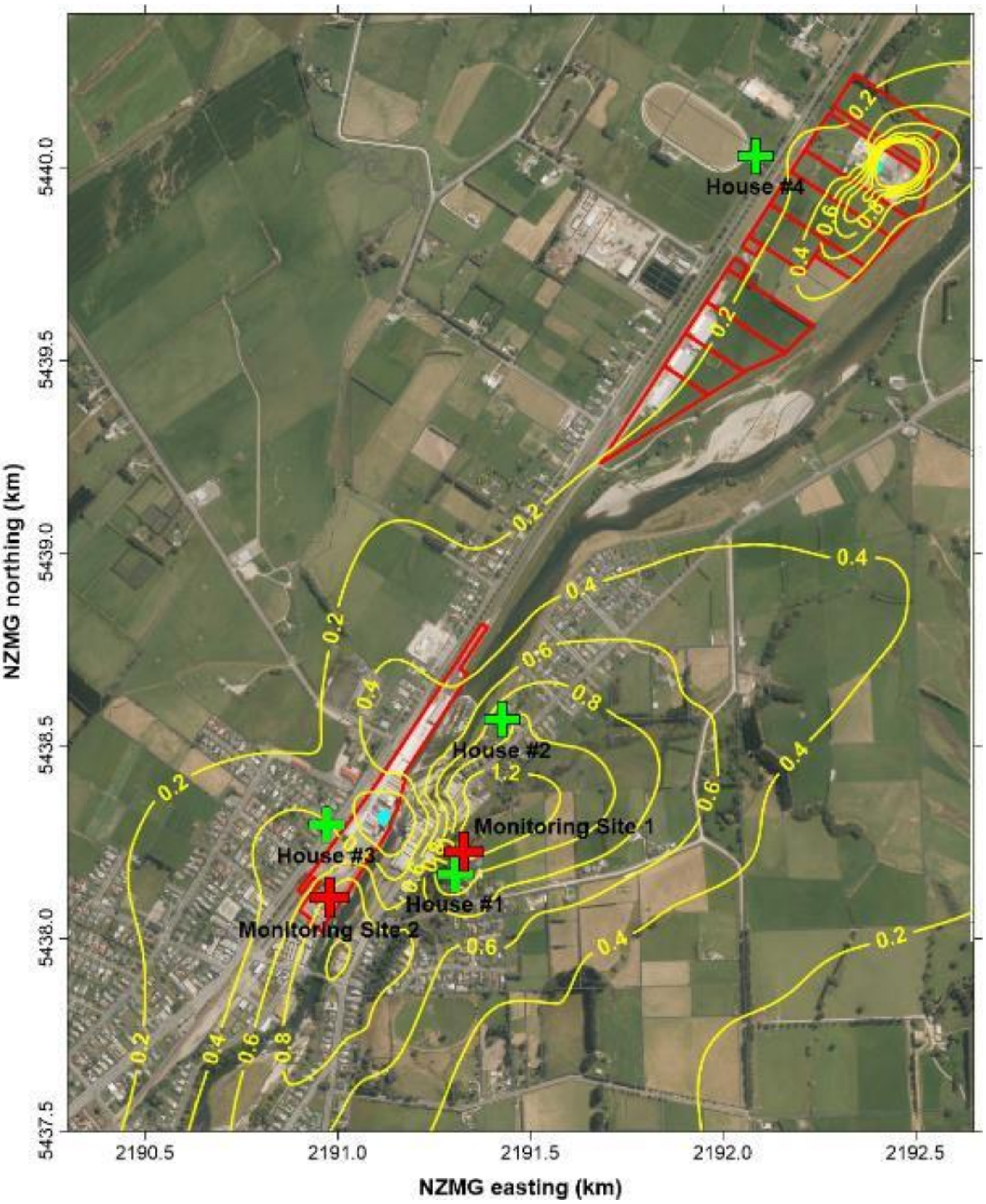

Figure 25: Predicted annual average SO_2 ground level concentrations (μg/m³), excluding background concentrations. BFB at 100 % MCR, CFB 3 at 40 % MCR.

8.0 ASSESSMENT OF EFFECTS (CFB 2)

8.1 General

The cumulative assessment of site plus background air contaminant levels are discussed in this section for the continued use of CFB 2 (and with CFB 1 as its back-up) with a full baghouse filter and the existing hide plant's CFB 3. Cumulative air quality impacts are evaluated using background air quality levels discussed in Section 4.0 for the following locations:

- Alliance's southern boundary (ASB);
- the Most Impacted off-site Location (MIL); and
- the four Most Impacted Residential Dwellings (MIRDs).

8.2 Respirable Particulate

8.2.1 Alliance southern boundary (CFB 2)

The background contributions at Alliance's southern boundary (ASB) are presented in Table 11 (Section 5.3) as a function of daily average weather conditions (specified as four categories A, B, C and D).

Model predicted CFB impacts and associated background concentrations at the ASB are summarised in Table 1 to Table 3 in Appendix G. These results indicate that when the CFB 2 is predicted to cause its highest level of ambient impact at the ASB that:

- Cumulative 24-hour PM_{10} are estimated to be up to 30 % of NES;
- Cumulative annual PM_{10} are estimated to be up to 60 % AAQG;
- Cumulative 24-hour $PM_{2.5}$ are estimated to be up to 36 % of WHO;
- Cumulative annual $PM_{2.5}$ are estimated to be up to 70 % of WHO.

The results in Table 4 in Appendix G relates to the occasions when background 24-hourly average particulate levels were most dominant. These results indicate that when non-compliance with the WHO guideline for 24-hour $PM_{2.5}$ may possibly occur at the ASB on some days, they are as a result of high background levels.

On such days, CFB 2 would only contribute $PM_{2.5}$ that is less than 1 % of the WHO criterion.

8.2.2 Most impacted off-site location (CFB 3)

Model predicted CFB impacts, background concentrations and cumulative impacts at the Most Impact Off-site Location (MIL – CFB 3) are summarised in Table 5 and Table 6 in Appendix G. In this case the MIL location is relatively close to the CFB 3 and is located at the north-eastern boundary of the hide plant, on a small strip of land between two Alliance owned properties, as shown in Figure 8. Beyond this MIL, the 24-hours concentrations decrease rapidly with distance.

These results indicate that when the CFB 3 is predicted to cause its highest level of ambient impact at the MIL that:

- Cumulative 24-hour PM_{10} are estimated to be up to 64 % of NES;
- Cumulative annual PM_{10} are estimated to be up to 65 % AAQG;
- Cumulative 24-hour $PM_{2.5}$ are estimated to be up to 80 % of WHO;
- Cumulative annual $PM_{2.5}$ are estimated to be up to 80 % of WHO.

8.2.3 Most impacted residential dwelling (MIRD - CFB 2)

The most impacted residential dwelling (MIRD - CFB 2), occurs at House #1 as shown in Figure 8. Model predicted particulate impacts for CFB 2 emissions and associated background concentrations for House #1 are summarised in Table 7, Table 8 and Table 9 (in Appendix G).

These results indicate that when the CFB 2 causes its highest level of ambient impact at House #1 that:

- Cumulative 24-hour PM_{10} are estimated to be up to 32 % of NES;
- Cumulative annual PM_{10} are estimated to be up to 60 % AAQG;
- Cumulative 24-hour $PM_{2.5}$ are estimated to be up to 40 % of WHO;
- Cumulative annual $PM_{2.5}$ are estimated to be up to 70 % of WHO.

The results in Table 10 and Table 11 (in Appendix G) relate to the ambient conditions when background 24-hourly average PM_{10} and $PM_{2.5}$ levels are most dominant (cold winter days).

These results indicate that on winter days with the most elevated background particulate levels, the cumulative impacts at House #1 are estimated as follows:

- Cumulative 24-hour PM_{10} are estimated to be up to 76 % of NES;
- Cumulative 24-hour $PM_{2.5}$ are estimated to be up to 112 % of WHO.

On such days when the WHO criterion for 24-hour $PM_{2.5}$ is approach or exceeded at the MIRD (House #1) due to high background particulate levels (due to domestic fires), CFB 2 would only contribute additional $PM_{2.5}$ that is approximately 1 % of the WHO criterion.

8.2.4 Houses #2 and #3 (impacted by CFB 2)

Houses #2 and #3 as shown in Figure 8, are predicted to have cumulative respirable particulate impacts that are very similar to those summarised for House #1 and therefore same analysis above, applies to these houses. See results in Table 12, Table 13 and Table 14 (House #2) and Table 15, Table 16 and Table 17 (House #3) in Appendix G.

8.2.5 House #4 (impacted by CFB 3)

Model predicted particulate impacts for CFB 3 emissions and associated background concentrations for House #4 (shown in Figure 8) are summarised in Table 18, Table 19 and Table 20.

These results indicate that when the CFB 3 causes its highest level of ambient impact at House #4 that:

- Cumulative 24-hour PM_{10} are estimated to be up to 30 % of NES;
- Cumulative annual PM_{10} are estimated to be up to 60 % AAQG;
- Cumulative 24-hour $PM_{2.5}$ are estimated to be up to 36 % of WHO;
- Cumulative annual $PM_{2.5}$ are estimated to be up to 70 % of WHO.

Results in Table 21 and Table 22 in Appendix G indicate that when background levels of respirable particulate are most elevated, that addition of impacts from CFB 3 emissions could cause cumulative ambient concentrations at House #4 as follows:

- Cumulative 24-hour PM_{10} are estimated to be up to 78 % of NES;
- Cumulative 24-hour $PM_{2.5}$ are estimated to be up to 116 % of WHO.

During these conditions, when background ambient levels of $PM_{2.5}$ are highest, CFB 3 is predicted to cause approximately 4 %, or less of the WHO criteria for 24-hour $PM_{2.5}$.

8.3 Sulfur Dioxide and Nitrogen Dioxide

A cumulative assessment of sulfur dioxide and nitrogen dioxide impacts due to the CFBs for the most impacted off-site locations (MIL) and most impacted residential dwellings (MIRD), are presented in Table 14 and Table 15, respectively.

Results in Table 14 indicate that when the CFB 3 is predicted to cause its highest level of ambient impact at the MIL (north-eastern boundary of hide plant) that:

- Cumulative 1-hour SO_2 are estimated to be up to 53 % of NES;
- Cumulative 1-hour NO_2 are estimated to be up to 40 % NES;
- Cumulative 24-hour NO_2 are estimated to be up to 44 % of AAQG.

When the CFB 2 is predicted to cause its highest level of ambient impact at the MIL (approximately 200 m east of the CFB 2) that:

- Cumulative 24-hour SO_2 are estimated to be up to 81 % of AAQG;
- Cumulative annual SO_2 are estimated to be up to 35 % AAQG.

Results in Table 15 indicate when CFB 2 is predicted to cause the highest increase at the MIRD (house #1 and #2) that:

- Cumulative 1-hour SO_2 are estimated to be up to 44 % of NES;
- Cumulative 24-hour SO_2 are estimated to be up to 79 % of AAQG;
- Cumulative annual SO_2 are estimated to be up to 32 % AAQG;
- Cumulative 1-hour NO_2 are estimated to be up to 34 % NES;
- Cumulative 24-hour NO_2 are estimated to be up to 43 % of AAQG.

The predicted worst-case cumulative NO_2 impacts at most impacted off-site (non-residential area) and most impacted residential houses are well within (<50 %) their respective NES and MfE AAQG criteria for all relevant averaging periods.

The predicted worst-case cumulative short term SO_2 impacts are at most impacted off-site (non-residential area) and most impacted residential houses approach their respective NES and MfE AAQG criteria for all relevant averaging periods. Annual average cumulative impacts are low against the MfE AAQG.

With reference to the figures in Section 7.0, these impacts are isolated small areas surrounding the site. Impacts at other locations in Mataura are further reduced.

Table 14: Maximum cumulative SO_2 and NO_2 GLCs due to CFBs at MIL.

Pollutants	Maximum off site (µg/m³)			Maximum off-site location	Criterion (µg/m³)
	Modelled boiler GLCs	Background (µg/m³)	Cumulative GLCs		
1-hour SO_2	180 (CFB 3)	120	300	North-eastern boundary of hide plant	**570** (maximum) **350** (99.9th percentile)
24-hour SO_2	67 (CFB 2)	30	97	Approx. 200 m east of the CFB 1 (near house #1)	**120**
Annual SO_2	5.5 (CFB 2)	5	10.5	Approx. 200 m east of the CFB 1 (near house #1)	**30**
1-hour NO_2	20 (CFB 3)	60	80	North-eastern boundary of hide plant	**200**
24-hour NO_2	4 (CFB 3)	40	44	North-eastern boundary of hide plant	**100**

Table 15: Maximum cumulative SO_2 and NO_2 GLCs due to CFB 2 at MIRD.

Pollutants	Most impacted house (µg/m³)			Most impact house #	Criterion (µg/m³)
	Modelled GLCs	Background (µg/m³)	Cumulative GLCs		
1-hour SO_2	146 (CFB 2)	120	246	#2	**570** (maximum) **350** (99.9th percentile)
24-hour SO_2	65 (CFB 2)	30	95	#1	**120**
Annual SO_2	4.5 (CFB 2)	5	9.5	#1	**30**
1-hour NO_2	7 (CFB 2)	60	67	#2	**200**
24-hour NO_2	3 (CFB 2)	40	43	#1	**100**

9.0 ASSESSMENT OF EFFECTS (BFB)

9.1 General

The cumulative assessment of site plus background air contaminant levels are discussed in this section for the use of a new BFB and the existing CFB 3. Cumulative air quality impacts are evaluated using background air quality levels discussed in Section 5.0 for the following locations:

- Alliance's southern boundary (ASB);
- the Most Impacted off-site Location (MIL); and
- for the four Most Impacted Residential Dwellings (MIRDs).

9.2 Respirable Particulate

9.2.1 Alliance southern boundary

Model predicted BFB impacts and associated background concentrations at the ASB are summarised in Table 23, Table 24, and Table 25 (in Appendix G). These results indicate that when the BFB is predicted to cause its highest level of ambient impact at the ASB that:

- Cumulative 24-hour PM_{10} are estimated to be up to 30 % of NES;
- Cumulative annual PM_{10} are estimated to be up to 60 % AAQG;
- Cumulative 24-hour $PM_{2.5}$ are estimated to be up to 36 % of WHO;
- Cumulative annual $PM_{2.5}$ are estimated to be up to 70 % of WHO.

The results in Table 26 (Appendix G) relates to the occasions when background 24-hourly average particulate levels were most dominant. These results indicate that when non-compliance with the WHO guideline for 24-hour $PM_{2.5}$ may possibly occur at the ASB on some days, as are result of high background levels.

On such days, BFB would only contribute $PM_{2.5}$ that is approximately 1.2 % of the WHO criterion.

9.2.2 Most impacted off-site location (BFB)

Model predicted impacts due to BFB emissions, background concentrations and cumulative impacts at the Most Impact Off-site Location (MIL-BFB) are summarised in Table 27 and Table 28 (in Appendix G).

In this case the MIL due to BFB particulate emissions location is located near House #1 as shown in Figure 8. Beyond this MIL-BFB, the 24-hours concentrations decrease rapidly with distance.

These results indicate that when the BFB is predicted to cause its highest level of off-site ambient impact at the MIL-BFB, that:

- Cumulative 24-hour PM_{10} are estimated to be up to 68 % of NES;
- Cumulative annual PM_{10} are estimated to be up to 60 % AAQG;
- Cumulative 24-hour $PM_{2.5}$ are estimated to be up to 44 % of WHO;
- Cumulative annual $PM_{2.5}$ are estimated to be up to 70 % of WHO.

9.2.3 Most impacted residential dwelling (MIRD - BFB)

The most impacted residential dwelling (MIRD –BFB), occurs at House #1 as shown in Figure 8. Model predicted particulate impacts for BFB emissions and associated background concentrations for House #1 are summarised in Table 29, Table 30 and Table 21 (in Appendix G).

These results indicate that when the BFB causes its highest level of ambient impact at House #1 that:

- Cumulative 24-hour PM_{10} are estimated to be up to 32 % of NES;
- Cumulative annual PM_{10} are estimated to be up to 60 % AAQG;
- Cumulative 24-hour $PM_{2.5}$ are estimated to be up to 40 % of WHO;
- Cumulative annual $PM_{2.5}$ are estimated to be up to 70 % of WHO.

The results in Table 32 and Table 33 (in Appendix G) relate to the ambient conditions when background 24-hourly average PM_{10} and $PM_{2.5}$ levels are most dominant (cold winter days).

These results indicate that on winter days with the most elevated background particulate levels, the cumulative impacts at House #1 are estimated as follows:

- Cumulative 24-hour PM_{10} are estimated to be up to 76 % of NES;
- Cumulative 24-hour $PM_{2.5}$ are estimated to be up to 112 % of WHO.

On such days when the WHO criterion for 24-hour $PM_{2.5}$ is approach or exceeded at the MIRD-BFB (House #1) due to high background particulate levels (due to domestic fires), BFB would only contribute additional $PM_{2.5}$ that is approximately 1.2 % of the WHO criterion.

9.3 Sulfur Dioxide and Nitrogen Dioxide

A cumulative assessment of sulfur dioxide and nitrogen dioxide impacts due to the BFB energy supply option at the most impacted residential dwelling (MIRD) and off-site locations, are presented in Table 16 and Table 17, respectively.

Results in Table 16 indicate that when the CFB 3 is predicted to cause its highest level of ambient impact at the MIL (north-eastern boundary of hide plant) that:

- Cumulative 1-hour SO_2 are estimated to be up to 52 % of NES;
- Cumulative 24-hour SO_2 are estimated to be up to 58 % of AAQG;
- Cumulative annual SO_2 are estimated to be up to 27 % AAQG.

When the BFB is predicted to cause its highest level of ambient impact at the MIL that:

- Cumulative 1-hour NO_2 are estimated to be up to 56 % NES;
- Cumulative 24-hour NO_2 are estimated to be up to 60 % of AAQG.

Results in Table 17 indicate when BFB is predicted to cause the highest increase at the MIRD (house #1 and #2) that:

- Cumulative 1-hour SO_2 are estimated to be up to 27 % of NES;
- Cumulative 24-hour SO_2 are estimated to be up to 37 % of AAQG;
- Cumulative annual SO_2 are estimated to be up to 20 % AAQG;
- Cumulative 1-hour NO_2 are estimated to be up to 55 % NES;
- Cumulative 24-hour NO_2 are estimated to be up to 60 % of AAQG.

The predicted worst-case cumulative impacts are well within their respective NES and MfE AAQG criteria for all relevant averaging periods. As shown in Section 7.0, these elevated impacts occur at isolated small areas surrounding the site and rapidly reduce at greater distances.

Table 16: Maximum cumulative SO_2 and NO_2 GLCs due to BFB-CFB 3 at MIL.

Pollutants	Maximum off site (µg/m³)			Maximum off-site location	Criterion (µg/m³)
	Modelled GLCs	Background (µg/m³)	Cumulative GLCs		
1-hour SO_2	174 (CFB 3)	120	294	North-eastern boundary of hide plant	**570** (maximum) **350** (99.9th percentile)
24-hour SO_2	40 (CFB 3)	30	70	North-eastern boundary of hide plant	**120**
Annual SO_2	3 (CFB 3)	5	8	North-eastern boundary of hide plant	**30**
1-hour NO_2	58 (BFB)	60	112	550 m south-east of the BFB	**200**
24-hour NO_2	20 (BFB)	40	60	250 m south-east of BFB (near house #1)	**100**

Table 17: Maximum cumulative SO_2 and NO_2 GLCs due to BFB at MIRD.

Pollutants	Most impacted house (µg/m³)			Most impact house #	Criterion (µg/m³)
	Modelled GLCs	Background (µg/m³)	Cumulative GLCs		
1-hour SO_2	35 (BFB)	120	155	#2	**570** (maximum) **350** (99.9th percentile)
24-hour SO_2	14 (BFB)	30	44	#1	**120**
Annual SO_2	1.1 (BFB)	5	6	#1	**30**
1-hour NO_2	50 (BFB)	60	110	#2	**200**
24-hour NO_2	20 (BFB)	40	60	#1	**100**

10.0 EXISTING ENERGY PLANT (WITHOUT BAGHOUSE)

The cumulative air quality effects of this existing energy plant were assessed and reported by Golder (2020) for CFB 2 operating at 64 %MCR. Alliance operate the existing CFB 1, CFB 2 and CFB 3 at the site as described in this report, except CFB 1 and 2 have no full bag house filter and discharges particulate at over 10 times the rates assessed within this report for the CFB 2 with a full bag house and operating up to 68 %MCR. Further comment is provided on the assessed MCR in Section 11.2.3.

The modelling results at the most impacted off-site location and residential dwelling are listed in Table 18 and Table 19.

Table 18: Maximum predicted PM_{10}, $PM_{2.5}$, SO_2 and NO_2 GLCs at MIL (for existing CFB 2 without baghouse and 64 % MCR).

Pollutants	Modelled maximum off-site GLCs (µg/m³)	Location	Back-ground (µg/m³)	Cumulative GLCs	Criterion (µg/m³)	% Criterion
24-hour PM_{10}	30*	200 m south-east of CFB 2	14#	44	**50**	88 %
Annual PM_{10}	3	250 m east of CFB 2	12	15	**20**	75 %
24-hour $PM_{2.5}$	24*	200 m south-east of CFB 2	8#	32	**25**	128 %
Annual $PM_{2.5}$	2	250 m east of CFB 2	7	8	**10**	80 %
1-hour SO_2	174	North-eastern boundary of hide plant	120	294	**570 (max) 350 (99.9th percentile)**	52 %

Pollutants	Modelled maximum off-site GLCs (µg/m³)	Location	Back-ground (µg/m³)	Cumulative GLCs	Criterion (µg/m³)	% Criterion
24-hour SO_2	65	200 m south-east of CFB 2	30	95	**120**	80 %
Annual SO_2	6	300 m east of CFB 2	5	11	**30**	37 %
1-hour NO_2	20	North-eastern boundary of hide plant	60	80	**200**	40 %
24-hour NO_2	4	200 m south-east of CFB 2	40	44	**100**	44 %

Notes: * Modelled for weather condition D: daily averaged wind speed ≥3 m/s. # Using 99th upper limit 24-hour background concentration = upper estimated mean background at 99 % confidence.

Table 19: Maximum predicted PM_{10}, $PM_{2.5}$, SO_2 and NO_2 GLCs at MIRD (modelled for existing CFBs without baghouse).

Pollutants	Modelled maximum GLCs at MIRD (µg/m³)	Location	Back-ground (µg/m³)	Cumulative GLCs	Criterion (µg/m³)	% Criterion
24-hour PM_{10}	28*	House 1	14#	42	**50**	66 %
Annual PM_{10}	2	House 1	12	14	**20**	70 %
24-hour $PM_{2.5}$	23*	House 1	8#	31	**25**	92 %
Annual $PM_{2.5}$	1.6	House 1	7	8.6	**10**	86 %
1-hour SO_2	141	House 2	120	261	**570 (max) 350 (99.9th percentile)**	46 %
24-hour SO_2	62	House 1	30	92	**120**	77 %
Annual SO_2	4	House 1	5	9	**30**	30 %
1-hour NO_2	7	House 2	60	67	**200**	34 %
24-hour NO_2	3	House 1	40	43	**100**	43 %

Notes: * Modelled for weather condition D: daily averaged wind speed ≥3 m/s. # Using 99th upper limit 24-hour background concentration = upper estimated mean background at 99 % confidence.

11.0 DISCUSSION

11.1 Ambient Monitoring

From the analysis of ambient monitoring data, background sources of ambient particulate appear to significantly degrade the air quality within Mataura township during autumn and winter months, particularly on cold still days. The three highest daily concentration results (obtained when monitoring over April, May and June 2018) were slightly above the WHO guideline for 24-hour $PM_{2.5}$, but well within the annual average WHO guideline. The results for all days were also within the NESAQ for 24-hour PM_{10}.

Given the above, the new NESAQ limit for 24-hour $PM_{2.5}$ would be approached within the Mataura airshed. The new NESAQ is expected to allow for some daily average levels above the WHO guideline each year. Given this, and accounting for the upgrade of the existing CFB 2, or its replacement with a new BFB, then is possible that the proposed NESAQ would be met. This outcome is not certain because the background $PM_{2.5}$ levels were not monitored for the whole winter period in 2018 (i.e., the monitoring period included the summer to mid-winter).

The existing NES for 24-hour PM_{10} is also likely to be approached (to a much lesser extent than for the WHO guideline for $PM_{2.5}$) and complied within the Mataura airshed.

11.2 Energy Plant Impacts on Ambient Particulate

11.2.1 Main processing site

At the MIL and MIRD (which is House #1 in Figure 1), the operation of either the existing CFB 2 with a full bag-house filter, or a new BFB, are expected to cause maximum increases of ambient PM_{10} and $PM_{2.5}$ concentration beyond the site boundary, which are relatively low (i.e., less than 10 % of their respective 24-hour ambient standard/guideline). These maximum energy plant ambient impacts are expected to result in cumulative concentrations that are no more than approximately 32 % and 40 % of the 24-hour standard/guideline criteria for PM_{10} and $PM_{2.5}$ respectively. This is because the worst-case energy plant impacts only occur on days when the background air quality is not significantly degraded (i.e., cold still days).

During days when background ambient PM_{10} and $PM_{2.5}$ are significantly degraded due to domestic fires, the proposed energy plant options, are predicted to contribute a minor addition to cumulative levels beyond the site boundary (i.e., < 0.4 % of the NES for PM_{10} and < 0.8 % of the WHO guideline for $PM_{2.5}$ for the MIRD).

Despite the much higher efflux velocity of the BFB versus the CFB 2 option, these energy plant options are predicted to cause very similar ambient impacts per unit mass emission rate (g/s) of contaminant.

11.2.2 Hide processing site (CFB 3)

Within the northern area of Mataura, the existing smaller CFB 3 is predicted to cause maximum increases of 24-hour off-site PM_{10} and $PM_{2.5}$ concentrations with are less than 50 % of their respective 24-hour ambient standard/guideline. These maximum impacts occur on nearby uninhabited areas and are expected to result in cumulative levels, which reach 64 % and 80 % of the 24-hour standard/guideline criteria for PM_{10} and $PM_{2.5}$ respectively. These impacts would occur on a. Beyond this area of uninhabited land, the impact concentrations decrease rapidly.

The MIRD associated with CFB 3 ambient impacts (House #4) is predicted to be less impacted than predicted by CFB 2 emissions at House #1 (the MIRD associated with CFB 2 or BFB emissions).

11.2.3 Existing energy plant without baghouse

The existing CFB 2 energy plant has an order of magnitude higher PM_{10} and $PM_{2.5}$ emission rates compared to the proposed new energy plant supply options. The proposed energy supply options achieve approximately 90 % reduction in PM_{10} and $PM_{2.5}$ emissions compared to the existing CFB 2 energy plant when operating at 64 % MCR (without a full baghouse filter).

11.2.4 Summary

Energy plant impacts

The PM_{10} and $PM_{2.5}$ discharges from the two proposed new energy plant options are expected to have a minor effect on existing background air quality within Mataura and would result in a significant reduction in air quality effects compared to those caused by the existing energy plant.

Daily cumulative exposures

Based on monitoring in 2018 at the southern boundary (> 200 m from the energy plant) which is discussed by Golder (2020), cumulative concentrations of PM_{10}, while significantly degraded by domestic heating emissions, are expected to meet the NESAQ for daily exposure. However, the monitoring found the WHO ambient criteria for daily $PM_{2.5}$ exposure to be exceeded on three days during the 3 months of monitoring. On two of these days, background sources were the primary driver of these exceedances. It is noted that the proposed NESAQ for daily $PM_{2.5}$ exposure allows for three days of exceedance of the WHO criteria, therefore is possible that the proposed NESAQ would be met, although given the limited monitoring period, this outcome is not certain.

Annual cumulative exposures

The WHO and proposed NESAQ for annual average $PM_{2.5}$ exposure are expected to be met in all areas beyond the site boundary. Likewise, the existing MfE AAQG for annual average PM_{10} exposure is expected to be met in all areas beyond the site boundary.

The WHO (2005)[3] 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 $PM_{2.5}$ concentrations at the MIRD, this indicates a minor potential for health effects from cumulative particulate exposures at the residential dwelling which is most impacted by the proposal.

11.3 Nitrogen Dioxide

11.3.1 Main processing site

The worst-case cumulative concentrations of NO_2 due to the proposed BFB energy plant option and background levels are well within the NES and MfE AAQG health-based guidelines (i.e., ≤ 55 % for NES and ≤ 60 % for MfE AAQG) at the MIRD. The CFB 2 option would result in even lower cumulative ambient NO_2 levels due to coal combustion. It is understood that these MfE's hourly and 24-hourly NO_2 criteria are health based and NO_2 is a non-threshold pollutant, then these maximal levels indicate a less than minor potential for any health effect on people.

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

11.3.2 Hide processing site

The worst-case cumulative concentrations of NO_2 due to the existing CFB 3 plant and background levels are well within the NES and MfE AAQG health-based guidelines (i.e., ≤40 % for NES and ≤44 % for MfE AAQG) at the MIRD located within the northern area of Mataura. These maximal levels also indicate a less than minor potential for any health effect on people.

11.3.3 Existing energy plant without baghouse

The existing CFB 2 without baghouse and CFB 3 have very similar, less than minor potential for health effects as for the option of the CFB 2 with a full bag-house filter (combined with ongoing use of CFB 3 at the hide processing plant), as discussed above.

11.4 Sulphur Dioxide

11.4.1 Main processing site

The worst-case cumulative concentrations of SO_2 due to the proposed CFB 2 energy plant option and background levels are well within the NES and MfE AAQG health-based guidelines (i.e., ≤44 % for NES and ≤79 % for MfE AAQGs) at the MIRD. The BFB option would result much lower cumulative ambient SO_2 levels due to wood/DAF solids combustion. Again, based on the understanding that the MfE's hourly and 24-hourly SO_2 criteria are health based and for a non-threshold pollutant, these maximal cumulative levels indicate a less than minor potential for any health effect on people.

11.4.2 Hide processing site

The worst-case cumulative concentrations of SO_2 due to the existing CFB 3 plant and background levels are well within the NES and MfE AAQG health-based guidelines (i.e., ≤ 53 % for NES and ≤ 60 % for MfE AAQG) at the MIRD located within the northern area of Mataura. These maximal levels also indicate a less than minor potential for any health effect on people.

11.4.3 Existing energy plant

The existing CFB 2 and CFB 3 have a similar, less than minor potential for health effects as for the option of the CFB 2 with a full bag-house filter (combined with ongoing use of CFB 3) at the hide processing plant, as discussed above.

12.0 CONCLUSIONS

The main conclusions of this report are as follows:

- The discharge of ambient respirable particulate from either of the two new energy supply options (discharging at < 50 mg/Nm^3 of particulate) would result in a minor contribution to existing elevated concentrations during cold still winter days within Mataura.
- Cumulative NO_2 (1-hour and 24-hour) and SO_2 (1-hour, 24-hour and annual) concentrations at the most impacted residential dwellings are expected to have a less than minor potential for health effects upon people, as these are likely to be well within NES and MfE AAQG health based guideline values.
- Finally, it is concluded that both potential energy supply options would result in a significant reduction in cumulative ambient respirable particulate concentration levels at the most impact residential dwellings and all other locations within Mataura.

13.0 REFERENCES

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APPENDIX A

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Report Limitations

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APPENDIX B

Stoichiometry Calculations

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COMBUSTION CALCULATIONS

03 Oct 2018
1793285 - Hides CFB, 923 kW
40% MCR, 5% O_2 normal operation

Parameter	Value	Unit	Comment / source of data
FUEL ULTIMATE ANALYSIS	New Vale		
Carbon:	69.44	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Hydrogen:	4.76	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Oxygen:	24.40	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Nitrogen:	0.60	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Sulphur:	0.80	%wt (DAF basis)	Assume max 0.45% wt as received
Fuel moisture content:	40.0	%wt (as received basis)	Average of testings from Jun 2016 to Feb 2018
Ash content:	3.6	%wt (as received basis)	
DAF portion:	0.564	kg/kg fuel (as received basis)	
AIR REQUIREMENTS			
Theoretical O_2 required:	62.82	moles/kg (DAF basis)	
Excess air:	30.95	%	
Total O_2 required:	82.26	moles/kg (DAF basis)	
Flue gas CO_2 content:	14.88	%vol dry	
Flue gas O_2 content:	5.00	%vol dry	
APPLIANCE DETAILS			
Power Output:	923	kW	Based on 2000 AEE
Percentage of MCR:	43	%	Calculated based on max coal burning rate
Effective power output:	393	kW	
Efficiency:	50	%	Assume the same as the main CFB
As rcvd fuel CV:	14360	kJ/kg	Based on average GCV from June 2016 to January 2018
Equivalent Stack diameter:	0.60	m	Based on 2000 AEE
Heat produced by combustion:	786	kW	
Heat loss:	393	kW	
Maximum fuel burning rate:	0.05	kg/s (as received basis)	
	0.20	t/h (as received basis)	Max weekly coal burning rate 2017
STACK PROPERTIES			
Temperature:	523.15	K	Based on 2000 AEE
WET flow rate (POC sheet):	21.10	m³/kg DAF fuel	
Actual volumetric flow rate:	0.65	m³/s	
Stack x-sectional area:	0.28	m²	
Efflux velocity:	2.30	m/s	
DRY flow rate @ STP (POC sheet):	8.72	Nm³/kg DAF fuel	
	0.27	Nm³/sec	
	969	Nm³/hour	
WET flow rate @ STP (POC sheet):	11.02	Nm³/kg DAF fuel	
	0.34	Nm³/sec	
	1,224	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 Associates

COMBUSTION CALCULATIONS

03 Oct 2018
1793285 - Hides CFB, 923 kW
40% MCR, 12% CO_2 standard operation

Parameter	Value	Unit	Comment / source of data
FUEL ULTIMATE ANALYSIS	New Vale		
Carbon:	69.44	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Hydrogen:	4.76	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Oxygen:	24.40	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Nitrogen:	0.60	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Sulphur:	0.80	%wt (DAF basis)	Assume max 0.45% wt as received
Fuel moisture content:	40.0	%wt (as received basis)	Average of testings from Jun 2016 to Feb 2018
Ash content:	3.6	%wt (as received basis)	
DAF portion:	0.564	kg/kg fuel (as received basis)	
AIR REQUIREMENTS			
Theoretical O_2 required:	62.82	moles/kg (DAF basis)	
Excess air:	61.82	%	
Total O_2 required:	101.66	moles/kg (DAF basis)	
Flue gas CO_2 content:	12.01	%vol dry	
Flue gas O_2 content:	8.06	%vol dry	
APPLIANCE DETAILS			
Power Output:	923	kW	Based on 2000 AEE
Percentage of MCR:	43	%	Calculated based on max coal burning rate
Effective power output:	393	kW	
Efficiency:	50	%	Assume the same as the main CFB
As rcvd fuel CV:	14360	kJ/kg	Based on average GCV from June 2016 to January 2018
Equivalent Stack diameter:	0.60	m	Based on 2000 AEE
Heat produced by combustion:	786	kW	
Heat loss:	393	kW	
Maximum fuel burning rate:	0.05	kg/s (as received basis)	
	0.20	t/h (as received basis)	Max weekly coal burning rate 2017
STACK PROPERTIES			
Temperature:	523.15	K	Based on 2000 AEE
WET flow rate (POC sheet):	25.09	m³/kg DAF fuel	
Actual volumetric flow rate:	0.77	m³/s	
Stack x-sectional area:	0.28	m²	
Efflux velocity:	2.74	m/s	
DRY flow rate @ STP (POC sheet):	10.80	Nm³/kg DAF fuel	
	0.33	Nm³/sec	
	1,200	Nm³/hour	
WET flow rate @ STP (POC sheet):	13.10	Nm³/kg DAF fuel	
	0.40	Nm³/sec	
	1,455	Nm³/hour	
EMISSION CALCULATIONS			
SO_2 emission rate (no ash retention):	0.49	g/s	
SO_2 emission rate (5% ash retention):	**0.47**	g/s	
	1.68	kg/hr	
NO_X emission factor:	2.90	kg/tonne	US-EPA AP42 Table 1.7-1 (5.8 lb/ton)
NO_X emission rate:	**0.16**	g/s	Assume the same type of boiler
PM10 concentration:	640	mg/m³ @ dry STP 12% CO2	
PM_{10} emission rate:	**0.21**	g/s	
PM_{10} emission rate:	1	kg/hr	
Assume PM2.5 concentration:	512	mg/m³ @ dry STP 12% CO2	Assume 80% PM10 is PM2.5
$PM_{2.5}$ emission rate:	**0.17**	g/s	
$PM_{2.5}$ emission rate:	0.61	kg/hr	

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

06 Aug 2020
1793285 - Babcock & Wilcox Boiler No. 2
68% MCR, 8% O2 normal operation

Parameter	Value	Unit	Comment / source of data
FUEL ULTIMATE ANALYSIS	New Vale		
Carbon:	69.44	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Hydrogen:	4.76	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Oxygen:	24.40	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Nitrogen:	0.60	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Sulphur:	0.80	%wt (DAF basis)	Assume max 0.45% wt as received
Fuel moisture content:	40.0	%wt (as received basis)	Average of coal analysis from Jun 2016 to Feb 2018
Ash content:	3.6	%wt (as received basis)	
DAF portion:	0.564	kg/kg fuel (as received basis)	
AIR REQUIREMENTS			
Theoretical O_2 required:	62.82	moles/kg (DAF basis)	
Excess air:	61.04	%	
Total O_2 required:	101.16	moles/kg (DAF basis)	
Flue gas CO_2 content:	12.07	%vol dry	
Flue gas O_2 content:	8.00	%vol dry	
APPLIANCE DETAILS			
Power Output:	9400	kW	
Percentage of MCR:	68	%	Based on comms from Deta Consulting, email 5.08.2020
Effective power output:	6392	kW	
Efficiency:	65.00	%	Based on comms from Deta Consulting, email 5.08.2020
As rcvd fuel CV:	14360	kJ/kg	Based on min CV-AR from June 2016 to January 2018
Equivalent Stack diameter:	2.00	m	Based on 2000 AEE
Heat produced by combustion:	9834	kW	
Heat loss:	3442	kW	
Maximum fuel burning rate:	0.68	kg/s (as received basis)	
	2.47	t/h (as received basis)	
STACK PROPERTIES			
Temperature:	503.15	K	Min Temp based on stack testing from 2013 to 2016
WET flow rate (POC sheet):	24.03	m³/kg DAF fuel	
Actual volumetric flow rate:	9.28	m³/s	
Stack x-sectional area:	3.14	m²	
Efflux velocity:	2.95	m/s	
DRY flow rate @ STP (POC sheet):	10.75	Nm³/kg DAF fuel	
	4.15	Nm³/sec	
	14,943	Nm³/hour	
WET flow rate @ STP (POC sheet):	13.05	Nm³/kg DAF fuel	
	5.04	Nm³/sec	
	18,140	Nm³/hour	
EMISSION CALCULATIONS			
SO_2 emission rate (no ash retention):	6.16	g/s	
SO_2 emission rate (5% ash retention):	**5.86**	g/s	
	21.08	kg/hr	
NO_X emission factor:	2.90	kg/tonne	US-EPA AP42 Table 1.7-1 (5.8 lb/ton)
NO_X emission rate:	**1.99**	g/s	
PM10 concentration:	50	mg/m³ @ dry STP 12% CO2	Max. concentration based on stack testing from 2013 to 16
PM_{10} emission rate:	**0.21**	g/s	
PM_{10} emission rate:	0.75	kg/hr	
Assume PM2.5 concentration:	50	mg/m³ @ dry STP 12% CO2	Assume 100% PM10 is PM2.5
$PM_{2.5}$ emission rate:	**0.21**	g/s	
$PM_{2.5}$ emission rate:	0.75	kg/hr	

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

06 Aug 2020
1793285 - Babcock & Wilcox Boiler No. 2
68% MCR, 12% CO_2 standard operation

Parameter	Value	Unit	Comment / source of data
FUEL ULTIMATE ANALYSIS New Vale			
Carbon:	69.44	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Hydrogen:	4.76	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Oxygen:	24.40	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Nitrogen:	0.60	%wt (DAF basis)	Based on southland lignite coal ultimate analysis
Sulphur:	0.80	%wt (DAF basis)	Assume max 0.45% wt as received
Fuel moisture content:	40.0	%wt (as received basis)	Average of coal analysis from Jun 2016 to Feb 2018
Ash content:	3.6	%wt (as received basis)	
DAF portion:	0.564	kg/kg fuel (as received basis)	
AIR REQUIREMENTS			
Theoretical O_2 required:	62.82	moles/kg (DAF basis)	
Excess air:	61.82	%	
Total O_2 required:	101.66	moles/kg (DAF basis)	
Flue gas CO_2 content:	12.01	%vol dry	
Flue gas O_2 content:	8.06	%vol dry	
APPLIANCE DETAILS			
Power Output:	9400	kW	
Percentage of MCR:	68	%	Based on comms from Deta Consulting, email 5.08.2020
Effective power output:	6392	kW	
Efficiency:	65.00	%	Based on comms from Deta Consulting, email 5.08.2020
As rcvd fuel CV:	14360	kJ/kg	Based on min CV-AR from June 2016 to January 2018
Equivalent Stack diameter:	2.00	m	Based on 2000 AEE
Heat produced by combustion:	9834	kW	
Heat loss:	3442	kW	
Maximum fuel burning rate:	0.68	kg/s (as received basis)	
	2.47	t/h (as received basis)	
STACK PROPERTIES			
Temperature:	503.15	K	Min Temp based on stack testing from 2013 to 2016
WET flow rate (POC sheet):	24.13	m³/kg DAF fuel	
Actual volumetric flow rate:	9.32	m³/s	
Stack x-sectional area:	3.14	m²	
Efflux velocity:	2.97	m/s	
DRY flow rate @ STP (POC sheet):	10.80	Nm³/kg DAF fuel	
	4.17	Nm³/sec	
	15,016	Nm³/hour	
WET flow rate @ STP (POC sheet):	13.10	Nm³/kg DAF fuel	
	5.06	Nm³/sec	
	18,214	Nm³/hour	
EMISSION CALCULATIONS			
SO_2 emission rate (no ash retention):	6.16	g/s	
SO_2 emission rate (5% ash retention):	**5.86**	g/s	
	21.08	kg/hr	
NO_X emission factor:	2.90	kg/tonne	US-EPA AP42 Table 1.7-1 (5.8 lb/ton)
NO_X emission rate:	**1.99**	g/s	
PM10 concentration:	50	mg/m³ @ dry STP 12% CO2	Max. concentration based on stack testing from 2013 to 16
PM_{10} emission rate:	**0.21**	g/s	
PM_{10} emission rate:	0.75	kg/hr	
Assume PM2.5 concentration:	50	mg/m³ @ dry STP 12% CO2	Assume 100% PM10 is PM2.5
$PM_{2.5}$ emission rate:	**0.21**	g/s	
$PM_{2.5}$ emission rate:	0.75	kg/hr	

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 Associates

01 Apr 2020
1793285 -8 MW new BFB
100% MCR,7% O2, 100% wood
Calculation of emission rate using low end boiler effieciency and fuel CV

Parameter	Value	Unit	Comment / source of data
FUEL ULTIMATE ANALYSIS New Vale			
Carbon:	53.00	%wt (DAF basis)	100% wood
Hydrogen:	6.00	%wt (DAF basis)	100% wood
Oxygen:	40.70	%wt (DAF basis)	100% wood
Nitrogen:	0.30	%wt (DAF basis)	100% wood
Sulphur:	0.00	%wt (DAF basis)	100% wood
Fuel moisture content:	40.0	%wt (as received basis)	100% wood
Ash content:	1.0	%wt (as received basis)	100% wood
DAF portion:	0.590	kg/kg fuel (as received basis)	
AIR REQUIREMENTS			
Theoretical O_2 required:	46.66	moles/kg (DAF basis)	
Excess air:	49.82	%	
Total O_2 required:	69.91	moles/kg (DAF basis)	
Flue gas CO_2 content:	13.30	%vol dry	
Flue gas O_2 content:	7.00	%vol dry	
APPLIANCE DETAILS			
Power Output:	8000	kW	
Percentage of MCR:	100	%	
Effective power output:	8000	kW	
Efficiency:	75.00	%	provided by Alliance
As rcvd fuel CV:	11510	kJ/kg	High end cv
Equivalent Stack diameter:	0.76	m	
Heat produced by combustion:	10667	kW	
Heat loss:	2667	kW	
Maximum fuel burning rate:	0.93	kg/s (as received basis)	
	3.34	t/h (as received basis)	
STACK PROPERTIES			
Temperature:	443	K	170º C as per boiler RFP
WET flow rate (POC sheet):	15.90	m³/kg DAF fuel	
Actual volumetric flow rate:	8.69	m³/s	
Stack x-sectional area:	0.45	m²	
Efflux velocity:	19.16	m/s	Use 15 m/s in the model
DRY flow rate @ STP (POC sheet):	7.44	Nm³/kg DAF fuel	
	4.07	Nm³/sec	
	14,650	Nm³/hour	
WET flow rate @ STP (POC sheet):	9.80	Nm³/kg DAF fuel	
	5.36	Nm³/sec	
	19,296	Nm³/hour	
EMISSION CALCULATIONS			
SO_2 emission rate (no ash retention):	0.0	g/s	
SO_2 emission rate (5% ash retention):	**0.00**	g/s	
	0.00	kg/hr	
NO_X emission factor:	3000.00	mg/m³ dry 7% O2	conservatively assume 5 times higher than NOx emission for wo
NO_X emission rate:	**12.2**	g/s	
PM_{10} emission rate:	**50.00**	mg/m³ dry 7% O2	boiler manufacturer's specification
PM_{10} emission rate:	0.20	g/s	
$PM_{2.5}$ emission rate:	**0.20**	g/s	assume same as PM10

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
POC =	Products of combustion	CV =	Calorific value

COMBUSTION CALCULATIONS

Golder Associates

01 Apr 2020
1793285 -8 MW new BFB
100% MCR,7% O2, Blend fuel 75% wood and 25% DAF sludge,
Calculation of emission rate using low end boiler effieciency and fuel CV

Parameter	Value	Unit	Comment / source of data
FUEL ULTIMATE ANALYSIS	New Vale		
Carbon:	57.51	%wt (DAF basis)	Blend fuel 75% wood and 25% DAF sludge
Hydrogen:	7.07	%wt (DAF basis)	Blend fuel 75% wood and 25% DAF sludge
Oxygen:	33.97	%wt (DAF basis)	Blend fuel 75% wood and 25% DAF sludge
Nitrogen:	1.32	%wt (DAF basis)	Blend fuel 75% wood and 25% DAF sludge
Sulphur:	0.13	%wt (DAF basis)	Blend fuel 75% wood and 25% DAF sludge
Fuel moisture content:	43.0	%wt (as received basis)	Blend fuel 75% wood and 25% DAF sludge
Ash content:	1.3	%wt (as received basis)	Blend fuel 75% wood and 25% DAF sludge
DAF portion:	0.557	kg/kg fuel (as received basis)	Blend fuel 75% wood and 25% DAF sludge
AIR REQUIREMENTS			
Theoretical O_2 required:	55.97	moles/kg (DAF basis)	
Excess air:	48.94	%	
Total O_2 required:	83.36	moles/kg (DAF basis)	
Flue gas CO_2 content:	12.25	%vol dry	
Flue gas O_2 content:	7.00	%vol dry	
APPLIANCE DETAILS			
Power Output:	8000	kW	
Percentage of MCR:	100	%	
Effective power output:	8000	kW	
Efficiency:	75.00	%	provided by Alliance
As rcvd fuel CV:	11510	kJ/kg	High end cv
Equivalent Stack diameter:	0.76	m	
Heat produced by combustion:	10667	kW	
Heat loss:	2667	kW	
Maximum fuel burning rate:	0.93	kg/s (as received basis)	
	3.34	t/h (as received basis)	
STACK PROPERTIES			
Temperature:	443	K	170º C as per boiler RFP
WET flow rate (POC sheet):	18.62	m³/kg DAF fuel	
Actual volumetric flow rate:	9.61	m³/s	
Stack x-sectional area:	0.45	m²	
Efflux velocity:	21.19	m/s	Use 15 m/s in the model
DRY flow rate @ STP (POC sheet):	8.77	Nm³/kg DAF fuel	
	4.53	Nm³/sec	
	16,295	Nm³/hour	
WET flow rate @ STP (POC sheet):	11.48	Nm³/kg DAF fuel	
	5.93	Nm³/sec	
	21,340	Nm³/hour	
EMISSION CALCULATIONS			
SO_2 emission rate (no ash retention):	1.3	g/s	
SO_2 emission rate (5% ash retention):	**1.23**	g/s	
	4.43	kg/hr	
NO_X emission factor:	500.00	mg/m³ dry 7% O2	boiler manufacturer's specification
NO_X emission rate:	**2.3**	g/s	
PM_{10} emission rate:	**50.00**	mg/m³ dry 7% O2	boiler manufacturer's specification
PM_{10} emission rate:	0.23	g/s	
$PM_{2.5}$ emission rate:	**0.23**	g/s	assume same as PM10

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
POC =	Products of combustion	CV =	Calorific value

APPENDIX C

Nitrogen Oxide Conversion Rate Regime

1.0 INTRODUCTION

One of the important primary pollutants from combustion activities is NO_X. NO_X refers to the sum of the two most common oxides of nitrogen, namely nitric oxide (NO) and nitrogen dioxide (NO_2). The contaminant of concern for potential human health effects is NO_2. However, the relative proportions of NO and NO_2 in a discharge plume change from their original amounts with distance downstream. This Appendix describes a method for diagnosing NO_2 from the total NO_X, as a post-processing step, to provide modelled ground-level concentrations (GLCs) of NO_2.

2.0 METHOD

The modelled NO_X has been post-processed using a method described by Janssen et al. (1988), which gives the ratio of NO_2 to NO_X as a function of distance from the source. The function was derived empirically from measurements of NO, NO_2 and ozone (O_3) in stack plumes of Dutch power plants over a period of 10 years. Janssen et al. (1988) found that NO to NO_2 oxidation in power plant plumes could be described approximately by the relationship given in Equation 1.

$$[NO_2]/[NO_X] = A(1-\exp(-\alpha x)) \qquad \text{Equation 1}$$

In Equation 1, $[NO_2]$ and $[NO_X]$ are the volume mixing ratios, or concentrations (as NO_2), of NO_2 and NO_X. The non-dimensional parameter, *A*, is referred to as the 'ozone' parameter, and α is the 'wind' parameter. The downwind distance is denoted by *x*.

Encapsulated in *A* is the oxidation of NO to NO_2 in the presence of O_3 and the photolysis of NO_2 by sunlight (to re-form NO). The wind parameter, α, also depends on $[O_3]$, and it implicitly converts reaction rates to a downwind distance scale, using the wind speed at the plume height. If *x* is in km, α is in units of 1/km.

The Janssen et al. method has been used for NO_X plumes from the proposed generator because chemical equilibrium will not have been reached close to the site. Alternative methods such as the ozone-limiting method would assume that oxidation from NO to NO_2 was complete, and would over-estimate the NO_2 near to the source. Also, the availability of O_3 would be reduced, due to the time required for atmospheric mixing processes to replace O_3 consumed by the oxidation reaction.

Janssen et al. (1988) placed no lower limit on the downwind distance, and Equation (1) gives zero $[NO_2]$ at the source (where x=0). This is not realistic, as measurements of $[NO_2]/[NO_X]$ in gas turbine power station stacks in New Zealand indicate the fraction may be up to 20 %, and measurements of $[NO_2]/[NO_X]$ in boilers indicate the fraction may be up to 10 %. For the boiler, NO_2 is conservatively assumed to comprise approximately 10 % of total NO_X at the discharge point. Then, a reasonable variation of Equation 1 is that given in Equation 2.

$$[NO_2]/[NO_X] = 0.1 + 0.8A(1 - exp(-\alpha x)) \qquad \text{Equation 2}$$

The values of *A* and α depend on ambient ozone levels, incoming solar radiation and wind speed. These empirical relationships, originally developed in the Netherlands, are shown in Table 1, Table 2 and Table 3. It has been assumed that the relationships also apply in New Zealand. The following section describes the use of ambient measurements to determine values of *A* and α suitable for the proposed site. These have been used in the main body of the report to post-process modelled NO_X to provide estimates of NO_2 ground-level concentrations around the plant.

Table 1: Values for *A* and α in winter (solar radiation up to 400 W/m^2).

Ozone background concentration	Wind speed at plume height < 5 m/s	Wind speed at plume height 5 m/s to 15 m/s	Wind speed at plume height > 15 m/s
120 – 200 ppb			
60 – 120 ppb			
40 – 60 ppb			
30 – 40 ppb	A = 0.87; α = 0.07	A = 0.87; α = 0.07	A = 0.87; α = 0.15
20 – 30 ppb	A = 0.83; α = 0.07	A = 0.83; α = 0.07	A = 0.83; α = 0.10
10 – 20 ppb	A = 0.74; α = 0.07	A = 0.74; α = 0.07	A = 0.74; α = 0.07
0 – 10 ppb	A = 0.49; α = 0.05	A = 0.49; α = 0.05	A = 0.49; α = 0.05

Table 2: Values for *A* and α in spring or autumn (solar radiation up to 1200 W/m^2).

Ozone background concentration	Wind speed at plume height < 5 m/s	Wind speed at plume height 5 m/s to 15 m/s	Wind speed at plume height > 15 m/s
120 – 200 ppb			
60 – 120 ppb			
40 – 60 ppb	A = 0.85; α = 0.10	A = 0.85; α = 0.15	A = 0.85; α = 0.30
30 – 40 ppb	A = 0.80; α = 0.10	A = 0.80; α = 0.10	A = 0.80; α = 0.25
20 – 30 ppb	A = 0.74; α = 0.10	A = 0.74; α = 0.10	A = 0.74; α = 0.15
10 – 20 ppb	A = 0.635; α = 0.10	A = 0.635; α = 0.10	A = 0.635; α = 0.10
0 – 10 ppb			

Table 3: Values for *A* and α in summer (solar radiation up to 1800 W/m^2).

Ozone background concentration	Wind speed at plume height < 5 m/s	Wind speed at plume height 5 m/s to 15 m/s	Wind speed at plume height > 15 m/s
120 – 200 ppb	A = 0.93; α = 0.40	A = 0.93; α = 0.65	A = 0.93; α = 0.80
60 – 120 ppb	A = 0.88; α = 0.20	A = 0.88; α = 0.35	A = 0.88; α = 0.45
40 – 60 ppb	A = 0.81; α = 0.15	A = 0.81; α = 0.25	A = 0.81; α = 0.35
30 – 40 ppb	A = 0.74; α = 0.10	A = 0.74; α = 0.15	A = 0.74; α = 0.25
20 – 30 ppb	A = 0.67; α = 0.10	A = 0.67; α = 0.10	A = 0.67; α = 0.10
10 – 20 ppb			
0 – 10 ppb			

3.0 DETERMINATION OF THE OZONE AND WIND PARAMETERS

As described above, the ozone and wind parameters, *A* and α, depend on ambient ozone, wind speed and solar radiation. They are determined from measurements presented in the following sections.

Ambient Ozone Concentrations

Baseline surface O_3 concentrations in New Zealand have been monitored at Baring Head, near Wellington, since 1991. Figure 1 shows hourly ozone concentrations at that site in 2008 - 2010, under baseline conditions (wind direction from the sea, direction between 150° and 210°, and speed greater than 5 m/s). There is a marked seasonal cycle, with minimum values of 10 - 20 ppb during the summer (days 335 to 365, and days 1 to 59) and maximum values of 25 - 35 ppb in the winter (days 152 to 243). Spring and autumn values are about 20 - 30 ppb. Under baseline conditions there is a relatively narrow range of ozone concentrations; the southerly winds are from the ocean, where the ozone destruction processes are slow.

Based on the ambient O_3 data, concentrations of 20 ppb in summer, 30 ppb in spring and autumn, and 35 ppb in winter have been used to look up parameter values in Table 1, Table 2 and Table 3.

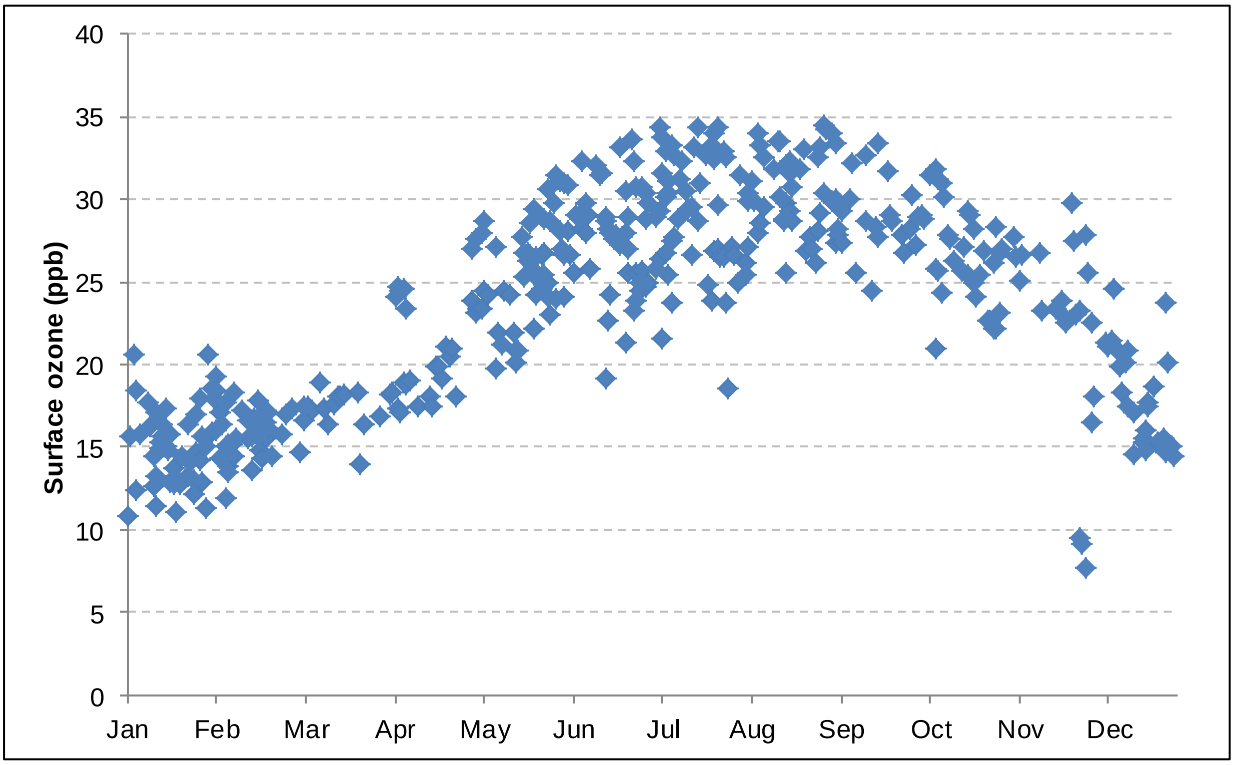


Figure 1: Daily average of surface ozone at Baring Head for 1 Jan 2008 to 1 Jan 2011 (NIWA).

Solar Radiation Data

Table 1, Table 2 and Table 3 provide seasonally-varying parameter values under incoming solar radiation rates of 400 W/m^2, 1200 W/m^2 and 1800 W/m^2 respectively. The ultraviolet solar radiation alters the chemical equilibrium between NO and NO_2 by dissociation of NO_2 molecules to re-form NO, and (through sensible heating at the surface) affects atmospheric mixing and dispersion. Parameters *A* and α have been used based on solar radiation levels experienced in Darfield, approximately 1.5 km to the west-southwest of the site's Area 2.

Figure 2 shows the maximum solar radiation rate at Darfield Electronic Weather Station (EWS) for each day from January 2007 to December 2010 (data publicly available and obtained from the National Climate Database and supplied by NIWA). This is expected to be conservative for the site. The solar flux rates show a variation over the year, from about 1,200 W/m^2 in summer to about 400 W/m^2 in winter.

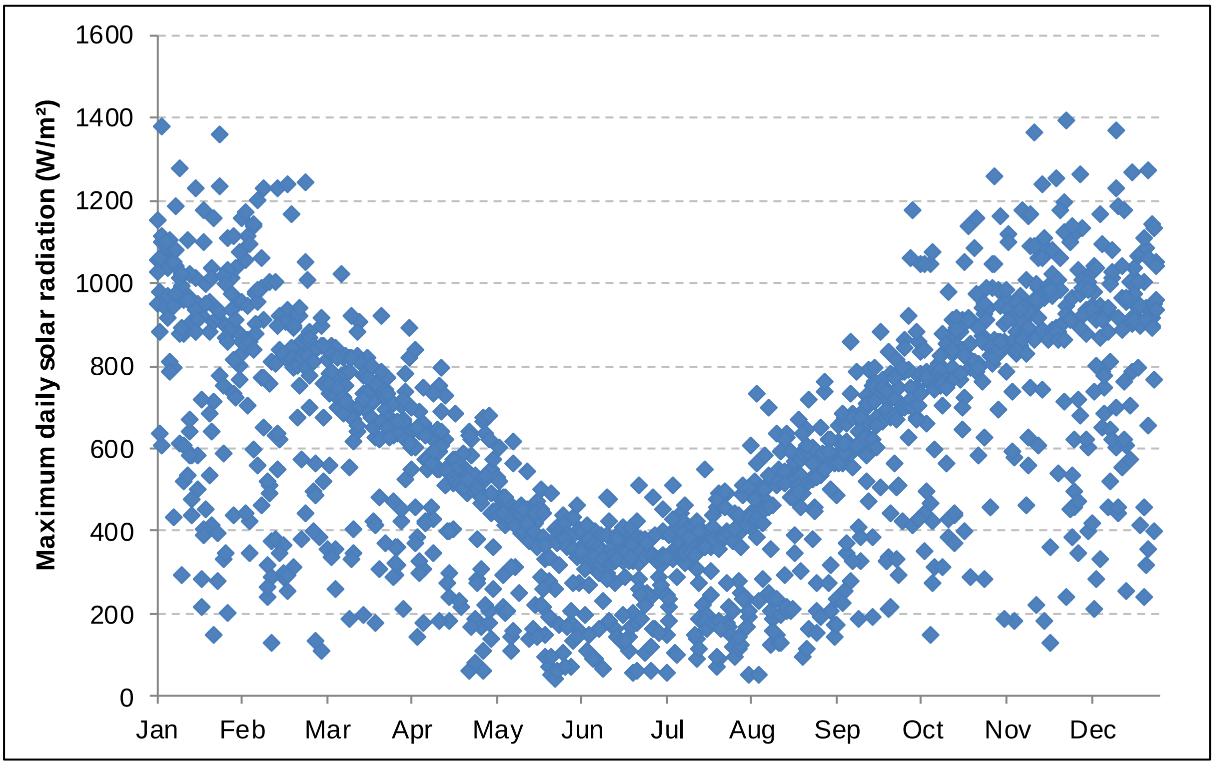


Figure 2: Maximum daily solar radiation at Darfield EWS for January 2007 to December 2010.

4.0 CONCLUSION

Suitable values of *A* and α have been selected from Table 1, Table 2 and Table 3, based on observed incoming solar radiation in Darfield and baseline O_3. These are shown in Table 4.

Table 4: Values of parameters *A* and α from the Janssen et al. method.

Season	O_3 (ppb)	Solar radiation (W/m²)	Ozone parameter (*A*)	Wind parameter (α, 1/km)	Table number
Summer	20	1,200	0.635	0.1	Table 2
Autumn/Spring	30	700	0.83	0.07 – 0.1	Table 1
Winter	35	400	0.87	0.07 – 0.15	Table 1

For a conservative prediction of NO_2, the highest value of *A* and the highest value of α in Table 4 have been used in the dispersion modelling. These are 0.87 and 0.15, respectively. The ratio of [NO_2] to [NO_X] is then given in Equation 3:

$$[NO_2]/[NO_X] = 0.1 + 0.696(1 - exp(-0.15x)) \qquad \text{Equation 3}$$

5.0 REFERENCES

Janssen LHJM, Van Wakeren JHA, Van Duren H and Elshout AJ 1988. A Classification of NO Oxidation Rates in Power Plant Plumes Based on Atmospheric Conditions. *Atmospheric Environment.* 22, No 1, 1988, pp 43-53.

NIWA 2013. Baring Head Atmospheric Ozone data. Sylvia Nichol, Gordon Brailsford, and Mike Harvey. http://www.niwa.co.nz/atmosphere/our-data/trace-gases. Accessed Aug 2013.

APPENDIX D

Ambient Particulate Monitoring

1.0 AMBIENT PARTICULATE MONITORING

1.1 Overview

Ambient monitoring for PM_{10} and $PM_{2.5}$ have been completed by Alliance during 2018 at two locations. The first being the elevated terrain immediately to the east of the CFB 1 stack (i.e., at Hillcrest Avenue), which was undertaken to meet consent monitoring requirements and was reported by Golder (2018). The second monitoring programme was undertaken at the southern boundary of the Alliance site as shown in Figure 1.

1.2 Monitoring Periods and Locations

Ambient monitoring of particulate matter (PM_{10} and $PM_{2.5}$) concentrations was carried out at two sites in 2018.

This first monitoring station was located at the hillside approximately 200 m east of the main boiler and was accessed from Hillcrest Avenue. The location was chosen as it was predicted by the previous dispersion modelling reported by Montgomery Watson (2000) to be the highest impacted offsite location with respect to PM_{10} concentration. The Hillside monitoring programme was carried out by Golder (2018) over the period of 8 February to 26 March 2018.

The second monitoring site was located inside the Alliance property boundary, approximately 250 m south southwest of the main CFB 1 stack. The location was selected because the wind data from the first monitoring programme data showed a predominant wind direction from CFB 1 towards this location. The Southern boundary programme was undertaken by Golder over the period of 28 March to 4 July 2018.

During both the monitoring period, the site has confirmed that CFB1 operated at 30% MCR from 3 am on Mondays to 2 am on Saturdays.

1.3 Monitoring method

Ambient PM_{10} and $PM_{2.5}$ were measured simultaneously with a broadband spectroscopy-based instrument (T640x PM Mass Monitor). The equipment was installed and operated by Golder.

The Model T640x PM Mass Monitor is not included in Schedule 2 of New Zealand's National Air Quality Standards for Air Quality which defines the required methods for monitoring PM_{10}. However, this monitor has been approved by the United States Environmental Protection Agency (USEPA) as a Federal Equivalent Method to their reference method for the determination of particulate matter as PM_{10}.

This site-specific monitoring programme also included the meteorological parameters of wind speed and direction, temperature and relative humidity.

1.4 Monitoring bias adjustment

To account for any systematic bias in the monitoring method co-location study results for a trial operated by the Canterbury Regional Council (CRC) during September and October 2018 were used to establish a preliminary K-factor for Golder's T6040x unit. This co-location study compared the CRCs and Golder's T640 units to ambient PM_{10} and $PM_{2.5}$ measurements within the Timaru airshed against parallel results obtained from NES compliant methods - a TEOM and Partisol monitors.

The preliminary results of this study have been analysed and indicate K factors for Golders T640x unit for 24 hour average PM_{10} and $PM_{2.5}$ of 0.8 and 0.9 respectively.

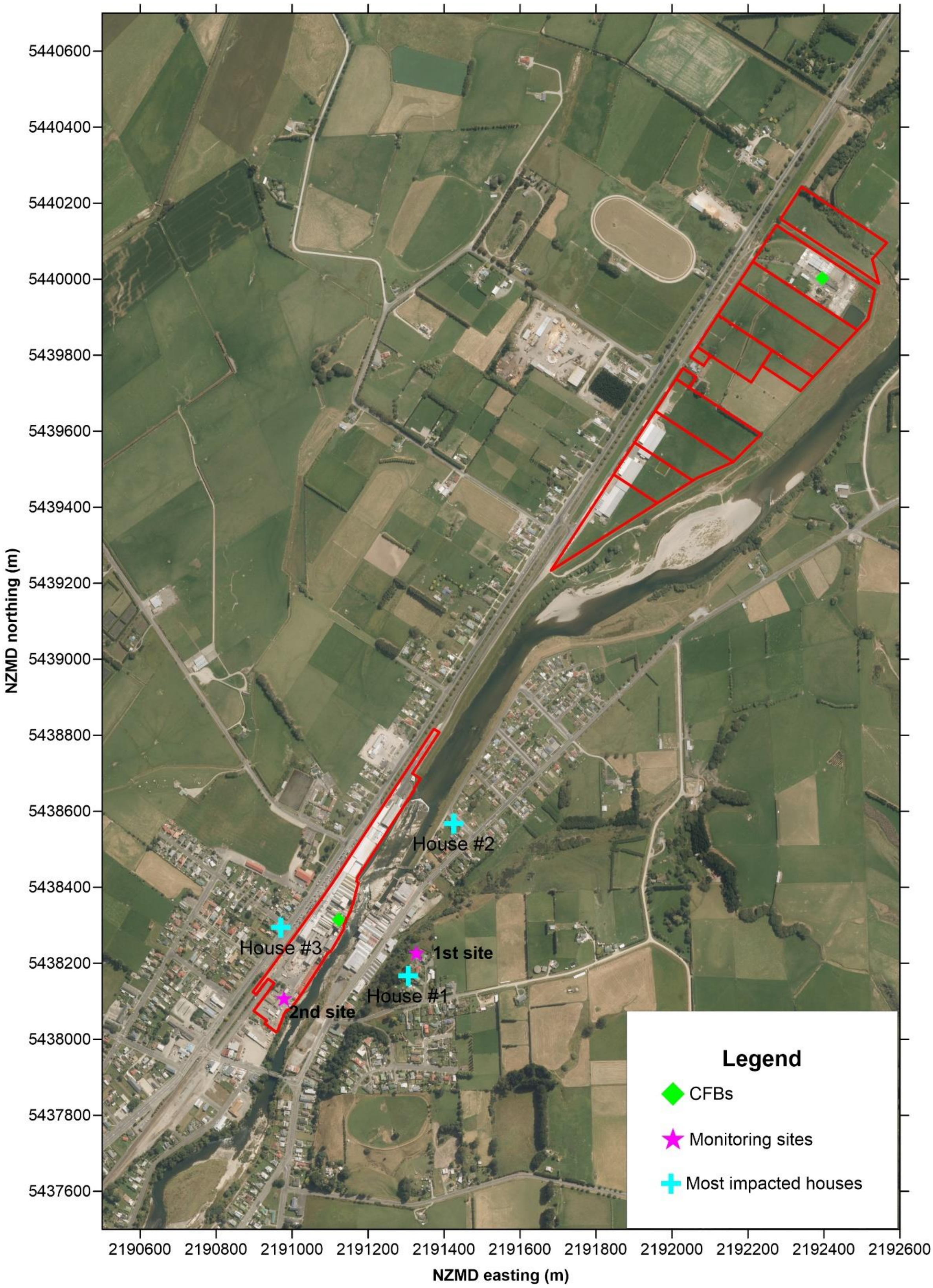


Figure 1: Alliance Mataura site and surrounds.

1.0 AMBIENT PARTICULATE MONITORING RESULTS

1.1 Cumulative Concentrations

Measured cumulative ambient concentrations of PM_{10} and $PM_{2.5}$ at the two ambient monitoring sites in Mataura are provided in Table 1 and Table 2. These levels are compliant with the NES for 24-hour average PM_{10} but not the WHO for 24 hour average $PM_{2.5}$.

The 50th percentile values for these colder months also provide an estimate of the long term average PM_{10} and $PM_{2.5}$ concentrations that would occur at these two sites during winter months.

Whilst the NES criteria are complied with, the ambient particulate levels measured at Alliance's southern site boundary are significantly elevated, such that they approach this key criteria. Further assessment and evaluation of the monitoring results in discussed below with respect to what extent the Alliance CFBs contribute to these elevated levels versus the contributions from background source and especially domestic home heating emissions.

A summary of the monitoring results from both programmes are provided in Table 1 and Table 2, Figure 2 and Figure 3.

Table 1: PM_{10} Percentiles (24-hour average) measured in Mataura during 2018.

Station	24 Hour Average PM_{10} Concentration (µg/m³)						NES
	10th percentile	25th percentile	50th percentile	75th percentile	95th percentile	Max	(µg/m³)
Hillcrest Avenue*	5	7	11	12	15	19	50
Southern boundary#	8	12	16	23	32	46	50

Notes: * Measured from 8 February to 26 March 2018 (Golder, 2018). # Measured from April – 4 July 2018.

Table 2: $PM_{2.5}$ Percentiles (24-hour average) measured in Mataura during 2018.

Station	24 Hour Average $PM_{2.5}$ Concentration (µg/m³)						WHO
	10th percentile	25th percentile	50th percentile	75th percentile	95th percentile	Max	(µg/m³)
Hillcrest Avenue	2	3	5	5	7	9	25
Southern boundary	4	7	10	15	23	33	25

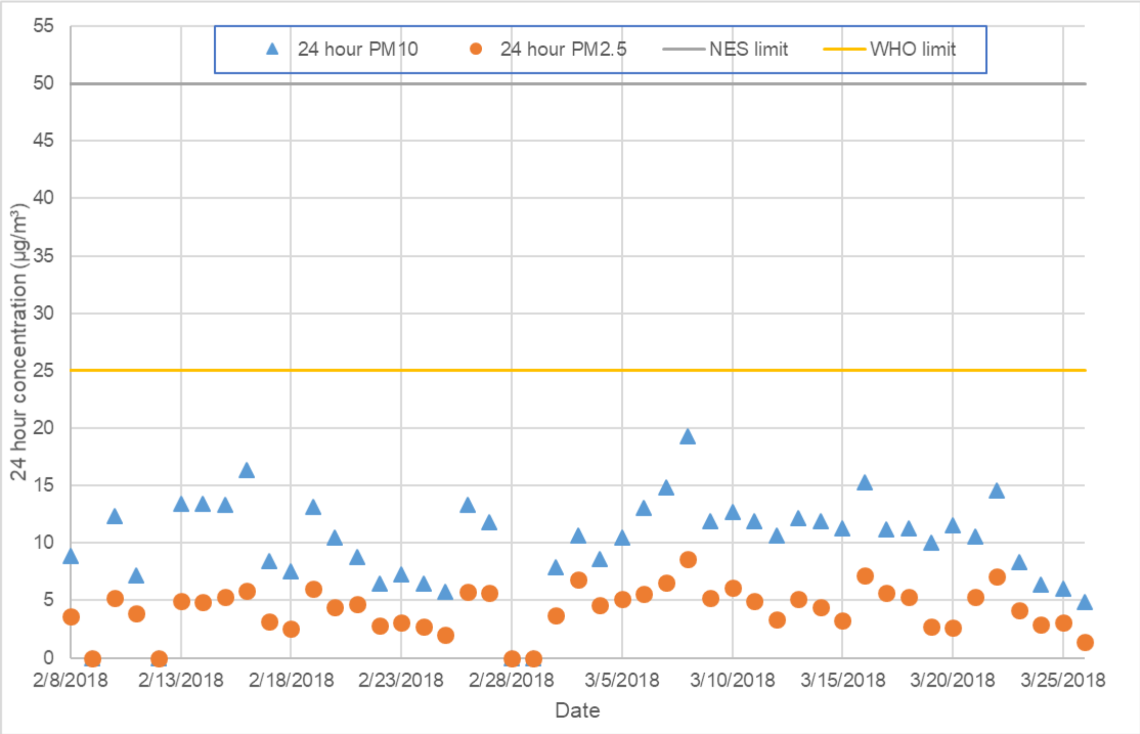


Figure 2: Hillcrest Avenue Monitoring station 24 hour average PM_{10} and $PM_{2.5}$ concentrations.

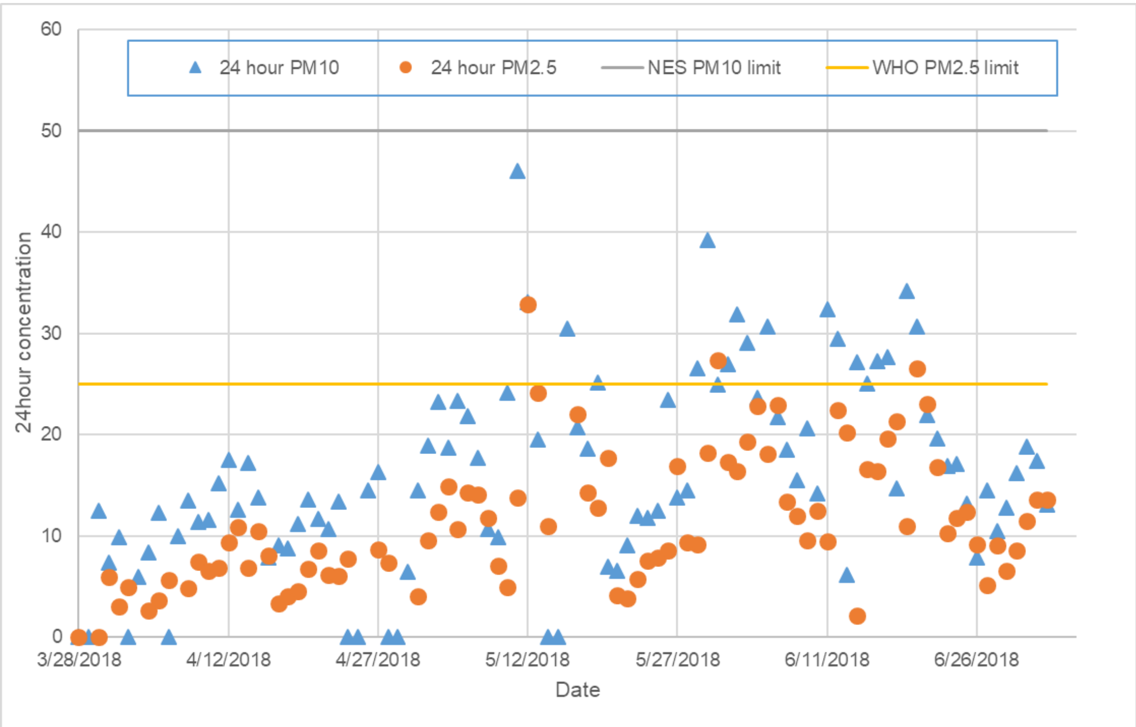


Figure 3: Southern Boundary Monitoring station 24 hour average PM_{10} and $PM_{2.5}$ concentrations.

2.0 ANALYSIS OF AMBIENT MONITORING

2.1 Background Concentrations

Background PM_{10} and $PM_{2.5}$ concentrations within Mataura township were established from the monitoring undertaken at the southern Alliance boundary. The background levels were segregated from cumulative results by analysing monitored data for every hour of each day for the 90 days of monitoring.

For the vast majority of days when the CFB 1 influenced the monitor for less than 12 hours, the hourly PM_{10} and $PM_{2.5}$ concentrations (not influenced by CFB 1) were collated and used to estimate the 24 hour background concentration for that day that has no CFB influence. This is considered to provide an accurate estimate of background concentrations for all 90 days of monitoring for April, May, June up to July 4th 2018 with the CFB 1 influenced removed and for a central location within Mataura.

The 90 days of estimated 24 hour background PM_{10} and $PM_{2.5}$ concentrations (mean values) were evaluated against daily average wind speed and temperature criteria so that appropriate background levels could be added to modelled ambient impacts due to the CFBs alone. Upper limits of mean values have been estimated at 75% and 99% confidence levels. The results of data analysis are provided in Table 3. And annual averages (based on percentage of time conditions occur) is provided in Table 4.

Table 3: Summary of estimated background 24 HOUR particulate versus weather conditions.

Daily weather category	Daily average wind speed (m/s)	Daily average temp.	Percentage of time conditions occur*	PM_{10} (24 hour) µg/m³			$PM_{2.5}$ (24 hour) µg/m³		
				Mean	Upper 75th confidence limit#	Upper 99th confidence limit**	Mean	Upper 75th confidence limit	Upper 99th confidence limit
A	< 2	< 5°C	2%	24	29	38	17	21	29
B	<2	≥ 5°C	9%	20	22	26	13	15	18
C	≥2 and <3	all	25%	13	13	15	8	9	9
D	≥3	all	64%	11	12	14	6	7	8

Notes: *Based on annual CALMET meteorological dataset for 2003. # Upper 75th confidence limit = upper estimate of mean at 75% confidence. **Upper 99th confidence limit = upper estimate of mean at 99% confidence.

Table 4: Summary of estimated background ANNUAL particulate.

Location in Mataura	PM_{10} (Annual) µg/m³	$PM_{2.5}$ (Annual) µg/m³
	Mean	Mean
Township	12	7
Hill top areas	10	4

The results in Table 3 are likely to be applicable to the assessment of cumulative impacts of PM_{10} and $PM_{2.5}$ that is discharged from the CFBs and background levels for receptors on raised terrain to the east of the site. These hilltop receptors are likely to be downwind of the CFBs during relatively windy conditions, as such the background concentrations in Table 3 for days of moderate to strong wind are likely to apply, whereas elevated levels due to cold still days in Mataura township are not likely to be applied.

The results in Table 3 were also used to estimate realistic annual average PM_{10} and $PM_{2.5}$ concentrations when also utilising the site specific meteorological data set (as used for the dispersion modelling assessment).

The year of met-data was used to confirm the frequency of occurrence throughout the year of the daily weather categories specified in Table 3. These frequencies were used to calculate annual average background concentrations of PM_{10} and $PM_{2.5}$ by summing weighted background concentrations in Table 3 in accordance to the frequency of their associated daily averaged weather conditions. This would provide a realistic (albeit conservative) estimate of the annual average PM_{10} and $PM_{2.5}$ concentrations that are likely to occur in Mataura Township.

Based on the percentage of time that the meteorological conditions occur, the resultant annual average background concentration for Mataura township is 12 µg/m^3 and 7 µg/m^3 respectively for PM_{10} and $PM_{2.5}$ respectively. For annual average impacts on the hilltop area of Mataura, the estimated annual average concentrations for Mataura are likely to be too conservative and there the average of monitoring results from the Hillcrest monitoring site was instead used for this assessment. From Tables 4 and 5 these annual average values are 10 µg/m^3 and 4 µg/m^3 respectively for PM_{10} and $PM_{2.5}$ respectively.

2.2 Coal Fired Boiler Contributions

Incremental impacts of PM_{10} and $PM_{2.5}$ ambient concentrations due to CFB 1 emissions were estimated using the established background levels at the southern Alliance boundary monitoring site. Background concentrations and total cumulative measured PM_{10} concentrations are shown in Figure 4. Background concentrations were established as described in Section 2.1 with all values used (i.e. no exclusions for days when non CFB wind directions were less than 12 hours of the day). On occasions, the background only concentrations are higher than the measured concentrations. This is because there were periods during those days when the wind was blowing from the direction of the boiler stack the concentrations were lower than those observed when the wind was not blowing from the direction of the boiler. Ranked values are shown in Table 5.

Therefore, it is concluded that the background from the direction of the boiler is variable and can be lower than the background from other directions. This is more apparent for upper ranks compared to concentrations below approximately rank 20.

To determine the incremental impact of the CFB 1 emissions upon monitored cumulative concentrations requires the subtracting the 24 hour average background concentration from the measured cumulative 24 hour PM_{10} and concentrations for any one day. The analysis of the monitoring data revealed that this assumption was not valid for the days that recorded the higher ranked impacts. However, it is still considered valid to days of recorded 24 hour PM_{10} and $PM_{2.5}$ concentrations that were the 20th rank or lower.

From reviewing the data in Table 5, with the exception of the maximum measured concentration of 46 µg/m^3, the maximum increment the boiler contributes to 24 hour PM_{10} is 9 ug/m^3. For the maximum concentration of 46 µg/m^3, it is uncertain what the background is, but the boiler is most likely to have been the major contributor to this.

From reviewing the data in Table 5, with the exception of the maximum measured concentration of 33 µg/m³, the maximum increment the boiler contributes to 24 hour $PM_{2.5}$ is 6 ug/m³. For the maximum concentration of 33 µg/m³, it is uncertain what the background is, but the boiler is most likely to have been the major contributor to this.

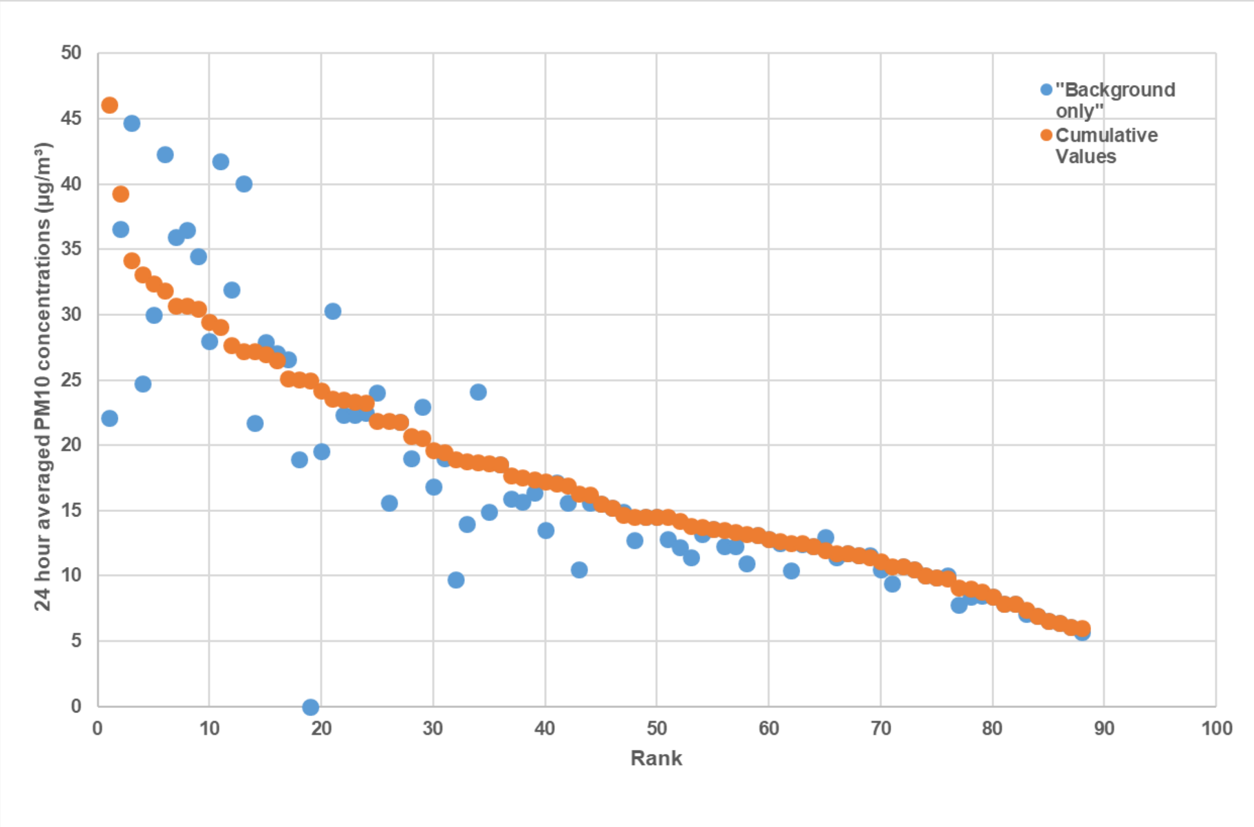


Figure 4: Measured PM_{10} concentrations by rank with background only contributions also shown.

2.3 $PM_{2.5}$/PM_{10} Ratio

The measured cumulative concentration, boiler contributions and background concentrations were also reviewed to estimate the $PM_{2.5}$/PM_{10} ratio. Background concentrations were established as described in Section 2.1. Boiler contributions were derived from subtracting the 24 hour average background concentration from the measured cumulative 24 hour PM_{10}. Their respective $PM_{2.5}$/PM_{10} ratios are shown in Table 5.

A maximum ratio of 0.8 and an average ratio of 0.6 are observed for both cumulative and background concentrations. Particularly for those days when the boiler was upwind of the monitor for over 12 hours per day, the ratio for cumulative concentrations is in a range of 0.6 to 0.8 with an average ratio of 0.7. This is consistent with the average ratio of 0.7 that were calculated for the boiler contribution only. It confirms that using the maximum ratio of 0.8 is considered to be appropriate and conservative to estimate $PM_{2.5}$ effects from the boiler.

Table 5: Ranked PM_{10} and $PM_{2.5}$ concentrations.

Rank	Date	24-hour average PM_{10}			24-hour average $PM_{2.5}$			Hours from boiler	$PM_{2.5}$/ PM_{10} Ratio		
		Total	Back-ground only	Boiler only*	Total	Back-ground only	Boiler only*		Total	Back-ground only	Boiler only
1	Thursday 10/05/18	46.1	22		33	12		23	0.71	0.55	0.9
2	Tuesday 29/05/18	39.3	37		27	26		6	0.70	0.70	0.7
3	Monday 18/06/18	34.2	45		27	35		10	0.78	0.79	
4	Friday 11/05/18	33.1	25		24	18		8	0.73	0.72	0.8
5	Sunday 10/06/18	32.4	30		22	20		5	0.69	0.68	0.9
6	Friday 1/06/18	31.9	42		19	25		15	0.61	0.58	
7	Tuesday 19/06/18	30.7	36		23	27		7	0.75	0.76	
8	Monday 4/06/18	30.7	36		23	28		15	0.75	0.76	
9	Tuesday 15/05/18	30.4	34		22	25		11	0.72	0.73	
10	Monday 11/06/18	29.4	28		20	19		4	0.69	0.69	0.7
11	Saturday 2/06/18	29.0	42		23	33		15	0.79	0.79	
12	Saturday 16/06/18	27.7	32		21	24		17	0.77	0.76	
13	Friday 15/06/18	27.2	40		20	30		22	0.72	0.75	
14	Wednesday 13/06/18	27.2	22		17	13		9	0.61	0.58	0.7
15	Thursday 31/05/18	27.0	28		16	11		18	0.61	0.40	
16	Monday 28/05/18	26.5	27		18	19		2	0.69	0.69	
17	Friday 18/05/18	25.1	27		18	19		4	0.71	0.71	

Rank	Date	24-hour average PM_{10}			24-hour average $PM_{2.5}$			Hours from boiler	$PM_{2.5}$/ PM_{10} Ratio		
		Total	Back-ground only	Boiler only*	Total	Back-ground only	Boiler only*		Total	Back-ground only	Boiler only
18	Thursday 14/06/18	25.0	19		16	11		15	0.66	0.56	1.0
19	Wednesday 30/05/18	25.0	0		17	0		24	0.69		0.7
20	Wednesday 9/05/18	24.2	20	5	14	10	4	6	0.57	0.51	0.8
21	Sunday 3/06/18	23.6	30	-7	18	23	-5	18	0.77	0.77	
22	Friday 25/05/18	23.5	22	1	17	16	1	6	0.72	0.72	0.6
23	Friday 4/05/18	23.4	22	1	14	13	1	14	0.61	0.59	1.1
24	Wednesday 2/05/18	23.2	23	1	15	14	1	7	0.64	0.64	0.7
25	Wednesday 20/06/18	21.9	24	-2	17	19	-2	8	0.77	0.78	
26	Saturday 5/05/18	21.9	16	6	14	10	4	19	0.64	0.67	0.6
27	Tuesday 5/06/18	21.8	22	0	13	14	0	9	0.62	0.64	
28	Wednesday 16/05/18	20.7	19	2	14	13	1	9	0.69	0.71	0.5
29	Friday 8/06/18	20.6	23	-2	13	14	-1	13	0.61	0.60	
30	Thursday 21/06/18	19.6	17	3	10	10	0	2	0.53	0.61	
31	Saturday 12/05/18	19.5	19	1	11	11	0	6	0.56	0.57	0.3
32	Tuesday 1/05/18	18.9	10	9	12	6	6	10	0.66	0.61	0.7
33	Saturday 30/06/18	18.8	14	5	14	9	4	21	0.72	0.67	0.9
34	Thursday 3/05/18	18.7	24	-5	11	15	-4	19	0.57	0.60	
35	Thursday 17/05/18	18.6	15	4	13	10	3	3	0.69	0.66	0.8

Rank	Date	24-hour average PM_{10}			24-hour average $PM_{2.5}$			Hours from boiler	$PM_{2.5}$/ PM_{10} Ratio		
		Total	Back-ground only	Boiler only*	Total	Back-ground only	Boiler only*		Total	Back-ground only	Boiler only
36	Wednesday 6/06/18	18.6	19	0	12	12	0	0	0.64	0.64	
37	Sunday 6/05/18	17.7	16	2	12	11	1	5	0.67	0.67	0.6
38	Wednesday 11/04/18	17.5	16	2	11	9	1	4	0.62	0.60	0.8
39	Sunday 1/07/18	17.4	16	1	14	13	1	6	0.78	0.78	0.7
40	Friday 13/04/18	17.2	14	4	10	8	3	3	0.61	0.56	0.8
41	Saturday 23/06/18	17.1	17	0	12	14	-1	23	0.72	0.80	
42	Friday 22/06/18	16.9	16	1	12	11	1	8	0.69	0.68	0.9
43	Thursday 26/04/18	16.3	10	6	7	5	2	6	0.45	0.50	0.4
44	Friday 29/06/18	16.2	16	1	11	11	1	5	0.71	0.70	0.9
45	Thursday 7/06/18	15.5	16	0	10	10	0	0	0.62	0.62	
46	Tuesday 10/04/18	15.2	15	0	9	9	0	0	0.62	0.62	
47	Sunday 17/06/18	14.6	15	0	11	11	0	11	0.75	0.74	
48	Monday 30/04/18	14.5	13	2	10	8	1	3	0.66	0.66	0.6
49	Tuesday 26/06/18	14.5	15	0	9	9	0	0	0.62	0.62	
50	Sunday 27/05/18	14.5	14	0	9	9	0	0	0.63	0.63	
51	Wednesday 25/04/18	14.5	13	2	9	8	1	11	0.60	0.63	0.4
52	Saturday 9/06/18	14.2	12	2	9	9	1	12	0.67	0.70	0.5
53	Saturday 14/04/18	13.8	11	2	8	6	2	7	0.59	0.54	0.8

Rank	Date	24-hour average PM_{10}			24-hour average $PM_{2.5}$			Hours from boiler	$PM_{2.5}$/ PM_{10} Ratio		
		Total	Back-ground only	Boiler only*	Total	Back-ground only	Boiler only*		Total	Back-ground only	Boiler only
54	Saturday 26/05/18	13.8	13	1	9	9	1	3	0.68	0.67	0.9
55	Thursday 19/04/18	13.5	14	0	9	9	0	0	0.63	0.63	
56	Saturday 7/04/18	13.5	12	1	7	6	1	5	0.55	0.52	0.8
57	Sunday 22/04/18	13.4	12	1	8	7	1	2	0.58	0.56	0.9
58	Sunday 24/06/18	13.2	11	2	9	8	2	8	0.69	0.69	0.7
59	Monday 2/07/18	13.1	13	0	9	9	0	0	0.66	0.66	
60	Thursday 28/06/18	12.8	13	0	9	9	0	0	0.67	0.67	
61	Thursday 12/04/18	12.6	13	0	7	7	0	5	0.54	0.53	1.9
62	Thursday 29/03/18	12.5	10	2	6	5	1	9	0.48	0.49	0.4
63	Thursday 24/05/18	12.5	12	0	9	9	0	4	0.68	0.70	
64	Wednesday 4/04/18	12.3	12	0	6	6	0	0	0.46	0.46	
65	Tuesday 22/05/18	11.9	13	-1	8	9	-2	9	0.63	0.71	
66	Wednesday 23/05/18	11.7	11	0	8	8	0	2	0.67	0.69	0.1
67	Friday 20/04/18	11.7	12	0	6	6	0	0	0.53	0.53	
68	Monday 9/04/18	11.6	12	0	7	7	0	0	0.59	0.59	
69	Sunday 8/04/18	11.4	12	0	7	7	0	8	0.58	0.61	
70	Wednesday 18/04/18	11.1	11	1	7	6	0	2	0.61	0.62	0.5
71	Monday 7/05/18	10.7	9	1	7	6	1	0	0.66	0.66	0.7

Rank	Date	24-hour average PM_{10}			24-hour average $PM_{2.5}$			Hours from boiler	$PM_{2.5}$/ PM_{10} Ratio		
		Total	Back-ground only	Boiler only*	Total	Back-ground only	Boiler only*		Total	Back-ground only	Boiler only
72	Saturday 21/04/18	10.7	11	0	6	6	0	0	0.56	0.56	
73	Wednesday 27/06/18	10.5	10	0	7	7	0	0	0.62	0.62	
74	Friday 6/04/18	10.0	10	0	5	5	0	0	0.49	0.49	
75	Tuesday 8/05/18	9.9	10	0	5	5	0	0	0.50	0.50	
76	Saturday 31/03/18	9.8	10	0	5	5	0	3	0.50	0.49	
77	Monday 21/05/18	9.1	8	1	6	5	1	2	0.64	0.64	0.6
78	Monday 16/04/18	9.0	8	1	4	4	0	8	0.45	0.47	0.2
79	Tuesday 17/04/18	8.8	9	0	5	5	0	5	0.52	0.56	
80	Tuesday 3/04/18	8.4	8	0	4	4	0	0	0.43	0.43	
81	Sunday 15/04/18	7.8	8	0	3	3	0	4	0.42	0.41	
82	Monday 25/06/18	7.8	8	0	5	5	0	0	0.65	0.65	
83	Friday 30/03/18	7.4	7	0	3	3	0	7	0.41	0.39	1.0
84	Saturday 19/05/18	7.0	7	0	4	4	0	0	0.60	0.60	
85	Sunday 20/05/18	6.6	7	0	4	4	0	1	0.58	0.58	0.5
86	Sunday 29/04/18	6.4	6	0	4	4	0	0	0.63	0.63	
87	Tuesday 12/06/18	6.1	6	0	2	2	0	0	0.35	0.35	
88	Monday 2/04/18	6.0	6	0	3	2	0	11	0.44	0.44	0.4

Notes: *Boiler only = total – background concentrations.

APPENDIX E

CALPUFF Modelling Set Up

Introduction

As mentioned in the main text, CALPUFF version 7.0 was run from for the months of August 2003 to August 2004 (inclusive). Most standard options were used, including the PRIME building-wake algorithm and the 'pdf' formulation for dispersion under convective conditions. Concentrations of PM_{10}, $PM_{2.5}$, NO_X, and SO_2 were calculated by the model on regular sampling grids centred on the Alliance Mataura meat processing site and hide plant. The CALPUFF model domain is shown in Figure 1.

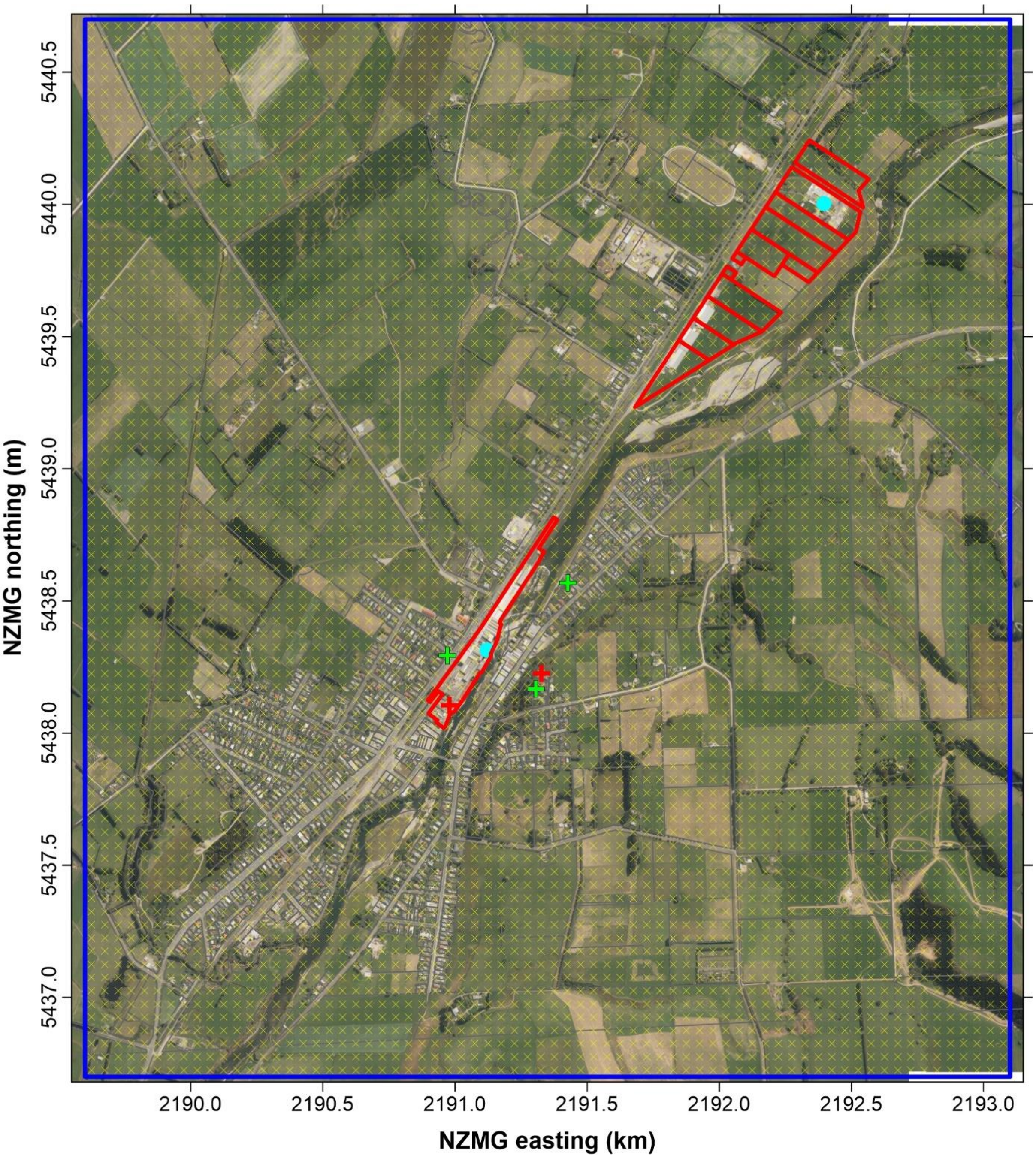


Figure 1: CALPUFF model domain. Sampling grids locations marked as yellow crosses, sensitive receptor locations marked as green crosses, monitoring sites marked as red crosses, the site boundary marked in red.

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		01:00	25 August 2003
End date/time		22:00	24 August 2004
Base time zone	XBTZ	-12 (NZST)	
Time step	NSECDT	3600 s	

Table 2: Pollutant specifications.

Parameter		Value	
Number of chemical species	NSPEC	5	
Number of emitted species	NSE	5	
Species; modelled; emitted; deposited?		PM_{10} NO_x $PM_{2.5}$ SO_2 NO_2	Yes; Yes; No Yes; Yes; No Yes; Yes; No Yes; Yes; No Yes; Yes; No
Chemical mechanism	MCHEM	0 (No chemistry)	
Dry deposition	MDRY	0 (No dry deposition)	
Wet deposition	MWET	0 (No wet deposition)	

Table 3: Technical options.

Parameter		Value
Dispersion coefficient calculation	MDISP	2 use micrometeorological variables
Back-up calculation	MDISP2	3 PG for rural; MP for urban
PDF for dispersion under convective conditions	MPDF	1 (On)
Building downwash	MBDW	2 PRIME algorithm
Check parameters for regulatory settings		No (they are USEPA-specific)
Minimum σv over land (default 0.5 m/s)		0.5 m/s

Table 4: Map projection (the parameters match those of CALMET).

Parameter	Value
Map projection	Tangential Transverse Mercator (TTM)
Datum region	WGS-84
Projection origin	46.37 S, 168.53 E
False origin *(NZTM coordinates)*	(2166, 5417) km

Table 5: Grid control.

Parameter		Value
SW corner of grid cell (1,1)		2189.6 km, 5436.2 km (NZMD)
Grid dimensions	NX x NY; DGRIDKM	70 x 90 grid cells at spacing 0.05 km
Vertical grid, number of layers		12
Cell-face heights for vertical grid (m)		0, 20, 50, 90, 130, 200, 300, 450, 650, 950, 1400, 2000, 2896

Table 6: Grid control (subset of CALMET grid points used by CALPUFF).

Parameter	Value
CALPUFF computational grid range E-W	1 to 70 out of NX=70
CALPUFF computational grid range S-N	11 to 90 out of NY=90
Use of gridded receptors?	NO

Table 7: Discrete receptors.

Type	NZTM Easting (m)	NZTM Northing (m)	Ground Elev. (m)*
Monitoring Site 1	2191327	5438225	80.35
Monitoring Site 2	2190978	5438105	55.66
House 1	2191305.53	5438167.48	82.17
House 2	2191425.76	5438567.7	56.99
House 3	2190970.65	5438293.93	56.04

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

Stack Source Parameters

Table 8: Stack discharge parameters.

Point source ID	Description	NZMD Easting (m)	NZMD Northing (m)	Stack height (m)	Base elevation (m)	Stack diameter (m)	Efflux velocity (m/s)	Temp. (K)
SRC_1	Hide Store 40% MCR	2192395	5440002	19.8	58.31	0.6	2.3	523
SRC_2	Main CFB at 68% MCR	2191122	5438314	30	57	2	2.8*	503
SRC_3	Main BFB at 100% MCR	2191122	5438314	29	57	0.76	15	443

Notes: *Note this is slightly lower than calculated, and therefore conservative.

Table 9: Emission parameters.

Point source ID	PM_{10} (g/s)	$PM_{2.5}$ (g/s)	NO_X (g/s)	SO_2 (g/s)
SRC_1#	0.21	0.17	0.16	0.47
SRC_2*	0.2	0.2	1.9	5.6
SRC_3+	0.23	0.23	13.6	1.31

Notes: # emission rate for 40% MCR condition. *emission rate for lower MCR, resultant concentrations were scaled by 1.046 to account for increased emissions under 68% MCR scenario. +emission rate for 100% MCR.

Building Parameters

```
'P'
'METERS'  1.00000000
'UTMY'  0.0000
9
'BLD_1'  1          55.39  'Boiler house SW'
   4         18.00
         2191107.85     5438300.21
         2191111.36     5438305.62
         2191124.35     5438297.19
         2191120.83     5438291.78
'BLD_2'  1          55.34  'Boiler House NE'
   4          6.00
         2191111.37     5438305.77
         2191117.07     5438314.54
         2191130.07     5438306.10
         2191124.38     5438297.32
'BLD_3'  1          57.22  'Building 3 - SW of Boiler House'
   4          9.00
         2191085.78     5438245.29
         2191104.73     5438275.60
         2191120.00     5438266.06
         2191101.05     5438235.74
'BLD_4'  1          57.00  'North Group - 1'
   4         27.00
         2191153.19     5438486.47
         2191186.57     5438537.87
         2191204.00     5438526.55
         2191170.62     5438475.15
'BLD_5'  1          57.00  'North Group - 2'
   4         35.00
         2191168.77     5438470.89
         2191202.84     5438523.37
         2191219.99     5438512.23
         2191185.92     5438459.75
'BLD_6'  1          57.00  'North Group - 3'
   4         23.00
         2191114.83     5438425.70
         2191153.75     5438485.63
         2191171.51     5438474.09
         2191132.59     5438414.16
'BLD_7'  1          57.00  'North Group - 4'
   4         24.00
         2191136.45     5438418.82
         2191168.37     5438469.90
         2191186.26     5438458.72
         2191154.34     5438407.64
'BLD_8'  1          58.37  'Hide Store N'
   6          6.00
         2192384.24     5440025.56
         2192398.74     5440047.78
         2192412.30     5440039.11
         2192416.40     5440045.89
         2192430.58     5440037.22
         2192411.83     5440007.27
'BLD_9'  1          57.94  'Hide Store E'
   8          8.00
         2192427.75     5440032.02
         2192454.23     5440015.15
         2192433.58     5439983.15
         2192440.20     5439978.27
         2192434.68     5439970.39
         2192393.38     5439997.66
         2192398.59     5440005.85
         2192407.25     5439999.86
2
'SRC_1'        58.31     19.80     2192395.44     5440002.58
'SRC_2'        57.00     30.00     2191122.39     5438314.03
'SRC_3'        57.00     29.00     2191122.39     5438314.03
```

Figure 2: Building parameter (BPIP) input file.

APPENDIX F

CALMET Modelling Set Up

1.0 INTRODUCTION

CALMET meteorological fields were generated for use with the CALPUFF model using a multi-stage process. This involved the use of hourly upper-air profiles from the prognostic model, TAPM, the setup from which is described in Section 3.0 below. This is considered by Golder to be preferable to using only the 12-hourly measurements above Invercargill as the radiosonde profiles are only measured every 12 hours.

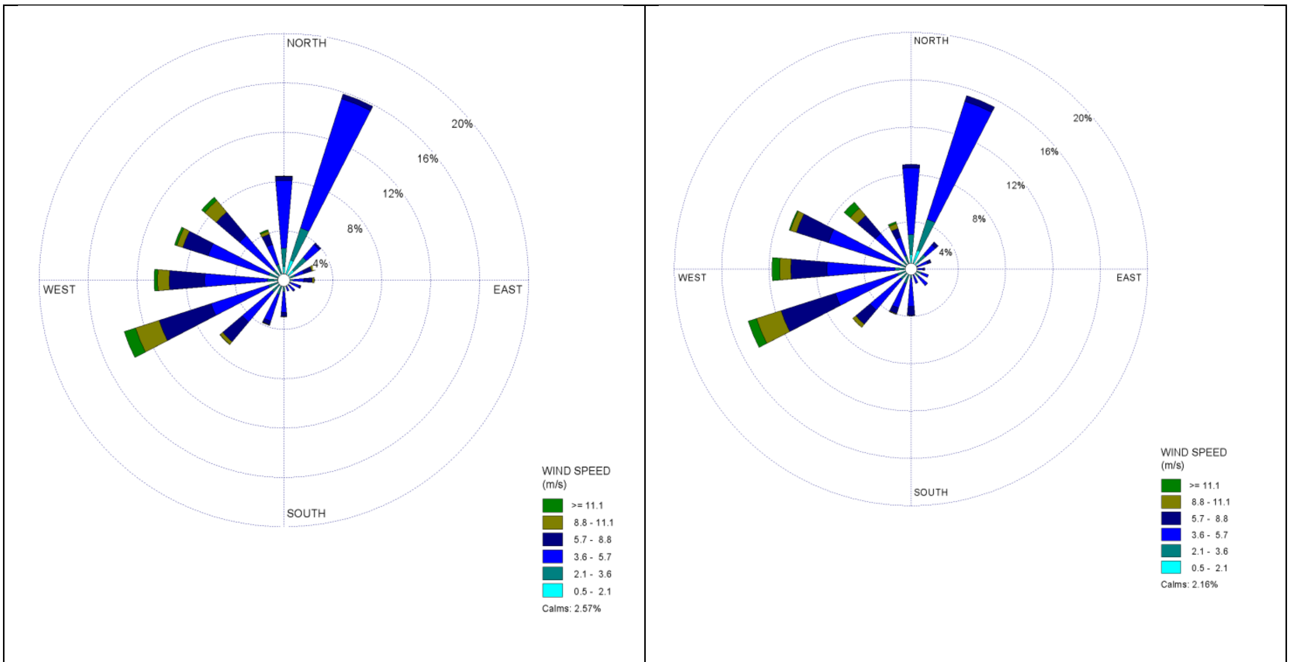
The multi-stage process is described in detail by Gimson *et al.* (2010). TAPM was run over New Zealand on a set of nested grids, with the highest resolution over Southland. Vertical profiles were extracted from its three-dimensional, hourly outputs, coinciding with several surface-based monitoring sites, with an extra profile location away from surface sites. The configuration of TAPM used here and a discussion of its performance are contained in Section 3.0 of this Appendix. An 'initial' CALMET run was based on available surface data and the single TAPM sounding, in which profiles above the surface sites were calculated by CALMET. The CALMET and TAPM site-based vertical profiles were blended so as to produce a gradual change from the CALMET profiles near the surface to the TAPM profiles aloft, thereby generating new profiles. This was done to avoid sudden changes in wind patterns, which can result in an unrealistic "bulls-eye" effect in the resulting wind fields. The new profiles were then treated as observations in an 'intermediate' CALMET run. The initial and intermediate CALMET runs cover the same area as TAPM's 3-km grid (the finest), but on a 1-km grid.

A 'final' CALMET run was then carried out at 50 m horizontal resolution. This was done over a sub-region containing the town of Mataura and the surrounding hills. The 'final' CALMET run used the 'intermediate' run for an initial estimate of the meteorological fields, as none of the surface sites are in the 50 m domain (the closest monitoring sites are in Edendale and Gore).

The following sections of this Appendix discuss the choice of year to model (Section 2.0), and describe the configurations of TAPM (Section 3.0) and CALMET (Section 4.0).

2.0 AVAILABLE METEOROLOGICAL DATA AND MODEL YEAR SELECTION

Meteorological modelling was carried out for a full year, coinciding with the availability of monitoring data from the Edendale. The Edendale data were available for the periods 25 September 2003 to 25 August 2004 and 29 March 2006 to 5 June 2006. The wind patterns for these periods are shown as wind roses in Figure 1. Wind roses for Invercargill Airport AWS site from 2000 to 2005 have been examined (see Figure 2). There is little variation between years; it can be assumed that the Edendale data sets are obtained in typical years and may be used for the dispersion modelling. Therefore, the full-year modelling period includes the 11-month period in 2003/2004 during which there were observations available from Edendale.



2003/2004 period | 2005/2006 period

Figure 1: Edendale wind roses.

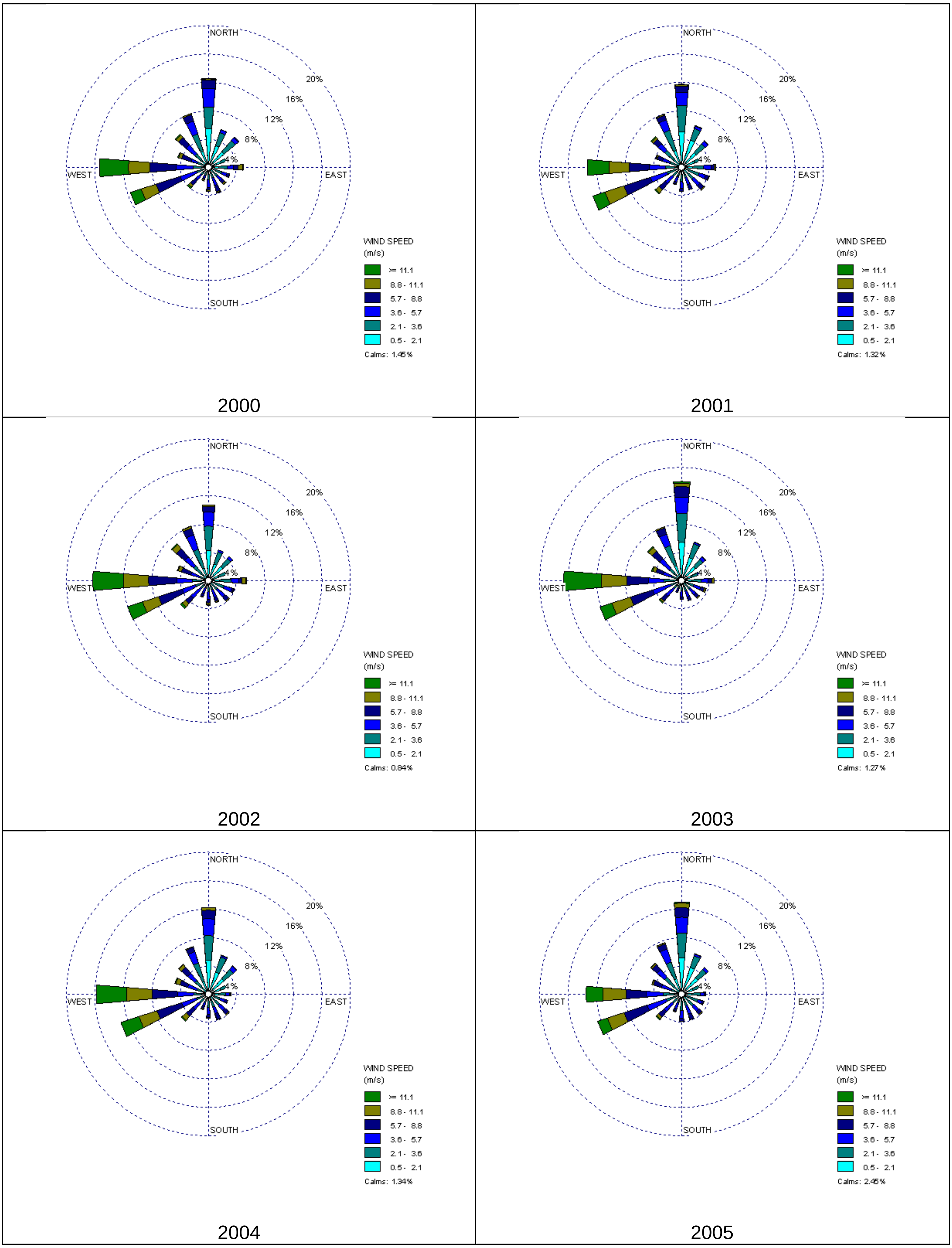


Figure 2: Invercargill Airport AWS wind roses: years 2000 to 2005.

3.0 TAPM MODELLING

3.1 Model Configuration

The TAPM model run was set up as described in Table 1. The model domain is centred using latitude/longitude coordinates, and projected onto a rectangular grid system. In this case, we have used the New Zealand Map Grid (NZMG). TAPM employs a one-way grid nesting. Each grid has the same centre, and the same number of points, so the higher resolution grids cover successively smaller areas. The vertical levels 'telescope' up from the surface, with lower levels closer together and the gap between them increasing with height. The monthly soil-moisture content was increased from its default setting (0.15 each month), to account for an annual cycle with wetter winters. TAPM's pollution-dispersion modules were not used for this project. All other parameters take default values.

Table 1: TAPM configuration parameters.

Parameter	Value
Start and end dates	24 August 2003 to 26 August 2004
Grid centre (Lat/Long)	46° 12.5' S 168° 48' E
Grid centre (NZMG)	(2185795, 5436123) (m)
No. of grids; no. of grid points in the horizontal	3; 32 x 36
Horizontal grid-cell spacing	30km, 10km, 3km
No. of grid levels in the vertical	25; from 10m to 8000m
Monthly deep-soil moisture (monthly values, January to December)	0.2, 0.2, 0.2, 0.2, 0.27, 0.35, 0.35, 0.35, 0.27, 0.2, 0.2, 0.2

3.2 Model Performance

TAPM results were used as a substitute for the upper-air data over Invercargill for the CALMET model. This was done so that hourly, rather than 12-hourly, data were available, and at locations nearer to the region of interest. For this approach to be viable, TAPM needs to perform well, particularly at upper levels. In regions of complex terrain, TAPM will not resolve the terrain well, and its performance as measured against surface-based data is not expected to be as good as at upper levels.

The performance of TAPM has been evaluated with commonly-used statistical measures, such as the index of agreement (IOA) and other skill scores (Willmott, 1982). The IOA varies between 0 for no agreement, and 1 for an exact match. It is considered a better measure than the correlation coefficient. Values of the IOA at several hourly surface sites, and at several levels in the 12-hourly Invercargill profiles are shown in Table 2. Data from 925 mb (respectively 850 mb, 700 mb) were compared with results from the 750 m (respectively 1500 m, 3000 m) level. The IOA was calculated for wind-velocity components U and V, temperature (T) and relative humidity (RH).

Table 2: Index of agreement between model and observations.

Site	Altitude	IOA for U	IOA for V	IOA for T	IOA for RH
Tiwai Point	10 m	0.92	0.79	0.87	0.72
Lumsden	10 m	0.85	0.69	0.89	0.71
Gore	10 m	Not available	Not available	0.92	0.76
Edendale	10 m	0.88	0.82	0.92	Not available
Invercargill	10 m	0.86	0.81	0.91	0.77
Invercargill	925 mb	Not available	Not available	0.95	Not available
Invercargill	850 mb	0.93	0.91	0.95	Not available
Invercargill	700 mb	0.94	0.93	0.97	Not available

All IOAs are quite high (at least 0.69), indicating that TAPM performs well. With increasing height, the model performance improves, with all IOAs 925 mb and higher being above 0.9.

The statistical model evaluation has shown that TAPM performs well at upper levels over Invercargill, and we can therefore use the model as an hourly substitute for the 12-hourly Invercargill data, and use extracted profiles at other locations in the CALMET runs.

4.0 CALMET MODELLING

The following information provides details of the user input parameters for generating the CALMET three-dimensional meteorological data set. The start and end times for the CALMET run are shown in Table 3.

Table 3: Run control parameters.

Parameter	Value
Starting date/time	25/8/2003 00:00:00
Finish date/time	25/8/2004 23:00:00
UTC time zone	UTC+1200 (which is NZST)

The initial and intermediate CALMET runs were done on a 90 km by 105 km domain, which includes the terrain around Mataura that may influence the local meteorology. A grid spacing of 1 km was chosen to allow the region to be modelled using currently-available computational resources. The final CALMET runs were done on a 3.5 km by 4.5 km domain at 50 m resolution, centred on Mataura, with much more terrain detail. The map projection and grid control parameters are shown in Table 4.

Table 4: CALMET map projection and grid control parameters (columns are merged for parameters that are the same in all runs).

Parameter	Initial/Intermediate	Final
Geodetic datum	WGS-84	
Projection origin	46.37S, 168.53E	
NZMG origin	5417 km northing; 2166 km easting	
Domain SW corner (NZMG)	(2141 km, 5384 km)	(2189.6 km, 5346.2 km)
Grid spacing	1 km	50 m
Number of Cells	NX = 90; NY = 105	NX = 70; NY = 90
Cell face heights (m)	0, 20, 50, 90, 130, 200, 300, 450, 650, 950, 1400, 2000, 2896	

Surface and upper-air wind and temperature data are blended by the model, as are surface wind data and parameterised terrain effects. Parameter choices are made to determine the weighting of the different data components. These are shown in Table 5. They vary between runs, as the runs have different purposes, or are carried out at different terrain resolution.

Table 5: CALMET wind field options and parameters.

Parameter	Value
Vertical extrapolation of surface wind observations (initial)	Extrapolation using similarity theory
Vertical extrapolation of surface wind observations (intermediate and final)	No extrapolation, as profile blending has been done
Layer dependent biases (initial)	-1, -0.9, -0.8, -0.7, -0.6, -0.4, -0.2, 0.0, 0.0, 0.0, 0.0, 0.0
Layer dependent biases (intermediate and final)	-1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1
Site maximum radius of influence parameters (initial and intermediate)	RMAX1 = 5 km RMAX2 = 5 km RMAX3 = 100 km
Distance from site of equal weighting of initial wind field and observations	R1 = 2.5 km R2 = 2.5 km
Radius of influence of terrain features (initial and intermediate)	TERRAD = 30 km
Radius of influence of terrain features (final)	TERRAD = 2 km

Default settings were used for other mixing height, terrain-effect, temperature radius of influence, cloud and precipitation parameters. The surface meteorological stations and their locations are shown in Table 6. Data from these were used in all CALMET runs. In the intermediate and final CALMET runs, these were also the locations of blended upper-air profiles. No precipitation stations were used.

Table 6: Surface meteorological stations and locations of extracted TAPM upper-air profiles.

Name	Source	NZMG X (km)	NZMG Y (km)	Time zone	Anem. ht. (m)
Edendale	Fonterra	2185.158	5424.800	-12	10
Invercargill Aero AWS	CliDB (11104)	2150.833	5410.791	-12	10
Tiwai Point AWS	CliDB (5823)	2155.490	5392.351	-12	10
Gore AWS	CliDB (5778)	2192.000	5447.000	-12	10
Lumsden AWS	CliDB (5496)	2155.945	5485.770	-12	10

5.0 REFERENCES

Gimson N, Chilton R, & Xie S 2010. *Meteorological Datasets for the Auckland Region – User Guide*. Report prepared by Golder Associates (NZ) Limited for Auckland Regional Council. Auckland Regional Council Technical Report 2010/022.

Willmott 1982. “Some comments on the evaluation of model performance”. Bulletin of the American Meteorological Society 63: 1309-1313.

APPENDIX G

Tables of Cumulative PM Concentrations

COAL FIRED BOILER TABLES

Table 1: Cumulative 24 hr PM_{10} concentration at Alliance Southern Boundary (Highest CFB 2 Contribution).

Rank	Modelled CFB 2 GLC (µg/m³)(1)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit (2)	99th Upper Limit (3)	Mean	75th Upper Limit	99th Upper Limit	
1	1.0	11	12	14	12	13	15	**50**
2	1.0	11	12	14	12	13	15	**50**
3	0.9	11	12	14	12	13	15	**50**
4	0.8	11	12	14	12	13	15	**50**
5	0.8	11	12	14	12	13	15	**50**

Notes: (1) Modelling results under daily weather category D (average wind speed >3 m/s). (2) 75th upper limit = upper limit of mean background level at 75 % confidence. (3) 99th upper limit = upper limit of mean background level at 99 % confidence.

Table 2: Cumulative 24 hr $PM_{2.5}$ concentration at Alliance Southern Boundary (Highest CFB 2 Contribution).

Rank	Modelled CFB 2 GLC (µg/m³)(1)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit (2)	99th Upper Limit (3)	Mean	75th Upper Limit	99th Upper Limit	
1	1.0	6	7	8	7	8	9	**25**
2	1.0	6	7	8	7	8	9	**25**
3	0.9	6	7	8	7	8	9	**25**
4	0.8	6	7	8	7	8	9	**25**
5	0.8	6	7	8	7	8	9	**25**

Notes: (1) Modelling results under daily weather category D (average wind speed >3 m/s). (2) 75th upper limit = upper limit of mean background level at 75 % confidence. (3) 99th upper limit = upper limit of mean background level at 99 % confidence.

Table 3: Cumulative annual PM_{10} and $PM_{2.5}$ concentration at Alliance Southern Boundary (Highest CFB 2 Contribution).

Pollutant	Modelled CFB 2 GLC (µg/m³)	Background GLC (µg/m³)*	Cumulative GLC (µg/m³)	Assessment criterion (µg/m³)
PM_{10}	0.1	12	12	**20**
$PM_{2.5}$	0.1	7	7	**10**

Table 4: Cumulative 24 hr $PM_{2.5}$ concentrations at Alliance Southern Boundary (High Background).

Rank	Modelled CFB 2 GLC (µg/m³)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit (1)	99th Upper Limit (2)	Mean	75th Upper Limit	99th Upper Limit	
1	0.2	17	21	28	17	21	28	**25**
2	0.1	17	21	28	17	21	28	**25**
3	0.2	17	21	28	17	21	28	**25**
4	<0.01	17	21	28	17	21	28	**25**
5	<0.001	17	21	28	17	21	28	**25**

Notes: (1) 75th upper limit = upper limit of mean background level at 75 % confidence. (2) 99th upper limit = upper limit of mean background level at 99 % confidence.

Table 5: Cumulative PM_{10} GLCs due to CFB 3 and Background (Most Impacted off-site location).

Averaging period	Location	Modelled CFB 3 GLC (µg/m³)*	Background (µg/m³)#	Cumulative GLC (µg/m³)	Assessment criterion (µg/m³)	Modelled Weather condition*
24-hour	North eastern boundary of hide plant	18	14#	32	**50**	D
Annual	North eastern boundary of hide plant	1	12	13	**20**	-

Notes: * Weather condition D: daily averaged wind speed ≥3 m/s. # Using 99th upper limit 24-hour background concentration = upper limit of mean background level at 99 % confidence.

Table 6: Cumulative $PM_{2.5}$ GLCs due to CFB 3 and Background (Most Impacted off-site location).

Averaging period	Location	Modelled CFB 3 GLC (µg/m³)	Background 99th Limit (µg/m³)	Cumulative GLC (µg/m³)	Assessment criterion (µg/m³)	Modelled Weather condition*
24-hour	North eastern boundary of hide plant	12	8	20	**25**	D
Annual	North eastern boundary of hide plant	1	7	8	**10**	-

Notes: * Weather condition D: daily averaged wind speed ≥3 m/s. # Using 99th upper limit 24-hour background concentration = upper limit of mean background with 99 % confidence.

Table 7: Cumulative 24 hr PM_{10} GLCs predicted at House #1 (Highest CFB 2 Contribution).

Rank	Modelled CFB 2 GLC (µg/m³)(1)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit (2)	99th Upper Limit(3)	Mean	75th Upper Limit	99th Upper Limit	
1	2.3	11	12	14	13	14	16	**50**
2	1.6	11	12	14	13	14	16	**50**
3	1.5	11	12	14	13	14	16	**50**
4	1.5	11	12	14	13	14	16	**50**
5	1.4	11	12	14	13	14	16	**50**

Notes: (1) Modelling results under daily weather category D (average wind speed >3 m/s). (2) 75th upper limit = upper limit of mean background level at 75 % confidence. (3) 99th upper limit = upper limit of mean background level at 99 % confidence.

Table 8: Cumulative 24 hr $PM_{2.5}$ GLCs predicted at House #1 (Highest CFB 2 Contribution).

Rank	Modelled CFB 2 GLC (µg/m³)(1)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³) 75th Upper Limit (2)
		Mean	75th Upper Limit (2)	99th Upper Limit (3)	Mean	75th Upper Limit	99th Upper Limit	
1	2.3	6	7	8	8	9	10	**25**
2	1.6	6	7	8	8	9	10	**25**
3	1.5	6	7	8	7	8	9	**25**
4	1.5	6	7	8	7	8	9	**25**
5	1.4	6	7	8	7	8	9	**25**

Notes: (1) Modelling results under daily weather category D (average wind speed >3 m/s). (2) 75th upper limit = upper limit of mean background level at 75 % confidence. (3) 99th upper limit = upper limit of mean background level at 99 % confidence.

Table 9: Cumulative annual PM_{10} and $PM_{2.5}$ GLCs predicted at House #1 (Highest CFB 2 Contribution).

Pollutant	Modelled CFB 2 GLC (µg/m³)	Background GLC (µg/m³)*	Cumulative GLC (µg/m³)	Assessment criterion (µg/m³)
PM_{10}	0.2	12	12	**20**
$PM_{2.5}$	0.2	7	7	**10**

Table 10: Cumulative 24 hr PM_{10} GLCs predicted at House #1 (High background).

Rank	Modelled CFB 2 GLC (µg/m³)(1)	Background GLC (µg/m³) (1)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit (2)	99th Upper Limit(3)	Mean	75th Upper Limit	99th Upper Limit	
1	0.2	24	29	38	24	29	38	**50**
2	0.035	24	29	38	24	29	38	**50**
3	0.004	24	29	38	24	29	38	**50**
4	<0.001	24	29	38	24	29	38	**50**
5	<0.001	24	29	38	24	29	38	**50**

Notes: (1) Modelling results and background concentrations are for daily weather Category A (average wind speed <2 m/s and temperature <5 ºC). (2) 75th upper limit = upper limit of mean background level at 75 % confidence. (3) 99th upper limit = upper limit of mean background level at 99 % confidence.

Table 11: Cumulative 24 hr $PM_{2.5}$ GLCs predicted at House #1 (High background).

Rank	Modelled CFB 2 GLC (µg/m³)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit *	99th Upper Limit #	Mean	75th Upper Limit	99th Upper Limit	
1	0.2	17	21	28	17	21	28	**25**
2	0.035	17	21	28	17	21	28	**25**
3	0.004	17	21	28	17	21	28	**25**
4	<0.001	17	21	28	17	21	28	**25**
5	<0.001	17	21	28	17	21	28	**25**

Notes: (1) Modelling results and background concentrations are for daily weather Category A (average wind speed <2 m/s and temperature <5 ºC). (2) 75th upper limit = upper limit of mean background level at 75 % confidence. (3) 99th upper limit = upper limit of mean background level at 99 % confidence.

Table 12: Cumulative 24 hr PM_{10} GLCs predicted at House #2.

Rank	Modelled CFB 2 GLC (µg/m³)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit	99th Upper Limit	Mean	75th Upper Limit	99th Upper Limit	
1	1.3	11	12	14	12	13	15	**50**
2	1.2	11	12	14	12	13	15	**50**
3	1.1	11	12	14	12	13	15	**50**
4	1.1	11	12	14	12	13	15	**50**
5	1.0	11	12	14	12	13	15	**50**

Notes: (1) Modelling results under daily weather category D (average wind speed >3 m/s). (2) 75th upper limit = upper limit of mean background level at 75 % confidence. (3) 99th upper limit = upper limit of mean background level at 99 % confidence.

Table 13: Cumulative 24 hr $PM_{2.5}$ GLCs predicted at House #2.

Rank	Modelled CFB 2 GLC (µg/m³)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit	99th Upper Limit	Mean	75th Upper Limit	99th Upper Limit	
1	1.3	6	7	8	7	8	9	**25**
2	1.2	6	7	8	7	8	9	**25**
3	1.1	6	7	8	7	8	9	**25**
4	1.1	6	7	8	7	8	9	**25**
5	1.0	6	7	8	7	8	9	**25**

Notes: (1) Modelling results under daily weather category D (average wind speed >3 m/s). (2) 75th upper limit = upper limit of mean background level at 75 % confidence. (3) 99th upper limit = upper limit of mean background level at 99 % confidence.

Table 14: Cumulative annual PM_{10} and $PM_{2.5}$ GLCs predicted at House #2 (Highest CFB 2 Contribution).

Pollutant	Modelled CFB 2 GLC (µg/m³)	Background GLC (µg/m³)*	Cumulative GLC (µg/m³)	Assessment criterion (µg/m³)
PM_{10}	0.1	12	12	**20**
$PM_{2.5}$	0.1	7	7	**10**

Table 15: Cumulative 24 hr PM10GLCs predicted at House #3.

Rank	Modelled CFB 2 GLC (µg/m³)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit	99th Upper Limit	Mean	75th Upper Limit	99th Upper Limit	
1	1.3	11	12	14	12	13	15	**50**
2	1.1	11	12	14	12	13	15	**50**
3	1.1	11	12	14	12	13	15	**50**
4	1.1	11	12	14	12	13	15	**50**
5	1.1	11	12	14	12	13	15	**50**

Notes: (1) Modelling results under daily weather category D (average wind speed >3 m/s). (2) 75th upper limit = upper limit of mean background level at 75 % confidence. (3) 99th upper limit = upper limit of mean background level at 99 % confidence.

Table 16: Cumulative 24 hr $PM_{2.5}$ GLCs predicted at House #3 due to the CFB 2 effects.

Rank	Modelled CFB 2 GLC (µg/m³)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit	99th Upper Limit	Mean	75th Upper Limit	99th Upper Limit	
1	1.3	6	7	8	7	8	9	**25**
2	1.1	6	7	8	7	8	9	**25**
3	1.1	6	7	8	7	8	9	**25**
4	1.1	6	7	8	7	8	9	**25**
5	1.1	6	7	8	7	8	9	**25**

Notes: (1) Modelling results under daily weather category D (average wind speed >3 m/s). (2) 75th upper limit = upper limit of mean background level at 75 % confidence. (3) 99th upper limit = upper limit of mean background level at 99 % confidence.

Table 17: Cumulative annual PM_{10} and $PM_{2.5}$ GLCs predicted at House #3 (Highest CFB 2 Contribution).

Pollutant	Modelled CFB 2 GLC (µg/m³)	Background GLC (µg/m³)*	Cumulative GLC (µg/m³)	Assessment criterion (µg/m³)
PM_{10}	0.1	12	12	**20**
$PM_{2.5}$	0.1	7	7	**10**

Table 18: Cumulative 24 hr PM_{10} GLCs predicted at House #4 due to the CFB 3 effects (High CFB 3 concentration).

Rank	Modelled CFB 3 GLC (µg/m³)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit	99th Upper Limit	Mean	75th Upper Limit	99th Upper Limit	
1	1.3	11	12	14	12	13	15	**50**
2	1.3	11	12	14	12	13	15	**50**
3	1.3	11	12	14	12	13	15	**50**
4	1.1	11	12	14	12	13	15	**50**
5	0.8	13	13	15	14	14	16	**50**

Notes: (1) Modelling results under daily weather category D (average wind speed >3 m/s). (2) 75th upper limit = upper limit of mean background level at 75 % confidence. (3) 99th upper limit = upper limit of mean background level at 99 % confidence.

Table 19: Cumulative 24 hr $PM_{2.5}$ GLCs predicted at House #4 due to the CFB 3 effects (High CFB 3 concentration).

Rank	Modelled CFB 3 GLC (µg/m³)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit	99th Upper Limit	Mean	75th Upper Limit	99th Upper Limit	
1	1.1	6	7	8	7	8	9	**25**
2	1.1	6	7	8	7	8	9	**25**
3	1.1	6	7	8	7	8	9	**25**
4	0.9	6	7	8	7	8	9	**25**
5	0.6	8	9	9	7	8	9	**25**

Notes: (1) Modelling results under daily weather category D (average wind speed >3 m/s). (2) 75th upper limit = upper limit of mean background level at 75 % confidence. (3) 99th upper limit = upper limit of mean background level at 99 % confidence.

Table 20: Cumulative annual PM_{10} and $PM_{2.5}$ GLCs predicted at House #4 (Highest CFB 2 Contribution).

Pollutant	Modelled CFB 2 GLC (µg/m³)	Background GLC (µg/m³)*	Cumulative GLC (µg/m³)	Assessment criterion (µg/m³)
PM_{10}	0.05	12	12	**20**
$PM_{2.5}$	0.04	7	7	**10**

Table 21: Cumulative 24 hr PM_{10} GLCs predicted at House #4 (High background).

Rank	Modelled CFB 2 GLC (µg/m³)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit *	99th Upper Limit #	Mean	75th Upper Limit	99th Upper Limit	
1	1.3	24	29	38	25	30	39	**25**
2	0.3	24	29	38	24	29	38	**25**
3	0.1	24	29	38	24	29	38	**25**
4	0.02	24	29	38	24	29	38	**25**
5	<0.0001	24	29	38	24	29	38	**25**

Notes: (1) modelling results and background concentrations are for daily weather Category A (average wind speed <2 m/s and temperature <5 ºC). (2) 75th upper limit = upper limit of mean background level at 75 % confidence. (3) 99th upper limit = upper limit of mean background level at 99 % confidence.

Table 22: Cumulative 24 hr $PM_{2.5}$ GLCs predicted at House #4 (High background).

Rank	Modelled CFB 2 GLC (µg/m³)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit *	99th Upper Limit #	Mean	75th Upper Limit	99th Upper Limit	
1	1.1	17	21	28	18	22	29	**25**
2	0.2	17	21	28	17	21	28	**25**
3	0.1	17	21	28	17	21	28	**25**
4	0.015	17	21	28	17	21	28	**25**
5	<0.0001	17	21	28	17	21	28	**25**

Notes: (1) Modelling results and background concentrations are for daily weather Category A (average wind speed <2 m/s and temperature <5 ºC). (2) 75th upper limit = upper limit of mean background level at 75 % confidence. (3) 99th upper limit = upper limit of mean background level at 99 % confidence.

BIOMASS FUEL BOILER TABLES

Table 23: Cumulative 24 hr PM_{10} GLCs predicted at Alliance Southern Boundary (Highest BFB Contribution).

Rank	Modelled BHB GLC (µg/m³)(1)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit (2)	99th Upper Limit (3)	Mean	75th Upper Limit	99th Upper Limit	
1	1.3	11	12	14	12	13	15	**50**
2	1.2	11	12	14	12	13	15	**50**
3	1.2	11	12	14	12	13	15	**50**
4	1.2	11	12	14	12	13	15	**50**
5	1.1	13	13	15	14	14	16	**50**

Notes: (1) Modelling results for rank 1 to 4 are under daily weather category D (average wind speed >3 m/s), while rank 5 is under daily weather category C (average wind speed between 2 to 3 m/s). (2) 75th upper limit = upper limit of mean background level at 75 % confidence. (3) 99th upper limit = upper limit of mean background level at 99 % confidence.

Table 24: Cumulative 24 hr $PM_{2.5}$ GLCs predicted at Alliance Southern Boundary (Highest BFB Contribution).

Rank	Modelled BHB GLC (µg/m³)(1)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit (2)	99th Upper Limit (3)	Mean	75th Upper Limit	99th Upper Limit	
1	1.3	6	7	8	7	8	9	**25**
2	1.2	6	7	8	7	8	9	**25**
3	1.2	6	7	8	7	8	9	**25**
4	1.2	6	7	8	7	8	9	**25**
5	1.0	8	9	9	9	10	10	**25**

Notes: (1) Modelling results for rank 1 to 4 are under daily weather category D (average wind speed >3 m/s), while rank 5 is under daily weather category C (average wind speed between 2 to 3 m/s). (2) 75th upper limit = upper limit of mean background level at 75 % confidence. (3) 99th upper limit = upper limit of mean background level at 99 % confidence.

Table 25: Cumulative 24 hr $PM_{2.5}$ GLCs predicted at Alliance Southern Boundary (High Background).

Rank	Modelled BHB GLC (µg/m³)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit (1)	99th Upper Limit (2)	Mean	75th Upper Limit	99th Upper Limit	
1	0.3	17	21	28	17	21	28	**25**
2	0.2	17	21	28	17	21	28	**25**
3	0.3	17	21	28	17	21	28	**25**
4	0.2	17	21	28	17	21	28	**25**
5	0.04	17	21	28	17	21	28	**25**

Notes: (1) 75th upper limit = upper limit of mean background level at 75 % confidence (2) 99th upper limit = upper limit of mean background level at 99 % confidence.

Table 26: Cumulative annual PM_{10} and $PM_{2.5}$ concentration at Alliance Southern Boundary (Highest CFB 2 Contribution).

Pollutant	Modelled CFB 2 GLC (µg/m³)	Background GLC (µg/m³)*	Cumulative GLC (µg/m³)	Assessment criterion (µg/m³)
PM_{10}	0.2	12	12	**20**
$PM_{2.5}$	0.2	7	7	**10**

Table 27: Cumulative PM_{10} GLCs due to BFB and Background (Most Impacted off-site location).

Averaging period	Location	Modelled BFB GLC (µg/m³)*	Background (µg/m³)#	Cumulative GLC (µg/m³)	Assessment criterion (µg/m³)	Modelled Weather condition*
24-hour	Near House #1	2.5	14#	17	**50**	D
Annual	Near House #1	0.2	12	12	**20**	-

Notes: * Weather condition D: daily averaged wind speed ≥3 m/s. # Using 99th upper limit 24-hour background concentration = upper limit of mean background level at 99 % confidence.

Table 28: Cumulative $PM_{2.5}$ GLCs due to BFH and Background (Most Impacted off-site location).

Averaging period	Location	Modelled CFB 3 GLC (µg/m³)	Background 99th Limit (µg/m³)	Cumulative GLC (µg/m³)	Assessment criterion (µg/m³)	Modelled Weather condition*
24-hour	Near House #1	2.5	8	11	**25**	D
Annual	Near House #1	0.2	7	7	**10**	-

Notes: * Weather condition D: daily averaged wind speed ≥3 m/s. # Using 99th upper limit 24-hour background concentration = upper limit of mean background level at 99 % confidence.

Table 29: Cumulative 24 hr PM_{10} GLCs predicted at House #1 due to the BFB effects (Highest BFB Contribution).

Rank	Modelled BFB GLC (µg/m³)(1)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit (2)	99th Upper Limit(3)	Mean	75th Upper Limit	99th Upper Limit	
1	2.6	11	12	14	16	15	17	**50**
2	1.8	11	12	14	13	14	16	**50**
3	1.8	11	12	14	13	14	16	**50**
4	1.7	11	12	14	13	14	16	**50**
5	1.7	11	12	14	13	14	16	**50**

Notes: (1) Modelling results under daily weather category D (average wind speed >3 m/s). (2) 75th upper limit = upper limit of mean background level at 75 % confidence. (3) 99th upper limit = upper limit of mean background level at 99 % confidence.

Table 30: Cumulative 24 hr $PM_{2.5}$ GLCs predicted at House #1 due to the BFB effects (Highest BFB Contribution).

Rank	Modelled BFB GLC (µg/m³)(1)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³) 75th Upper Limit (2)
		Mean	75th Upper Limit (2)	99th Upper Limit (3)	Mean	75th Upper Limit	99th Upper Limit	
1	2.6	6	7	8	9	10	11	**25**
2	1.8	6	7	8	8	9	10	**25**
3	1.8	6	7	8	8	9	10	**25**
4	1.7	6	7	8	8	9	10	**25**
5	1.7	6	7	8	8	9	10	**25**

Notes: (1) Modelling results under daily weather category D (average wind speed >3 m/s). (2) 75th upper limit = upper limit of mean background level at 75 % confidence. (3) 99th upper limit = upper limit of mean background level at 99 % confidence.

Table 31: Cumulative annual PM_{10} and $PM_{2.5}$ concentration at House #1 (Highest BFB Contribution).

Pollutant	Modelled BFB GLC (µg/m³)	Background GLC (µg/m³)*	Cumulative GLC (µg/m³)	Assessment criterion (µg/m³)
PM_{10}	0.2	12	12	**20**
$PM_{2.5}$	0.2	7	7	**10**

Table 32: Cumulative 24 hr PM_{10} GLCs predicted at House #1 (High Background).

Rank	Modelled BFB GLC (µg/m³)[(1)]	Background GLC (µg/m³) [(1)]			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit [(2)]	99th Upper Limit[(3)]	Mean	75th Upper Limit	99th Upper Limit	
1	0.3	24	29	38	24	29	38	**50**
2	0.03	24	29	38	24	29	38	**50**
3	0.004	24	29	38	24	29	38	**50**
4	0.003	24	29	38	24	29	38	**50**
5	<0.001	24	29	38	24	29	38	**50**

Notes: [(1)] Modelling results and background concentrations are for daily weather Category A (average wind speed <2 m/s and temperature <5 ºC). [(2)] 75th upper limit = upper limit of mean background level at 75 % confidence. [(3)] 99th upper limit = upper limit of mean background level at 99 % confidence.

Table 33: Cumulative 24 hr $PM_{2.5}$ GLCs predicted at House #1 (High background).

Rank	Modelled BFB GLC (µg/m³)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit *	99th Upper Limit #	Mean	75th Upper Limit	99th Upper Limit	
1	0.3	17	21	28	17	21	28	**25**
2	0.03	17	21	28	17	21	28	**25**
3	0.004	17	21	28	17	21	28	**25**
4	0.003	17	21	28	17	21	28	**25**
5	<0.001	17	21	28	17	21	28	**25**

Notes: [(1)] Modelling results and background concentrations are for daily weather Category A (average wind speed <2 m/s and temperature <5 ºC). [(2)] 75th upper limit = upper limit of mean background level at 75 % confidence. [(3)] 99th upper limit = upper limit of mean background level at 99 % confidence.

Table 34: Cumulative 24 hr PM_{10} GLCs predicted at House #2 (Highest BFB Contribution).

Rank	Modelled BFB GLC (µg/m³)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit	99th Upper Limit	Mean	75th Upper Limit	99th Upper Limit	
1	1.6	11	12	14	13	14	16	**50**
2	1.5	11	12	14	12	13	15	**50**
3	1.4	11	12	14	12	13	15	**50**
4	1.3	11	12	14	12	13	15	**50**
5	1.3	11	12	14	12	13	15	**50**

Notes: (1) Modelling results under daily weather category D (average wind speed >3 m/s). (2) 75th upper limit = upper limit of mean background level at 75 % confidence. (3) 99th upper limit = upper limit of mean background level at 99 % confidence.

Table 35: Cumulative 24 hr $PM_{2.5}$ GLCs predicted at House #2.

Rank	Modelled BFB GLC (µg/m³)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit	99th Upper Limit	Mean	75th Upper Limit	99th Upper Limit	
1	1.6	6	7	8	8	9	10	**25**
2	1.5	6	7	8	8	9	10	**25**
3	1.4	6	7	8	7	8	9	**25**
4	1.3	6	7	8	7	8	9	**25**
5	1.3	6	7	8	7	8	9	**25**

Notes: (1) Modelling results under daily weather category D (average wind speed >3 m/s). (2) 75th upper limit = upper limit of mean background level at 75 % confidence. (3) 99th upper limit = upper limit of mean background level at 99 % confidence.

Table 36: Cumulative annual PM_{10} and $PM_{2.5}$ concentration at House #2 (Highest BFB Contribution).

Pollutant	Modelled BFB GLC (µg/m³)	Background GLC (µg/m³)*	Cumulative GLC (µg/m³)	Assessment criterion (µg/m³)
PM_{10}	0.2	12	12	**20**
$PM_{2.5}$	0.2	7	7	**10**

Table 37: Cumulative 24 hr PM_{10} GLCs predicted at House #3 (Highest BFB Contribution).

Rank	Modelled BFB GLC (µg/m³)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit	99th Upper Limit	Mean	75th Upper Limit	99th Upper Limit	
1	1.3	11	12	14	12	13	15	**50**
2	1.1	11	12	14	12	13	15	**50**
3	1.0	11	12	14	12	13	15	**50**
4	1.0	11	12	14	12	13	15	**50**
5	1.0	11	12	14	12	13	15	**50**

Notes: (1) Modelling results under daily weather category D (average wind speed >3 m/s). (2) 75th upper limit = upper limit of mean background level at 75 % confidence. (3) 99th upper limit = upper limit of mean background level at 99 % confidence.

Table 38: Cumulative 24 hr $PM_{2.5}$ GLCs predicted at House #3 (Highest BFB Contribution).

Rank	Modelled BFB GLC (µg/m³)	Background GLC (µg/m³)			Cumulative GLC (µg/m³)			Assessment criterion (µg/m³)
		Mean	75th Upper Limit	99th Upper Limit	Mean	75th Upper Limit	99th Upper Limit	
1	1.3	6	7	8	7	8	9	**25**
2	1.1	6	7	8	7	8	9	**25**
3	1.0	6	7	8	7	8	9	**25**
4	1.0	6	7	8	7	8	9	**25**
5	1.0	6	7	8	7	8	9	**25**

Notes: (1) Modelling results under daily weather category D (average wind speed >3 m/s). (2) 75th upper limit = upper limit of mean background level at 75 % confidence. (3) 99th upper limit = upper limit of mean background level at 99 % confidence.

Table 39: Cumulative annual PM_{10} and $PM_{2.5}$ concentration at House #3 (Highest BFB Contribution).

Pollutant	Modelled BFB GLC (µg/m³)	Background GLC (µg/m³)*	Cumulative GLC (µg/m³)	Assessment criterion (µg/m³)
PM_{10}	0.2	12	12	**20**
$PM_{2.5}$	0.2	7	7	**10**

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APPENDIX C

Golder Associates (NZ)

Limited Odour Assessment: Alliance Mataura

August 2020

REPORT

Odour Assessment

Alliance Mataura

Submitted to:

Alliance Group Limited
PO Box 1410
Invercargill

Submitted by:

Golder Associates (NZ) Limited
Level 1, 214 Durham Street, Christchurch 8011, New Zealand

+64 3 377 5696

1793285_7403-007-R-Rev6

September 2020

Distribution List

Doyle Richardson

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APPENDICES

1.0 INTRODUCTION

This report[1] presents a review of existing odour effects resulting from the Alliance Group Limited (Alliance) meat processing and hide salting plants located in Mataura, Southland. The main plant (meat processing) is located at the centre of Mataura, approximately 12 km to the southwest of Gore township. The hide processing plant is sited approximately 2 km north of the main site as shown in Figure 1.

Alliance holds an existing resource consent (Environment Southland Consent No. AUTH-20158002) that authorises air discharges from the site, which expires on 15 December 2020.

The scope of this report is for an assessment of the odour effects from the site operation. This includes a description of the activities that are potentially odour producing activities, particularly the following activities/processes at its main and hide salting sites:

- Stock holding yards.
- Wastewater treatment (WWTP) and wastewater solids loadout.
- Rendering raw materials loadout.
- Skin processing.

This report presents a review of existing odour effects and recommended mitigation. Existing odour effects were determined via community odour observations recorded during an odour diary programme as well as via complaint records. The odour observations were used to investigate whether there are existing odour effects due to the site activities and/or whether there are particular site activities linked to off-site odour effects. Following a review of the community data, a site visit was undertaken to review site operation and potential offsite effects. Finally, recommendations on future mitigation to reduce offsite odour are also provided.

Golder understands that this report will form part of an assessment of effects (AEE) and associated application for renewal of the site's existing air discharge consent.

[1] Your attention is drawn to the "Report Limitations" in Appendix A.

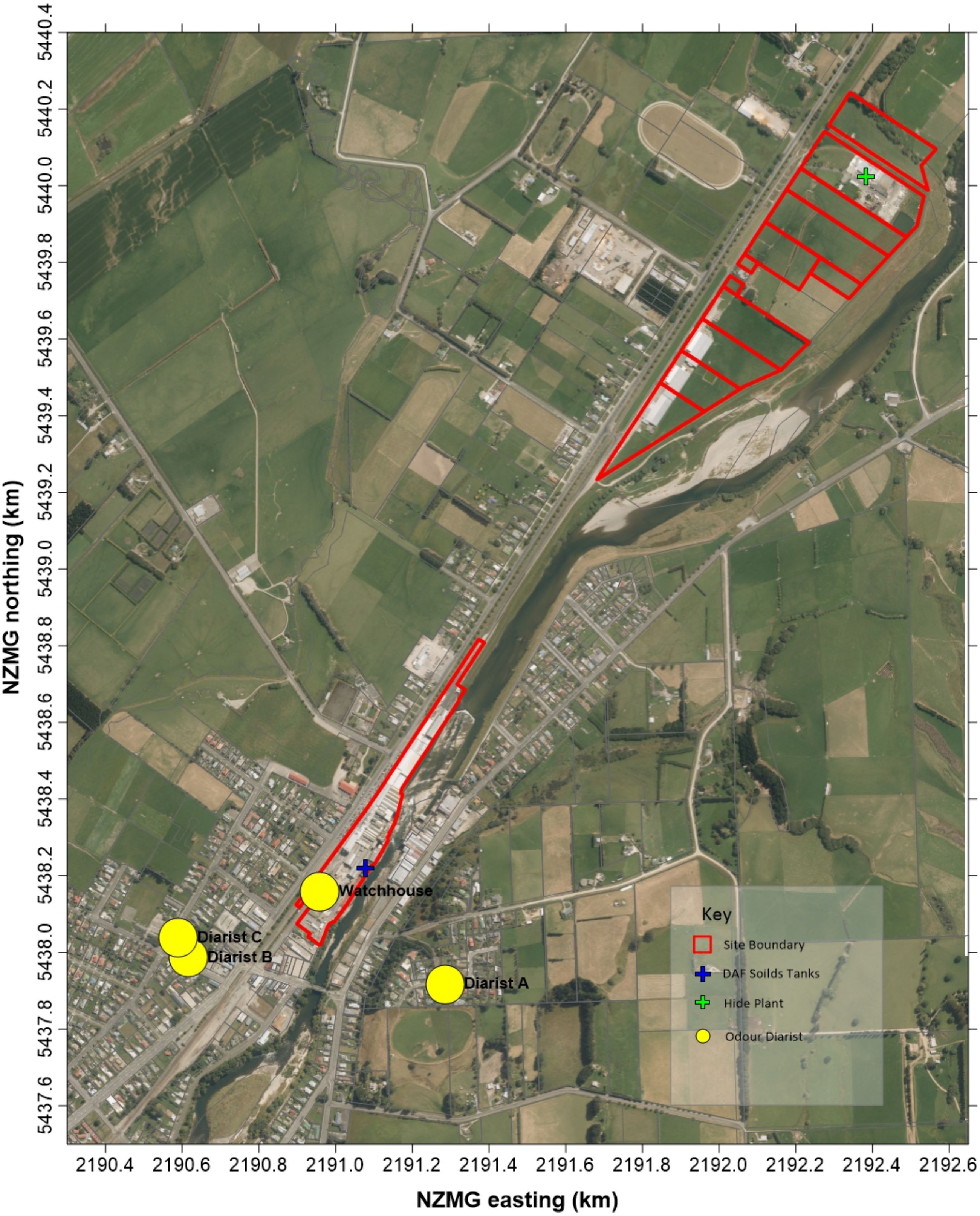

Figure 1: Site and diarist locations.

2.0 DESCRIPTION OF THE SITE ACTIVITIES

2.1 Overview

Alliance Mataura's cattle processing plant includes stock holding yards, slaughtering facilities, further processing (i.e., a cutting room and edible offal processing), a hide salting operation and a wastewater treatment plant. Processed carcasses, meat cuts and edible offal are refrigerated and stored in on-site chillers and freezers and transported off-site by road or rail. Inedible by-products are transported off-site for rendering. While blood was transferred off-site for processing during the period of the diary programme, the site maintains the ability to process blood onsite in the future.

Further details on plant operations that may result in offsite odour are provided in the following sections.

2.2 Wastewater Streams

2.2.1 Cattle yards

Cattle are held in yards at the north end of the site prior to slaughtering. Washing of the yards is undertaken to remove animal waste. This is carried out by regular use of high-pressure water hoses, with the resulting flow collected within a sump from where it is pumped over a contra-shear screen to remove solids before being pumped to the site's wastewater treatment plant. The stockyards hold cattle only.

2.2.2 Truck wash

Alliance operates a truck wash on-site for trucks that deliver stock and a stock truck effluent collection facility. Wastewater from these is also treated in the plant wastewater treatment system.

2.2.3 Process plant

Wastewater streams are produced from the slaughter and further processing chains from a range of activities including, sterilisation, room cleaning, product chutes and hides cooling. Blood drying also produces a liquid waste stream. Inedible by-products from the processing chains are pumped or blown to a raw material receivables bin where it is out loaded from the site multiple times throughout the day. Liquid draining's from this bin also form part of the wastewater stream.

Stomach content of cattle (commonly known as paunch grass) is separated and discharged to separate bins that are removed daily to an offsite compost manufacturing facility.

Process wastewater streams primarily comprises of fat, protein, and semi-digested gut contents.

2.3 Wastewater Treatment

2.3.1 Description

The wastewater treatment plant is a non-biological physical/chemical system. In the initial process step the wastewater passes through a system of screens (contra-shears) and a "Save-All" which remove solids by physical separation and settling, respectively.

These solids (compost solids) are collected in a bin and are periodically taken off-site for composting. The preliminarily treated wastewater is then transferred to balance tanks which supply a steady flow to the physio/chemical wastewater treatment plant.

The wastewater from the balance tanks is then sent back into the treatment process and is dosed with sulphuric acid and a flocculating agent as it is directed through one of six dissolved air flotation (DAF) tanks. This results in the separation of fine coagulated solids from the wastewater. The high phosphorus proportion of the waste stream is further treated by dosing it with lime and flocculant and then directed through a second DAF treatment process.

Separation of solids from the wastewater is achieved using dissolved air flotation technology that injects dissolved air into the DAF tanks which assists in floating the coagulated solids to the surface of the tanks, creating a floating high-protein layer of solids on its surface. These DAF solids (approx. 7.0 to 8.0 wt.% solids) are removed by scraping and are then pumped to a holding tank. The DAF solids are then pumped out via a steam coagulator prior to a decanter (installed in August 2017) which dewaters the DAF top-solids. DAF-top solids are dewatered to 50 wt.% solids, conveyed to a parked truck trailer, and trucked offsite daily for composting.

In the future dewatered DAF solids may be conveyed to a new biomass boiler for use as a biofuel. Alternatively, the wet DAF solids (with no dewatering) are transported off site for irrigation to farmland, or to the Alliance Lorneville wastewater treatment plant.

A DAF tank cleaning procedure is carried out on a regular basis to remove heavy solid material accumulating in the base of each tank, these solids are processed through the decanter along with the DAF solids.

2.4 Renderable Material

All inedible offal and other by-products generated from the slaughter and processing of stock is transferred to the Alliance Lorneville site for rendering. Renderable materials are pumped or blown from the process plant and discharged into a large 50 m^3 material storage bin with a discharge conveyor for loading out to trucks.

Bones are also transferred to Lorneville for making soup stock. Soup stock bones are stored in closed bins and removed by truck daily when the site is operating.

Blood is generally processed as soon as possible after collection and within 48 hours of being produced. It is collected from the slaughtering areas and pumped to a holding tank and is then screened to remove unwanted solids before it is coagulated (via injection with steam) and then decanted. As discussed earlier, the centrate (or liquid) from the decanting of coagulated blood solids is directed to the wastewater treatment plant. Drying of decanted blood solids is undertaken using a conventional in-direct steam heated rotary disc dryer.

Exhaust vapours from the blood dryer are cooled via a water-cooled condenser and the resultant non-condensed gases (NCGs) are extracted and utilised as combustion air for the boiler. The condensate generated from the pre-cooling of the dryer exhaust air is treated at the wastewater treatment plant.

Blood was not processed onsite during the 2019/2020 season.

2.5 Skin Processing

Cattle hides are treated at the skin processing site (2 km north of the main plant). This is a salting operation for preservative purposes and further processing is done elsewhere. This is expected to be a low-odour process.

2.6 Odour Sources

2.6.1 Introduction

There are several odour sources at the site and most are relatively minor. The sources that maybe recognisable off site on occasion are summarised below. Mitigation of these sources (where recommended) is discussed in Section 6.0.

2.6.2 Cattle yards

Cattle yards produce a character animal/manure type odour and with regular hose downs, are considered to only produce a minor level of odour offsite on most occasions.

2.6.3 Wastewater treatment sources

The physio/chemical wastewater treatment processes also have potential to generate odour as air is discharged from the DAF treatment process. Furthermore, increased odour could be associated with DAF solids being left on the surface of DAF tanks during weekends. Finally, there is potential for increased levels of odour when DAF tanks are drained and the accumulated bottom sludge (approximately weekly for a specific tank) is pumped to the DAF solids storage/dewatering plant.

2.6.4 DAF solids processing

Venting of steam and associated gases from the DAF solids decanter (installed in August 2017), is the primary source of odours from the solids processing operation. However, since July 2018 there has been extraction from the decanter liquid phase discharge chute with the extracted stream combusted within the site boilers. Fugitive odours associated with the operation of the DAF solids decanter including the associated discharge centrate, and to a lesser extent the storage and load out of dewatered DAF solids, also have the potential to result in offsite odours.

2.6.5 Storage and loadout of material

Storage and load out of material have the potential to cause the most odour at the site. In particular, screened wastewater solids (compost solids) and by-products for rendering are stored in large bins before removing from the site.

2.6.6 Blood processing

Blood process odours mostly result from dryer exhaust. However, this is cooled and combusted within the site boilers. Residual odours associated with steam vapours discharged to air during the decanting of coagulated blood could be noticeable off site, and if so, these are likely to only occur close to the site boundary, at relatively low intensity levels. The raw blood was screened, stored in tanks and trucked offsite to Lorneville during the last 2019/2020 season. Therefore, during the most recent 2019/2020 summer, the potential for any odour would only be associated with screening, storage and blood load out. These processes are expected to have a minor, or less potential for causing offsite odour.

3.0 RECEIVING ENVIRONMENT

Mataura is an urban area in Southland with a population of 1,629 people and 672 households, according to 2018 census information (Stats NZ, 2018). Mataura is predominantly residential, with commercial and industrial areas.

The site is located near the centre of the township and is predominantly surrounded by residential dwellings in all directions, except for directly due north of the plant.

The site wind patterns are significantly influenced by the raised terrain running along the eastern side of the Mataura River. As such, southerly and northerly wind conditions tend to align with a north northeast to south southwest bearing and cold air drainage flows can be expected to move along this same bearing and towards the south southwest towards town. A wind rose from Daiken Southland Limited's (Daiken) ambient monitoring station for the odour diary period (November 2019 to February 2020) is shown in Figure 2.

Based on a review of topography, the data collected at the Daiken site is expected to have a greater northerly component compared to that experienced at the Alliance Matura site, where this wind component is expected to be more north northeast to northeast. For other wind directions, the data collected at the Daiken site is expected to reflect that experienced at the Alliance Mataura location. The increased northeast component is apparent in the wind roses shown in the Alliance Mataura boiler assessment report (Golder 2020).

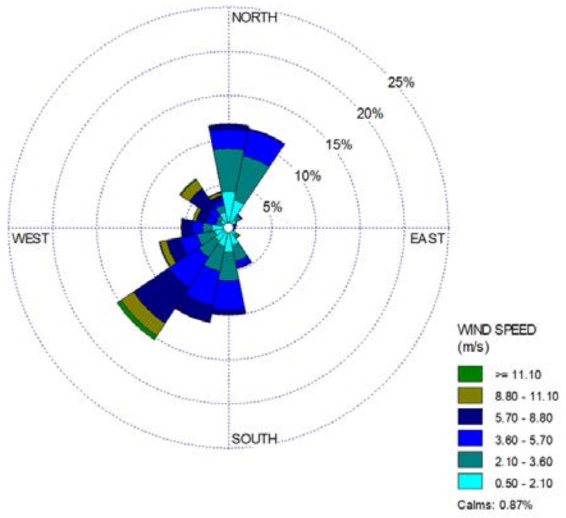

Figure 2: Windrose: Daiken, Mataura (November 2019 to February 2020).

4.0 ASSESSMENT APPROACH

The Ministry for the Environment 'Good Practice Guide for Assessing and Managing Odour in New Zealand' (MfE, 2016) describes a range of assessment techniques that can be used for assessing odour effects. It assigns a different priority to each technique, depending on whether the activity under consideration is an existing operation, an expanding operation, or a new operation. The priorities assigned by MfE (2016) to different odour assessment tools are very similar for an existing operation and for proposed modifications to an existing operation. The tools include the use of information from community meetings, odour diaries and/or surveys, complaint records, industry/council experience, meteorology and terrain assessment, and review of emission control systems.

The assessment of odour effects resulting from the Alliance site has been undertaken in accordance with the tools recommended by MfE (2016). It included a comprehensive 3-month odour diary programme (completed between 15 November 2019 and 22 February 2020) and analysis of those results, analysis of the site's recent complaints record, a site visit and review of emission control systems by Golder personnel, and application of expert knowledge of odour generating processes for sites of this kind.

Odour annoyance surveys were not considered to be practical for the Alliance site, given the low population density that would not lend itself to the use of a community annoyance survey tool.

Odour modelling is regarded as a low priority by MfE (2016) and has also not been undertaken for this assessment.

An assessment of cumulative effects of odour arising from different sources in the receiving environment needs to be undertaken, where off site sources give rise to odour with a character that is the same or similar to the odours generated on site and likely to impact on the same sensitive receptors. In other words, when the odour effects are likely to be additive. For this assessment there are no other potential sources of odour in the area that need to be considered.

5.0 ANALYSIS OF COMMUNITY FEEDBACK

5.1 Introduction

Odour complaint records were reviewed for the period October 2015 to 10 August 2020. The frequency of the complaints and distribution of wind speed associated with odour complaints are shown in Section 5.2.

Alliance ran an odour diary programme between 15 November 2019 to 22 February 2020. The diaries were provided to community members who had previously complained about odour from the Alliance site. The diary form was consistent with the example provided by MfE (2016). Complaints relating to odour were also received by the plant during this period.

For the period of the odour diary programme, a diary of site activities relating to the activities at the wastewater treatment plant, including DAF tank scraping and cleaning was kept by the site. The timing of load outs of renderable material was also estimated based on delivery records. The DAF solids decanter typically operates between 7.30 am and 3.00 pm and from 6.00 pm to 2.00 am and dewatered DAF solids are loaded out daily. Compost solids are loaded out when the storage bin is full. This can mean the duration between load outs can be up to a week.

As discussed in Section 3.0, wind data was available from the Daiken site 4.5 km southwest of the Alliance site. Wind speed and direction data was recorded every thirty minutes at the Daiken station for the period of the odour diary programme. This was used to identify concurrent wind direction during diary entries to determine the potential sources.

The analysis of odour diary entries and complaints, in combination with onsite activities has been used to understand the frequency of various onsite activities and how significantly they contribute to offsite odour effects.

5.2 Complaint History

Odour complaint records have been analysed from 1 October 2015 to 10 August 2020. Figure 3 shows a summary of the number of complaints received per month. A total of 53 complaints were received during this five-year period. There were fewer complaints prior to August 2017, when the DAF solids decanter was installed. Following this change there was an increase in odour complaints, with peak complaints received in December 2017 (6 complaints) and January 2018 (9 complaints). Many of these complaints have descriptions indicating odour sources from either the wastewater plant and/or the DAF solids decanter.

Following the above, Golder reviewed the site's odour sources in February 2018 and recommended the treatment of the exhaust from a roofline vent above the DAF solids decanter. The decanter centrate drain was also identified as an odour source, albeit more minor than the roof vent.

In July 2018, Alliance connected air extraction ducts to the DAF solids decanter and liquid phase discharge chute and directed extracted air to the site's main coal-fired boiler for use as combustion air. Odour complaint levels appear to have reduced following this mitigation measure being implemented. This indicates that the operation of DAF solids decanter (commencing in August 2017) is a primary cause of odour complaints associated with Alliance Mataura site.

Alliance has confirmed that odour complaints, which are registered with the site, are investigated by staff as per the site draft Air Discharge Management and Contingency Plan (Appendix C). This has been updated to include the recommendations of this report.

Wind speeds at the time of complaints were analysed to confirm the association of light wind conditions and odour complaint probability. Figure 4 shows that less than 10 % of odour complaints occur at moderate wind speeds (greater than 6 m/s) and approximately two thirds occur for light wind speeds below 4 m/s. This is consistent with the results of the odour during the odour diary programme (discussed below in Section 5.3), where reported observations of odour were also typically associated with light wind conditions. Therefore, the same sources which have caused occasional odour complaints to arise are likely to be the same sources associated with the Alliance Mataura odour diary observations.

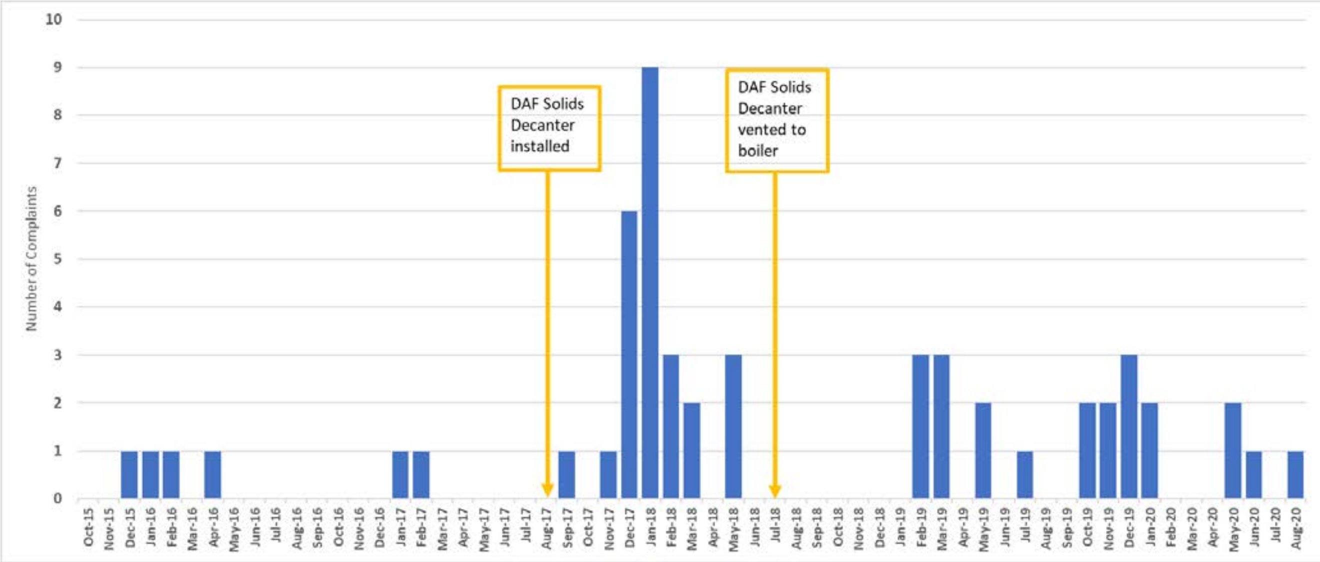

Figure 3: Number of complaints per month (Oct 2015 - Aug 2020).

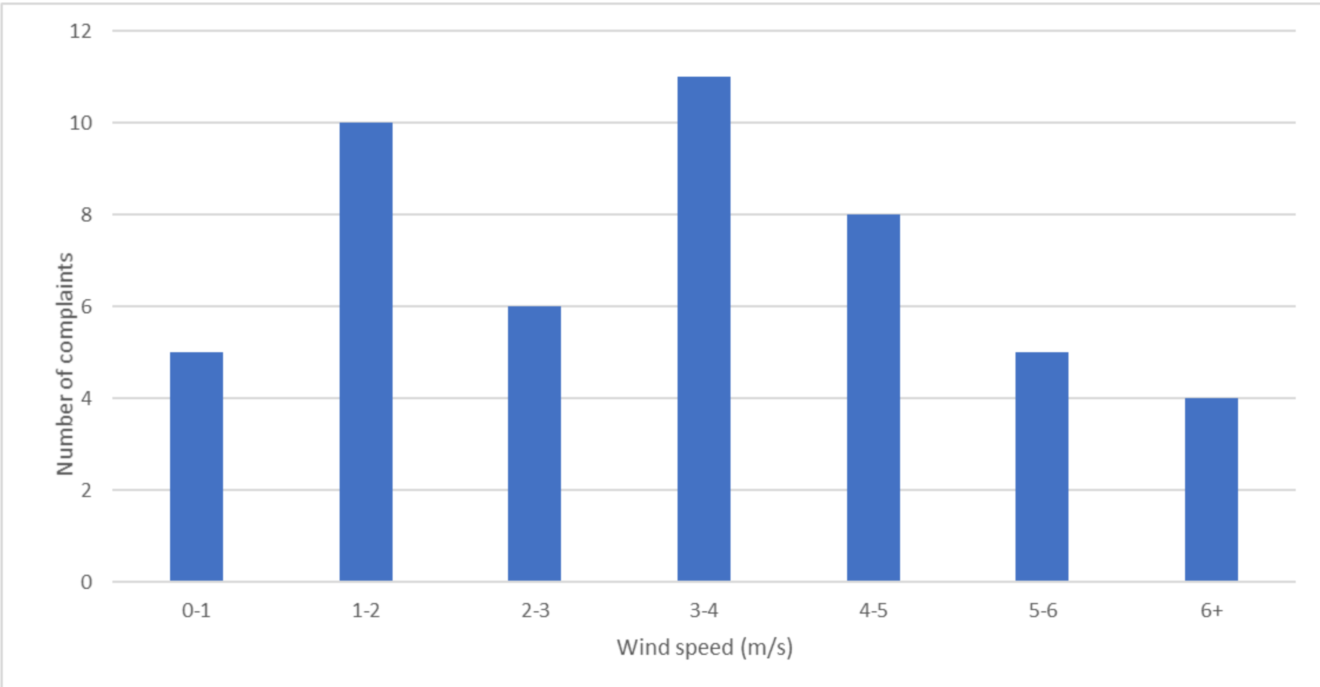

Figure 4: Number of complaints vs wind speed.

5.3 2019-2020 Odour Diary Programme

5.3.1 Odour diary entries

Four odour diaries were given out to record observations of odour for period from 15 November 2019 to 22 February 2020. This included three members of the public and a member of the Alliance's site security team who had previously provided regular feedback regarding odour. A summary of the odour diary locations are presented in Table 1 below and the collated diary records are provided in Appendix B. The location of the diarists is shown in Figure 1.

Table 1: Odour diary records.

Label	Location	Direction from site	Distance to the DAF tanks (m)	Number of odour diary entries
Diarist A	Culling Terrace	South east	360	15*
Diarist B	Carlyle Street	South west	500	5**
Watchhouse	Watchhouse	South west	140	15
Diarist C	Oakland Street	South west	500	0

*Where a diary entry refers to several days this has been counted as separate entries.
** Three of these records are prior to 15 November 2019 when site operational data was not available.

Some of the odour diary entries referred to several days or time periods. These have been separated into individual records so each could be included in analysis. For diary entries referring to a trend, e.g, one that recorded "noticed an odour on weekday nights between approximately 8.00 pm and 10.00 pm", the diary record was supplemented to include additional line items to include all of that week's weekdays between 8.00 pm and 10.00 pm. Where diary records were noted as being not from single locations, this was accounted for when considering if the diarist was downwind of the Alliance plant.

5.3.2 Complaints

There were eight complaints during the diary period. Six of the complaints received were made by Diarist A and four of these complaints were also diarised. The other two complaints were made by non-diarist members of the public. The complaint record is also provided in Appendix B.

5.4 Periodic Odour Generating Activities

For the same period as the diary programme, the times of periodic potentially odorous activities (as described in Section 2.6) were recorded by Alliance staff. These included activities associated with the wastewater treatment plants DAF solids movements, renderable by-product and compost solids material load out operations. No activities were recorded during the periods of 25 December 2019 to 5 January 2020 (due to Christmas Shutdown) and 7 to 12 February 2020 (due to flooding), except for one renderable material pick up which occurred on 25 December 2019.

The start and end time of site activities associated with wastewater treatment plant were recorded. If no end time was recorded, then the end time was assumed to be the nearest half hour to the start time. The types of activities recorded included activities such as: DAF tanks scraped, grit plant dropped[2], DAF tanks dropped

[2] Note that grit plant dropped is not expected to generate significant odour.

and cleaned, and drained beef recycle tank. In total there were approximately 450 wastewater treatment plant-associated site activities recorded relating to potentially odorous activities.

The load out times of renderable material was estimated based on Alliance Lorneville plant's delivery records. Alliance have advised that it can be assumed the compost solids materials were loaded onto trucks 40 minutes prior to the delivery of coal mine and loading would take 20 minutes.

The recorded activities were grouped to aid the analysis of offsite odour. The groups are:

- Tank Scraping: Tank scraping is the removal of the DAF solids from any of the onsite DAF tanks. (393 instances typically lasting 30 minutes each).
- Tank Dropped: This group included any tank draining activities including those described as DAF tank dropped and cleaned grit plant dropped or drained beef recycle tanks. (52 entries typically lasting 30 minutes).
- Infrequent Activities: This includes events recorded infrequently events such as blood buckets left out (Total of 2 entries).
- Renderable Material Loadout: This relates to load out of renderable material into trucks.
- Compost Solids Material Loadout: This relates to load out of compost solids (screen solids) into trucks.

Other potentially odorous activities onsite include DAF solids decanter operation and dewatered DAF solids loadouts. The DAF solids decanter operates most of the time between 7.30 am and 2.00 am and dewatered DAF solids load out typically occurs once per day. The stock holding yards have the potential to cause a low level of odour.

For each of the recorded site activities, the likelihood of them occurring at specific hours of the day is presented in Figure 5 and Figure 6. This was calculated based on analysis of the Alliance activity diary record and is the percentages of days (out of the odour diary programme) that an activity occurred in each hour. For example, the tank scraping activity occurred between 7.00 am and 8.00 am on 35 % of days. The activity may not have occurred for the entire hour.

Most of the site activities occur between 5.00 am and 10.00 pm, however it is noted that tank dropping activities are more likely to be occurring between 8.00 pm and 10.00 pm.

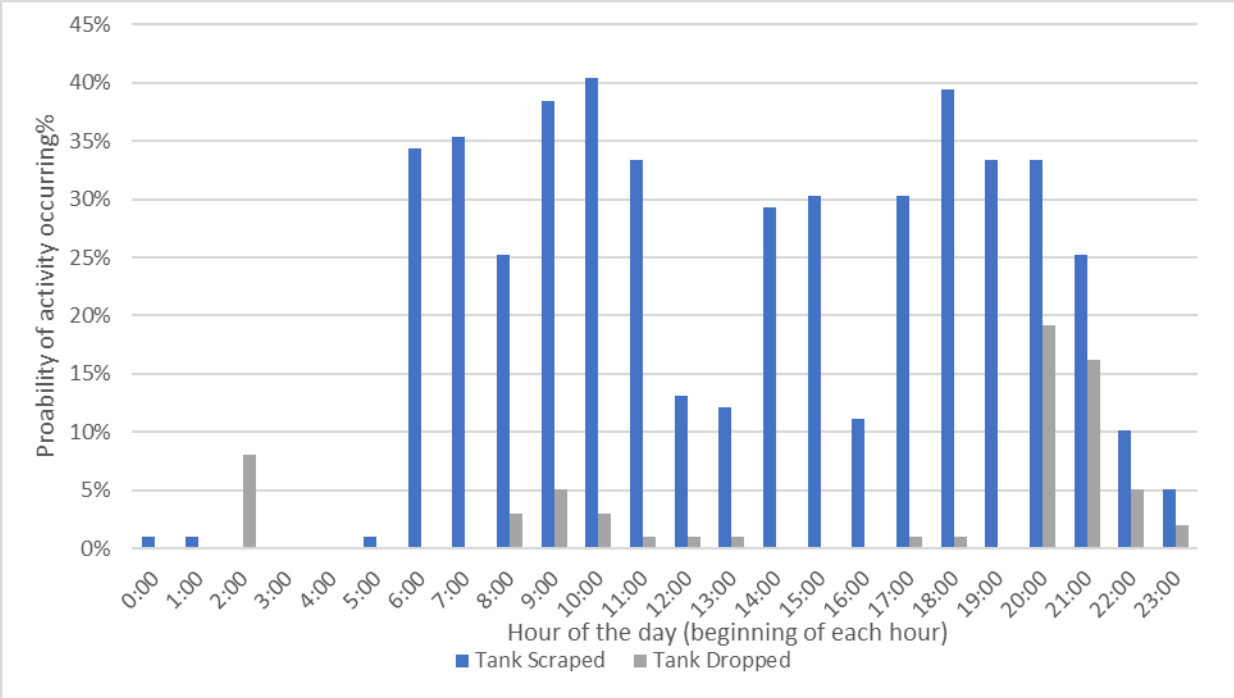

Figure 5: Probability of tank scraping or dropping occurring by time of day.

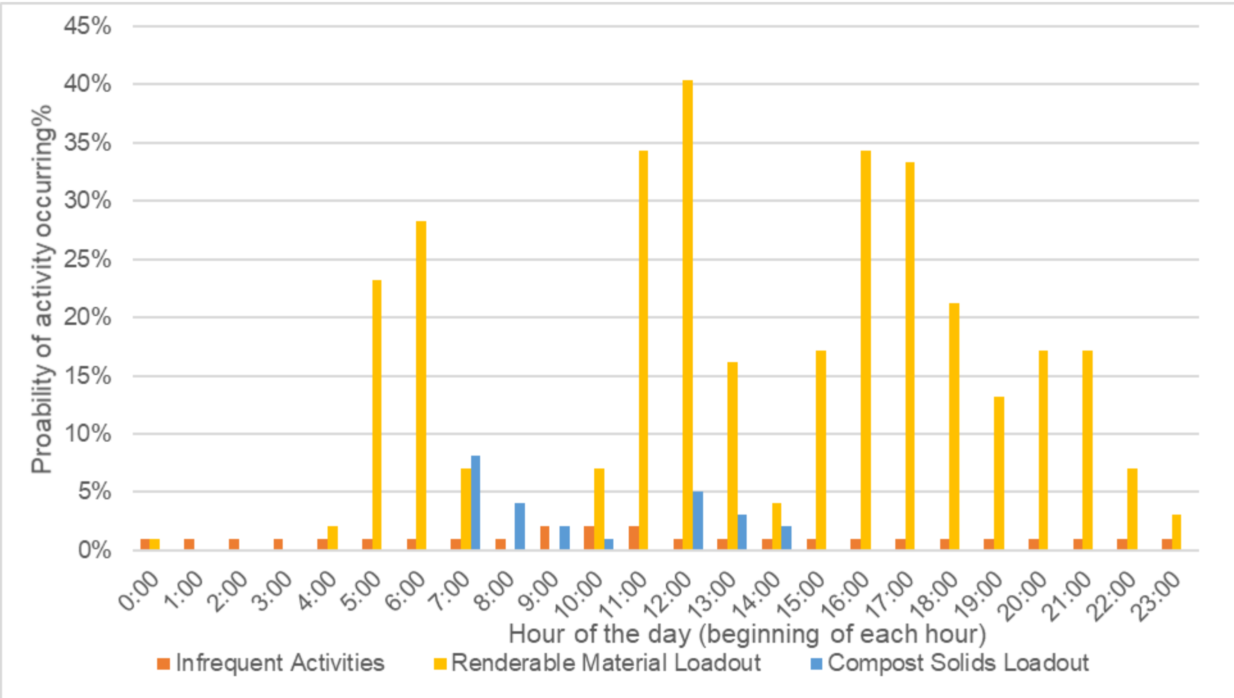

Figure 6: Probability of renderable material loadout, compost solids loadout and infrequent site activity occurring by time of day.

5.5 Analysis of Diary Entries and Complaints

5.5.1 Overview

The odour diary records were first reviewed to determine whether odour events were likely to be from the Alliance site. This was based primarily on wind direction, then if a character of the odour had been provided this was reviewed to confirm the odour could have come from the Alliance site. Percentage odour exposure was also calculated for each diarist as well as a review of any correlation between site activities and the odour diary and complaint records.

The individual odour diary records are provided in Appendix B.

5.5.2 Percentage of diary record downwind

For each odour diarist, the wind direction that blew from the Alliance site to their house or the specified location was determined and either the greater of a measured range for general locations such as Kana Street or a 60° range considered. For example, Culling Terrace is southeast of the Alliance site. Therefore, north-westerly winds in the range 299 to 359° would place the Alliance site up-wind of Diarist A on Culling Terrace. Further consideration was given to locations to the southwest of the site as wind direction experienced in Mataura is expected to be slightly different than at the measured data at the Daiken site. Locations to the southwest of the site (e.g., the Watchhouse) had the downwind angle increased toward the northerly direction by a further 30° to allow for the likely northerly winds in Mataura compared to that at the weather station (see Section 3.0).

Wind directions were extracted from the Daiken weather station database for the recorded duration of the odour event and the half hour prior to the event. For this assessment of the raw data, the confirmation of the record being downwind of site was made if any of the extracted wind directions were consistent with Alliance being up-wind of the diarist/complainants recorded location, and if the character of the odour (if recorded) was consistent with Alliance being the source.

Table 2 provides a summary of the percentage of diarists' records being downwind. Most diary records for Diarist A and Watchhouse diaries were entered when they were downwind of the Alliance site. It was noted that individual diarists recorded odour from a range of locations. For some of these locations it was not always clear (e.g., 40 % of records from Diarist A) whether or not the diarist was directly downwind of Alliance. Due to the uncertainty regarding Alliance being upwind, these cases, it was assumed the diarist was downwind of Alliance and all diary records were included in the analysis of odour exposure time etc.

5.5.3 Odour exposure time

The odour exposure time (Table 2) was calculated based on percentage of time odour was recorded over the diary period[3]. This was only completed for Diarist A and the Watchhouse diaries, as the other diaries did not include duration of events.

When the exposure time for Diarist A was calculated, if there was no end time stated it has been assumed the duration was two hours as this was the most common recorded duration. For the exposure time calculation for the Watchhouse, if no end time was recorded, one hour was assumed as this was the most common recorded duration.

Several of the entries were for different locations, such as on Kana Street by the old paper mill and in town, and these have all been included in the calculation of exposure. Where odour diary entries overlap, only the total time has been considered. The percentage exposure time is calculated by the total duration of recorded odour diary entries divided by the odour diary period which was from 15 November 2019 to 22 February 2020.

[3] The exposure time was calculated based on all hours of the diary programme. It is acknowledged that the diarist would not have been at the diary location for the entire diary period. Therefore, the exposure time is indicative only.

Table 2: Odour diary summary.

Name	Months of Diary Records	Odour Character	Range of Intensity	Exposure (% of time)	Number of Observations	Percentage of entries downwind	Entries with activity in previous hour or during entry
Diarist A	November - February	Character not recorded	Weak to strong	1.7	15	60%*	11
Diarist B	July, November-February	Offal	Weak to strong	-	5	0%**	2
Watchhouse	November - February	Offal/wastewater or blood	Very weak to strong	0.8	15	67%	8
Diarist C	November - February	No odour diary entries recorded.					

*The entries were not always at well-defined fixed locations so the percentage of entries downwind can only be considered indicative.
**Downwind and site activity analysis only relates two available entries within the analysis period 15 November 2019 – 22 February 2020.

5.5.4 Correlations between community feedback and site activities

The site activities that were occurring when an odour diary entry was made have been identified. These are shown for each diary entry in Appendix B.

For the diary completed by Diarist A, tank scraping and dropping activities were frequently occurring during diary records, with rendering loadout activities occasionally occurring.

For the diary completed at the Watchhouse, four out of the fifteen diary records were described as blood and were linked to blood buckets being stored adjacent to the Watchhouse. All the remaining diary records described the source of the odour as the wastewater treatment plant and half of these records were during tank scraping or dropping activities.

As shown in Figure 7 the odour observations were made between 5 am and 10 pm. This is consistent with the typical DAF solids decanter operation times. The likelihood of an odour diary having odour recorded between 10 am and 6 pm was relatively uniform. The odour was most frequently recorded for times between 8 pm to 11 pm on weekday evenings. It is noted that around 8 pm to 10 pm there are a higher frequency of the tank dropping activity (Figure 5) and Diarist A diary record observations (Figure 7) and four of the Diarist A's diary records occur when the tank dropping activity occurs (Appendix B) with three of these events occurring in the same week.

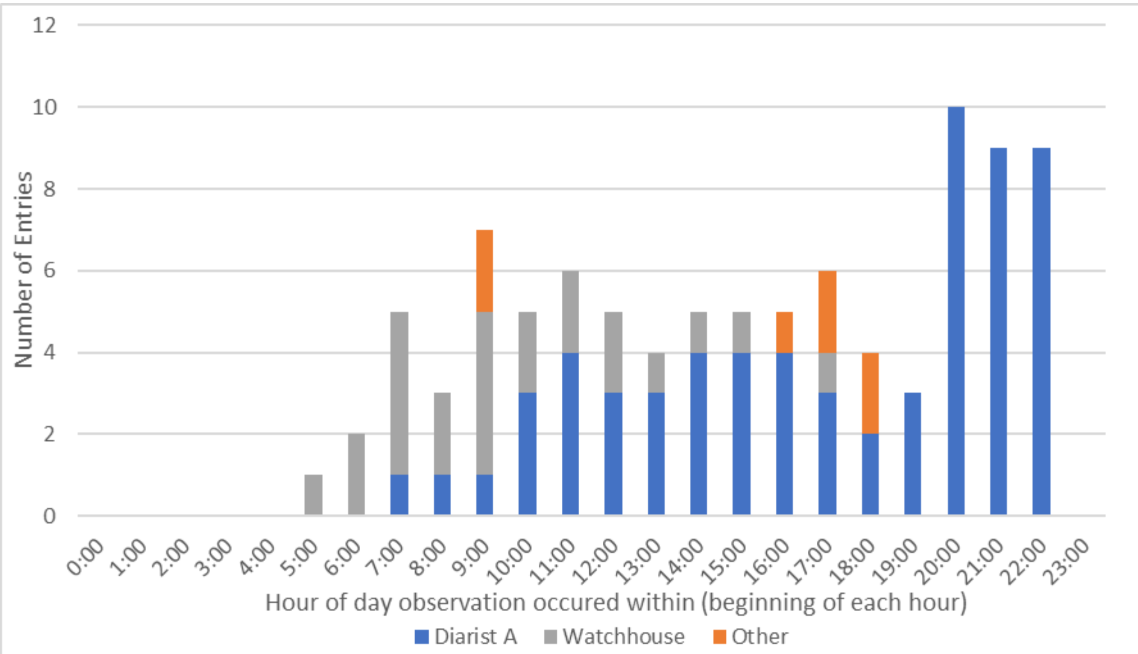

Figure 7: Odour diary or complaints records that occurred at each hour of the day.

The percentage of time that Culling Terrace and the Watchhouse are downwind during each hour of the day was also reviewed. This is shown in Figure 8. Culling Terrace is typically downwind 15 % of the time. It is more likely to be downwind around midnight, and less likely around 5 pm. The Watchhouse is most likely to be downwind in the early hours of the morning through to 11 am with the lowest likelihood in the late afternoon/early evening. There is no increased frequency of wind at any hour that explains the pattern of odour diary records.

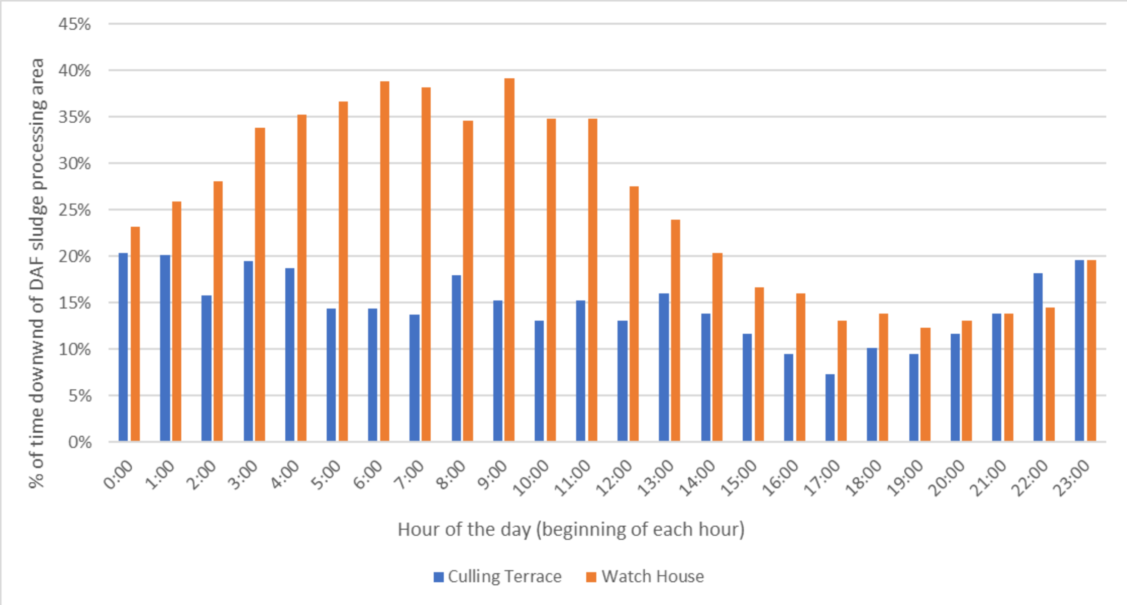

Figure 8: Percentage of time downwind of site during diary programme.

The recorded irregular site activities were evaluated to determine the frequency that these occurred concurrent with odour diary and complaint records. This is shown in Figure 9. Diary records and complaints are more likely to be coincident with site activities in the early morning and late afternoon periods. This is also consistent with the DAF Solids Decanter operation times.

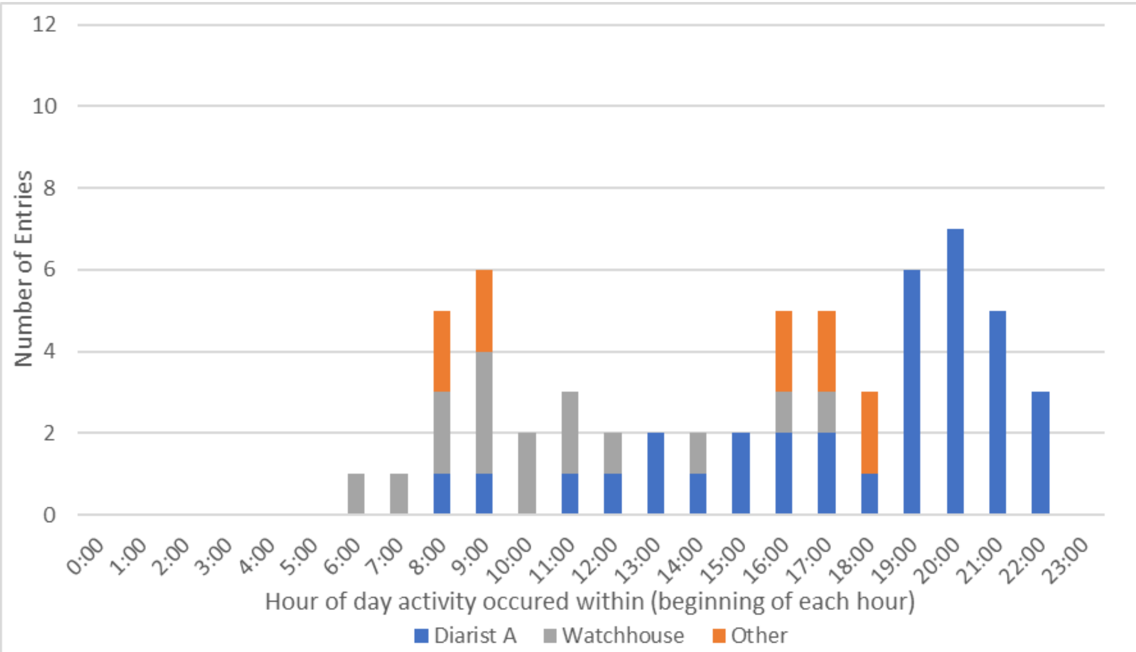

Figure 9: Number of hours site activity coincided with a diary entry (activity occurred within the same hour or in hour before an odour observation).

Table 3: Summary of odour diary entries or complaints coinciding with recorded site activities.

Site Activity	Total occurrences (hours)*	Percentage of hours in period when activity occurred*	Percentage of activity hours that coincide with recorded odour	Percentage of odour records (hours)** when these activities occurred.
Tank Scraped	478	20%	10 %***	37 %
Tank Dropped	66	3%	14 %	7 %
Infrequent Activities	27	1%	26%	5 %
Renderable Material Loadout	324	14%	6 %	14 %
Compost Solids Loadout	25	1%	0	0

*When an activity or diary record occurred within an hour it is counted as occurring for that hour. It may not have occurred for the entire hour.
**Including the hour prior to the record.
***This is the percentage activity time, i.e., 2 % (10 % of 20 %) of the time this activity coincided with a recorded odour.

The percentage of time that site activities occur (which have potential to produce odour) are shown in Table 3. Also shown is the percentage of time when an activity was occurring, which coincided with odour observations. Finally, the percentage of hours when odour was recorded, which coincided with the occurrence of a specific activity.

The infrequent activities appear to be over-represented in the odour observation records. All of these are associated with observations made onsite at the Watchhouse. These diary records described the odour as blood and Alliance have advised that these odour observations were during a period of temporary blood by-product storage nearby. No off-site records appear to be associated with this storage event.

With the exception of the evening DAF tank dropping being associated with a number of diary records, the remainder of the periodic odour generating activities appear to coincide within the odour observations at a frequency that would be expected from chance alone, i.e., there is no strong correlation between these activities and odour records. There is possibly an association between DAF tank dropping and subsequent odour observations. This is not a clear link, but if real, it is probably associated with odour emissions from dewatering of the resultant sludge.

This indicates that the periodic (potentially odour generating) activities were not dominant sources of observations of offsite odour – with the potential exception of the tank dropping activity. Site activities were reviewed by Golder during the July 2020 site visit, and the outcomes from this are discussed in Section 6.0.

5.6 Conclusions from Community Feedback

The diary programme was undertaken between 15 November 2019 to 22 February 2020. It involved three community odour diaries and one diary by a security staff member. During the diary programme, Alliance recorded the intermittent site activities (such as those discussed in Section 2.6) that have the potential to cause odour beyond the site boundary. This included DAF tank operational activities as well as periods when renderable by-product material was being loaded out. There are other more regular site activities including the DAF sludge decanter operation which also have the potential to cause offsite odour. Wind speed and direction data was available from the nearby Daiken Manufacturing Site.

For a residential diarist, it is considered that when diary records indicate odour exposure times above 1 %, that it is probable the long-term exposure is causing effects that are more than minor. The review of the offsite odour recorded during the diary programme via the diaries records, indicates that the odour exposure for Diarist A (at 1.7 % of time) could be associated with more than minor effects. While it is noted that around 40 % of the diary records were not clearly downwind of the Alliance Mataura site, this exposure is still at a level where additional mitigation, where practicable, would be justified.

There were infrequent activities which were associated with a number of the onsite observations (at the Watchhouse). However, these were typically associated with onsite odour observations and not associated with any odour being observed offsite.

While intermittent site activities appear to be associated with some offsite odour records, the analysis suggests that these are not prominent sources of offsite odour. In summary, no specific (potentially odorous) periodic activity at the site, was identifiable as a clearly dominant source of offsite odour observations, although the tank dropping activity was associated with a number of diary records. Overall, the diaries indicate that more routine discharges of odour, such as the DAF solids decanter operation, is a more likely source of offsite odour observations, however the tank dropping activity also needs to be considered.

A site visit was carried out to investigate the likely prominence of other site sources and the conclusions regarding potential sources of offsite odour and recommended mitigation are discussed in the following section.

6.0 SITE VISIT FINDINGS AND RECOMMENDED MITIGATION

6.1 Introduction

Golder staff visited the site on 15 July 2020[4] to review site activities (including those listed in Section 2.6) and assess odour onsite and offsite. This included the Alliance Mataura wastewater water collection, screening and treatment system (via settling and multi—staged dissolved air flotation (DAF)). Additionally, the contra-shear screening out solids from the wastewater streams, associated storage, DAF solids dewatering via decanting and load out, hogging and transfer of renderable by-products from the processing plant were all observed.

Findings and recommendations from the above assessments are provided in the following sections

6.2 DAF Solids Dewatering

Odour emissions associated with the dewatering of steam heated DAF solids appeared to have been substantially reduced from those previously observed (Golder site visit in February 2018), by the extraction of air from the decanter liquid phase discharge chute and ducting this flow to the site's boiler for combustion. However, the discharge of centrate from the decanter to wastewater drain was producing a sharp DAF solids odour, which could be recognised at the southern site boundary. This odour could possibly increase temporarily following the dropping of DAF tank solids and dewatering of the resultant sludge.

[4] Roger Cudmore Principal Air Quality Consultant

It is recommended that the point where decanter centrate is discharged to drain, is contained and treated. This could be achieved by enclosing the head space of the centrate discharge tank and extracting odorous air and treating via a small soil bark biofilter. It is estimated that an extraction flow in the order of 200 L/s from the enclosure would be sufficient to contain the odour emissions associated with the centrate discharge. This would require a small biofilter system with approximately 2 -3 m^3 of soil bark media which could be contained nearby within a tank, or similar structure. This bed may not require any irrigation given the level of moisture with the warm humid emission associated with the centrate discharge.

The dewatered DAF solids (at approximately 50 wt.% solids) was confirmed to have a relatively low odour potential and this can be maintained by ensuring that the feedstock of DAF solids at approximately 7 wt.%-8 wt.% solids is not processed in a degraded state. This observation was similar to that made previously (Golder site visit in February 2018). Ensuring that DAF solids are not able to become degraded and odorous prior to dewatering is recommended as a measure to be included into the site's Air Discharge Management & Contingency Plan (AMP).

6.3 Compost Solids Load Out

The current system for storage of screen solids in the material storage bin (approximate volume of 20 m^3) results in solids being stored for up to week or more, before auguring out to a truck and transfer to an offsite, third party composting facility. This activity may result in occasionally strong odour emissions, especially on warm days, although this was not apparent from the odour diary records. However, it is considered, storing solids for this length of time is not good practice. Reducing storage times to one day maximum and ensuring bins are cleaned via water hosing is recommended as a measure to be included into the site's AMP.

It is recommended that the screened solids storage system is modified, and instead use smaller pick up bins in place of the existing large load out bin. The same bins used for daily collection of paunch grass are recommended for this purpose and removal of screened solids on a daily basis to the local compost manufacturing facility is also recommended. This is likely to effectively mitigate the potential for the existing large bin to generate any unpleasant odour effects off-site during loadout.

6.4 Renderable By-products Storage and Load Out Bin

The large 50 m^3 renderable by-products storage/loadout bin that is north of the processing plant also has the potential to cause isolated odour events off site that are unpleasant. Regular removal of renderable by-products material (trucking off site to Lorneville for rendering) will minimise this potential - this already occurs. Further mitigation via ventilation of head space air from the bin and treatment via a small-medium sized biofilter is recommended as a contingency to mitigate the potential effects of odour emissions from the bin. An indicative size for the biofilter is a 5 m x 5 m raised bed, which holds around 20 – 25 m^3 of media. This bed would need an overhead high-pressure mist system to maintain bed moisture levels.

6.5 Energy Plant Developments

Should the site replace the existing coal-fired energy plant with a bio-mass fired plant, then combustion of dewatered DAF solids would allow this material to be transferred to the site energy plant for combustion rather than loading out as currently occurs. It is not expected that this system will need any additional enclosure and controls given its relatively low level of odour. However, the change to a biomass fired boiler, provides this opportunity for future consideration.

6.6 Minor Odour Sources

Other odour sources at the site are associated with the preliminary treatment (i.e., contra-shear screening and settling of solids) of waste streams discharged from the cattle processing plant and stock yards. This odour has a fresh waste/offal character and is not expected to be a significant offsite source.

Likewise, the dissolved air flotation treatment tanks which clarify the preliminarily treated low and high phosphorus waste streams and resultant DAF solids produce relatively mild raw wastewater odour character.

These preliminary and primary wastewater treatment related odours are not readily noticeable near or beyond the site boundary and are minor sources compared to those associated with the storage and load out of waste by-products and sludge decanter emissions.

7.0 CONCLUSION

This assessment of existing odour effects was based on an evaluation of the results from the Alliance Mataura odour diary programme, which was undertaken during the 2019-2020 summer, an analysis of odour complaint records (from 2015 to 2020) and site investigation and reviews of odour sources at the site by Golder (completed first in 2018 and followed up in 2020).

Based on the estimated odour exposure times from the odour diary programme and outcomes of independent site investigations, it is concluded that while odour effects beyond the site boundary are likely to have reduced in recent years, these may still be more than minor.

It is also concluded from the outcomes of Golder’s site investigations and from the analysis of odour complaint records, that the DAF sludge decanting/dewatering activity at the site is likely to be a key source of existing odour effects beyond the site boundary.

It is also concluded that there are several other sources of odour at the site, which are associated with the storage and load-out of screened solids from the site’s wastewater plant (i.e., compost solids), and rendering by-products. These sources are likely to contribute to the existing level of odour effects beyond the site boundary.

Recommended additional odour mitigation measures include:

- the extraction and biofilter treatment of emissions from the DAF solids decanter centrate drain and the rendering by-products storage/loadout bin; and
- increased load out frequency of compost solids is also recommended.

With successful implementation of odour mitigation measures recommended in this report and maintenance of existing odour controls via good site management practices, it is concluded that the potential for off-site exposure to any short term unpleasant odour will be minor or less.

Finally, it is concluded that the implementation of recommended odour mitigation measures at the site, should occur in conjunction with an updated site AMP which is appended to this report. We also suggest that the effectiveness of the recommended additional odour mitigation measures be reviewed two years after they are commissioned.

8.0 REFERENCES

Golder 2020. Air Quality Effects of Energy Plant Emissions, Alliance Mataura. Golder Associates (NZ) Limited report 1793285-7403-008-R-Rev0.

MfE 2016. Good Practice Guide for Assessing and Managing Odour. Ministry for the Environment, Wellington.

Statistics New Zealand 2018. QuickStats about Mataura. http://archive.stats.govt.nz/Census/2013-census/profile-and-summary-reports/quickstats-about-a-place.aspx?request_value=15161&tabname=Ageandsex&sc_device=pdf - Last accessed on 15/06/2020.

APPENDIX A

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APPENDIX B

Odour Observation Records

Table 1: Odour Diary Entries

Date	Start Time	End time	Odour diary writer	Description	Location	Intensity	Notes on entry	Site activity occurring before or during diary entry
12/07/2019	10:30	13:00	Diarist B	Diarist B - Odour Characteristic:Offal	Carlyle street	2	outside evaluation period	
15/07/2019	11:30		Diarist B	Diarist B - Odour Characteristic:offal	Township	4	outside evaluation period	
8/11/2019	9:00	13:00	Diarist B	Diarist B - Odour Characteristic:offal	Carlyle street	2	outside evaluation period	
16/11/2019	10:00	22:30	Diarist A	Diarist A - odour still there at 10:30pm, had to shut the windows	Culling Terrace	3		
19/11/2019	16:30		Diarist A	Diarist A	Culling Terrace	3		Scraped
26/11/2019	7:00	12:00	Diarist A	Diarist A	Culling Terrace	2		Scraped, Renderable loadout
26/11/2019	10:30	13:40	Diarist A	Diarist A noticed odour in township. They had noticed the odour as really strong at 11am when they were down on Bridge Street and it was still smelling now at 1:40pm	Township	6	Split out information from phone complaint that related to diary entry	Scraped, Renderable loadout

Date	Start Time	End time	Odour diary writer	Description	Location	Intensity	Notes on entry	Site activity occurring before or during diary entry
26/11/2019	12:00	14:30	Diarist A	No description	Culling Terrace	2		Renderable loadout
26/11/2019	20:30		Diarist A	Diarist A	Culling Terrace	1		Dropped
3/12/2019	20:30	22:00	Diarist A	Diarist A described as really bad	Culling Terrace	6	Assumed 8:30 pm as number in finish time and complaint call received about evening odour.	Scraped, Dropped
4/12/2019	19:30	22:00	Diarist A	Diarist A	Culling Terrace	3	Assume 7:30 pm as complaint received regarding evening odour. Assume end time 10pm based on call.	Scraped
9/12/2019	20:00	22:00	Diarist A	on 14/12/19 Diarist A said they had also noticed an odour on weekday nights between approx 8pm and 10pm.	Culling terrace		Added based on call 14/12/19 8pm-10pm	Scraped, Dropped
10/12/2019	20:00	22:00	Diarist A	Really Bad	Culling terrace	4	Entry has 8:00 assumed this is pm and based on call ends at 10pm	Scraped, Dropped
11/12/2019	20:00	22:00	Diarist A	on 14/12/19 Diarist A said they had also noticed an odour on weekday nights	Culling terrace		Added based on call 14/12/19 8pm-10pm	Scraped, Dropper

Date	Start Time	End time	Odour diary writer	Description	Location	Intensity	Notes on entry	Site activity occurring before or during diary entry
				between approx 8pm and 10pm.				
12/12/2019	20:00	22:00	Diarist A	on 14/12/19 Diarist A said they had also noticed an odour on weekday nights between approx 8pm and 10pm.	Culling terrace		Added based on call 14/12/19 8pm-10pm	
13/12/2019	20:00	22:00	Diarist A	Really Bad	Culling terrace	6	Entry has 8:00 assumed this is pm and based on call ends at 10pm	Scraped
14/12/2019	10:00		Diarist A	Bad smell in town. Wafted up	Township	1		
9/01/2020	9:00		Diarist B	Offal	Doctors Road	3		Scraped
13/01/2020	9:45		Diarist B	Offal	Main Street/Bridge Street	4		Scraped
17/01/2020	7:00	8:00	Watchhouse	Offal	Watch House	2		Renderable loadout, Scraped
18/01/2020	7:20	13:00	Watchhouse	Offal	Watch House	2		
19/01/2020	7:00		Watchhouse	Offal	Watch House	2		
20/01/2020	5:45		Watchhouse	Offal	Watch House	2		

Date	Start Time	End time	Odour diary writer	Description	Location	Intensity	Notes on entry	Site activity occurring before or during diary entry
21/01/2020	9:52		Watchhouse	Offal	Watch House	1		Scraped, Dropped
22/01/2020	14:59		Watchhouse	Offal	Watch House	4		Scraped
26/01/2020	15:30		Watchhouse	Offal	Watch House	2		
29/01/2020	6:20		Watchhouse	Offal	Watch House	2		
1/02/2020	9:00		Watchhouse	Offal	Watch House	4		
17/02/2020	6:00	7:00	Watchhouse	Offal	Watch House	4	Time not recorded on paper copy of diary but was included in spreadsheet provided by site.	
18/02/2020	11:07		Watchhouse	Offal	Watch House	4		Scraped, Renderable loadout
20/02/2020	9:15		Watchhouse	Blood	Pallet Area	4		Scraped, Infrequent
20/02/2020	12:22		Watchhouse	Blood	Pallet Area	4		Scraped, Infrequent, Renderable loadout
20/02/2020	17:51		Watchhouse	Blood	Pallet Area	3		Scraped, Infrequent, Renderable loadout
21/02/2020	10:51		Watchhouse	Blood	Pallet Area	5		Scraped, Infrequent
22/02/2020	8:00	8:10	Diarist A	Freezing works	Culling Terrace	4		

Table 2: Summary of complaints

Date	Start time	End time	Location	Description	Response	Downwind	Site activity occurring before or during complaint
26/11/2019	13:40	17:00	Culling Terrace	Received phone call from Diarist A (Culling Terrace) at 1:40pm, to notify me that they had noticed an odour up at their house they believed from the Plant. They had to shut their windows last night at 7pm due to the smell.	Went for a walk along Bridge Street, Kana Street and up on the hill on Culling Terrace, was unable to detect any odour	yes	Renderable loadout, Scraped
3/12/2019	20:30	22:00	Culling Terrace	Received a voice message from Diarist A at 9:23am, describing the odour from the previous evening (3/12/2019 8:30pm-10pm) as really really bad.		yes	Scraped, Dropped
4/12/2019	20:00	22:00	Culling Terrace	Received an odour complaint from Diarist A at 1:50pm. Diarist A had noticed the odour for the previous two evenings between 8pm and 10pm.	Spoke to wastewater department to check there had been no changes to usual processes and there had not been any changes	yes	Scraped
10/12/2019	14:40	15:10	Culling Terrace	Really bad		No	Scraped, Renderable loadout

Date	Start time	End time	Location	Description	Response	Downwind	Site activity occurring before or during complaint
14/12/2019	10:00	22:00	Old paper mill Kana Street	Diarist A said that Saturday at 10am the odour had been really bad when driving along the road past the old Paper Mill building, the odour continued until 10pm.	Checked onsite activities and nothing out of the ordinary had been occurring at the times described, was unable to perform walk around due to delay in receiving the complainant. No plant process was occurring at the time described of 10am Saturday 14th 2019.	yes	Renderable loadout
8/01/2020	17:40	18:30	Old paper mill on Kana street	Near Paper Mill/Waste Water. Received an odour complaint from a person on Hope Street, described the odour as had been occurring for most of the day near the papermill and thought the odour was coming from wastewater	Went for a walk along Bridge Street, Kana Street, Doctors Road, Culling Terrace and McKelvie Heights and was unable to detect any odour. Did note that ouvea premix was getting loaded out of the papermill.	No	Scraped, Renderable loadout
29/01/2020	11:00	11:10	Culling Terrace	Received an odour complaint from Diarist A, they had noticed an odour this morning and was unable to describe what the odour smelt like.	Went for a walk along Bridge Street, Kana Street, Doctors Road and Culling Terrace, was unable to detect any odour.	yes	Renderable loadout
29/01/2020	16:45	18:15	Main road	Environment Southland received an odour complaint from a member of the public. Complainant noticed the odour while	Completed walk around Plant including rendering load out bin, wastewater and south end of Plant. Completed walk of McQueen	No	Renderable loadout

Date	Start time	End time	Location	Description	Response	Downwind	Site activity occurring before or during complaint
				driving through Mataura. Alliance was notified by ES at 14:15pm.	Avenue, Bridge Street and Kana Street. Could not detect any odours.		

APPENDIX C

Management Plan

ALLIANCE GROUP LIMITED
Mataura Plant

AIR DISCHARGE MANAGEMENT & CONTINGENCY PLAN

TABLE OF CONTENTS

1. INTRODUCTION

Site Location

Alliance Group Limited (Alliance) operate a meat processing and hide salting plant ('the sites') located in Mataura, Southland. The meat processing plant is located at the centre of Mataura, approximately 12 km to the southwest of the Gore township. The hide processing plant is sited approximately 2 km north of the meat processing plant. Both site locations are shown in Figure 1 below.

The sites are required to operate in accordance with air discharge permit TBC to ensure that there is no discharge of odour or particulate matter beyond the boundary that is offensive or objectionable.

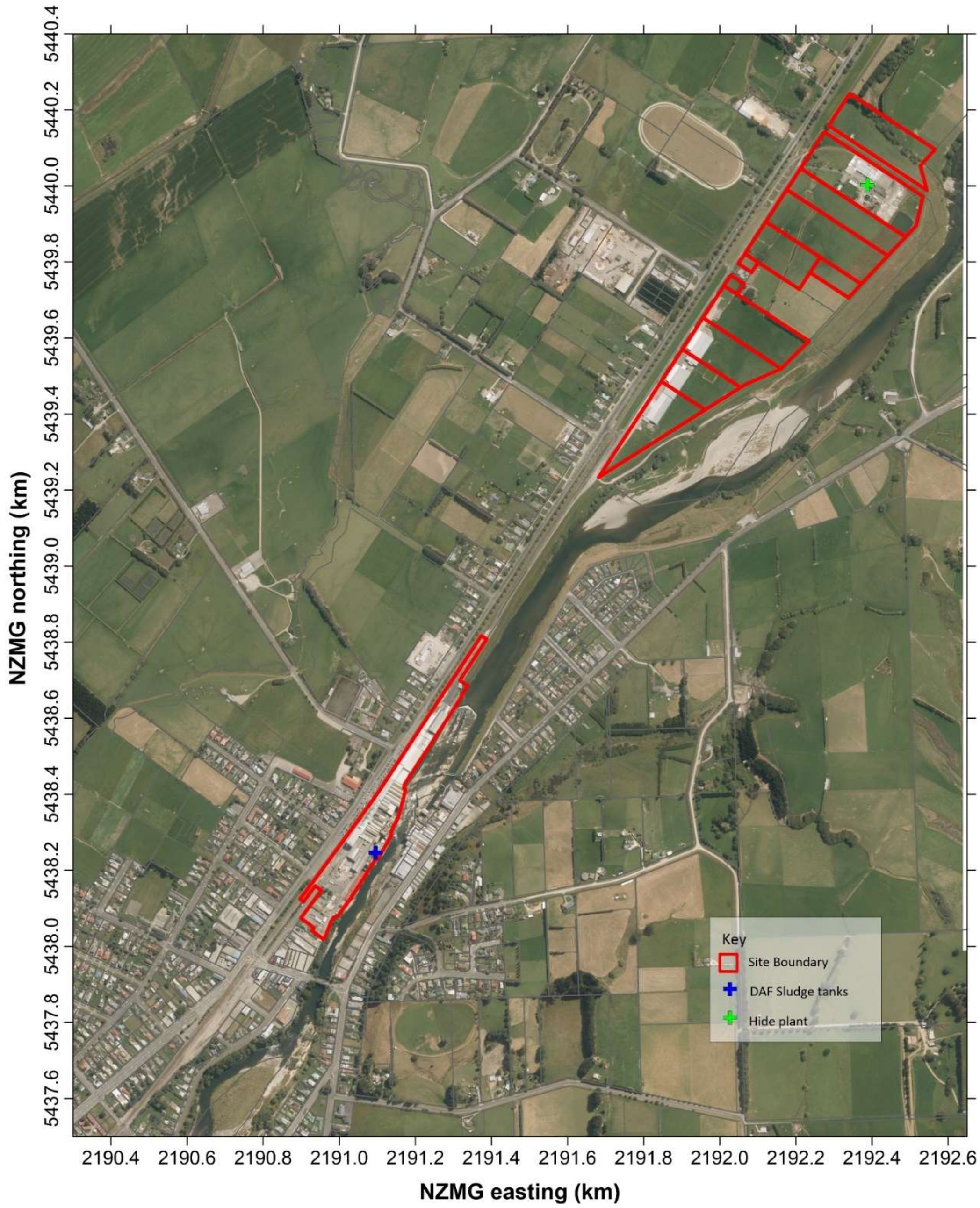

Figure 1: Site location

Document Purpose
The Alliance Air Discharge Management and Contingency Plan (ADMCP) has been developed to provide a framework for managing odour emissions and to maintain compliance with conditions of air discharge permit AUTH-2020xxxx.

To achieve this, the ADMCP incorporates the following key elements;

- A description of the receiving environment;
- Responsibilities of site personnel;
- A description of the plant operations air discharge sources;
- Monitoring, maintenance and mitigation measures for particulate and odour sources;
- Odour complaint response procedures;
- Incident response procedures;
- Contingency response procedures; and
- Document procedures.

2. TERMS, DEFINITIONS AND ABBREVIATIONS

Table 1 below describes the abbreviations and common terms used within the ADMCP.

Acronym	**Meaning**
DAF	Dissolved Air Flotation wastewater treatment plant
CIP	Clean in Place – chemically assisted process cleaning
PPE	Personal Protective Equipment.
WWT	Wastewater Treatment
PRO 117	Compliance Issues Register
MSDS / SDS	Material Safety Data Sheet / Safety Data Sheets
Term	**Definition**
Incident	An unplanned occurrence that results or could result in harm.
Odour	Odour discharged from Mataura Plant operations that is offensive or objectionable to such an extent that it has an adverse effect on the environment at or beyond the boundary of the Mataura property
Saveall	Primary wastewater treatment solids recovery tank
Balance Tank	Large short term storage tanks to enable flow balancing through the DAF plant

Table 1: ADMCP terms, definitions and abbreviations

3. RECEIVING ENVIRONMENT

Mataura is an urban area in Southland with a population of 1,629 people and 672 households, according to 2018 census information (Stats NZ, 2018). Mataura is predominantly residential, with commercial and industrial areas.

The site wind patterns are significantly influenced by the raised terrain running along the eastern side of the Mataura River. As such, southerly and northerly wind conditions tend to align with a north northeast to south southwest bearing and cold air drainage flows can be expected to move along this same bearing and towards the south southwest towards town. A wind rose from Daiken Southland Limited's (Daiken) ambient monitoring station for the odour diary period (November 2019 to February 2020) is shown in Figure 2.

Based on a review of topography, the data collected at the Daiken site is expected to have a greater northerly component compared to that experienced at the Alliance Mataura site, where this wind component is expected to be more north northeast to northeast. For other wind directions, the data collected at the Daiken site is expected to reflect that experienced at the Alliance Mataura location. The increased northeast component is apparent in the wind roses shown in the Alliance Mataura boiler assessment report (Golder 2020).

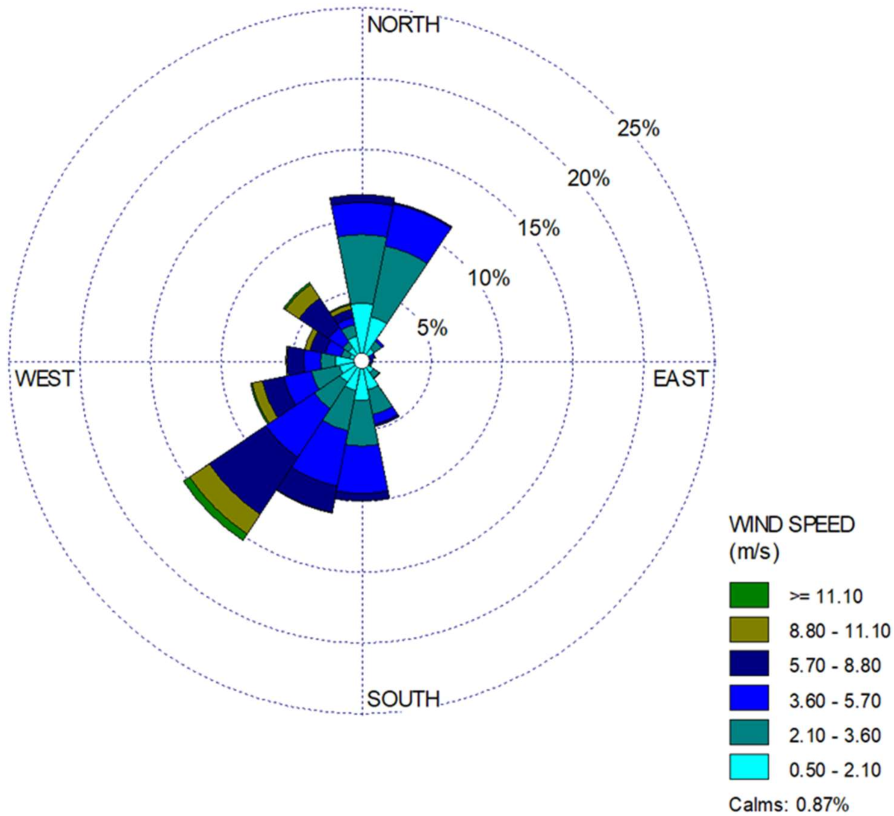

Figure 2: Windrose: Daiken, Mataura (November 2019 to February 2020).

4. RESPONSIBILITIES

The Plant Manager has overall responsibility for ensuring that the designated personnel adhere to the programmes documented within this procedure.

The Environmental Manager is responsible for ensuring that conditions set out in this document and the Discharge Permit are actioned and is also responsible to reporting to the council where required.

Department Managers and Supervisors are responsible for the ongoing compliance to the requirements set out in this procedure.

Additional responsibilities particularly with respect to odour management are described in the relevant following sections.

5. PLANT OPERATIONS

Air Discharge Sources

Plant activities which discharge contaminants to air or have a potential impact on the air environment are as follows:
Combustion emissions from:

- One 3.8 MW lignite-fired boiler (Boiler No.1).
- One 9.4 MW lignite-fired boiler (Boiler No.2).
- One 923 kW lignite-fired boiler (hide plant boiler).

Odour emissions from:

- Stock holding yards.
- Blood processing.

- Wastewater treatment and wastewater solids loadout.
- Rendering raw materials loadout.
- Operating wastewater solids decanter.

Miscellaneous minor emissions such as:

- Processing building ventilation, minor refrigerant losses and water vapour discharges from site processes.

6. MONITORING, MAINTENANCE AND MITIGATION

Introduction

The following sections outline the monitoring, mitigation and maintenance measures required for the above-mentioned discharge sources.

Combustion Emissions Management

Boiler Plant

Two coal fired Babcock and Wilcox (No 1 and No 2 as described above) boilers are operated on the main site to provide its steam and hot water requirements. A coal fired Boag boiler supplies the hot water requirements for the hide processing site.

Lignite coal is supplied by Greenbriar as Newvale Peas from its Eastern Southland mine. It has a sulphur content of around 0.4% - 0.5% and a calorific value of approximately 15 MJ/kg. Other contract conditions include: Total moisture; 40-45%: Ash; 3-6%; Fines < 3.35mm; 8% maximum: Size; 6-30mm.

Boiler Stack Height

The combined stack from Boilers No 1 and 2 is not to be reduced below the current height of 30 metres above the surrounding ground level. The stack from the hide plant boiler is not to be reduced below its current height of 19.5 metres above the surrounding ground level.

Boiler Operations

Boiler No.1 and Boiler No.2 may be operated simultaneously for a period of up to 48 hours duration, at a frequency of no more than twice per calendar year.

Boiler Servicing

The boilers used on the main site and hide processing site shall be serviced at least once per year by a person competent in the servicing of such boilers. This servicing shall include:

- Internal cleaning and replacement or repair of damaged equipment and services as necessary;
- Adjustment of the air to fuel ratio to optimise energy efficiency and to minimise the emission of products of incomplete combustion; and
- Calibration and adjustment of boiler monitoring equipment consistent with the intent of this consent.

Annual Maintenance schedule for the boilers is developed by the Engineering Manager prior to annual maintenance shut downs. The schedule includes the checks, repairs and maintenance which are to be carried out on the boilers.

Below to be updated following issuing of new consent

Records for all servicing carried out are to be collated by the Environmental Manager and reported to Environment Southland by 30 November each year.

Ringelmann

The opacity of emissions from Boiler No.1, Boiler No.2 and the hide plant boiler shall not be darker than Ringelmann Shade 1 as described in New Zealand Standard 5201:1973 except:

(a) In the case of a cold start for a period not exceeding 30 minutes in the first hour of operation;
(b) for a period not exceeding a total of five minutes in each succeeding hour of operation.

After periods of down time for either of the two main boilers onsite, cold starts will be managed to ensure that the above condition is not exceeded. Boiler operators ensure that on a start-up efficient operating parameters (including operating pressure and heat) are reached in as short a time frame as possible.

Coal Sampling

Condition X of Discharge Permit AUTH-2020xxxx states that: "The sulphur content of the coal burned in the boilers on the main site and the hide processing plant site shall not exceed 0.6 % by weight in any sample, based on the results of the testing undertaken in accordance with Condition X."

The following steps shall be taken to ensure compliance with Condition X of the consent:

- *(a) Analysis of coal to be burned in the boilers shall be undertaken at least once every six months providing that the coal source or blend remains constant.*
- *(b) Samples may be collected and analyses arranged by the coal supplier (Greenbriar). The Environmental Manager is to liaise with Solid Energy to confirm the availability of the relevant analytical results.*
- *(c) In the event that these are not available then the Environmental Manager or designate is to arrange for the collection and analysis of a composite coal sample representative of each 6 month period and targeting March and September for sampling.*
- *(d) If the coal source or blend changes the Environmental Manager should ensure that a representative analysis of the sulphur content is carried out as soon as practicable and within not less than five working days of beginning to burn the new coal.*
- *(e) A composite sample is to be generated on the selected sample day, by randomly selecting at least six "grab" samples of approximately 1 kg each from varying depths of the coal stored onsite and mixing in an empty dried blood bag and from this taking a 1 kg sample to be sent for analysis.*
- *(f) All coal samples required under this consent shall be analysed as soon as practicable for combustible sulphur as percent by weight of coal and gross calorific value as megajoules per kilogram of coal, on an as received basis, by a laboratory accredited by IANZ for these analyses.*
- *(g) A report summarising the results of the coal sampling and comparison with the limit specified in Condition X shall be provided to the Consent Authority within fifteen working days of receipt of the sampling results by the consent holder. The sulphur content of coal burned in the boilers on the main site and the hide processing plant shall not exceed 0.6% by weight in any sample.*

Stack Testing

Condition X of Discharge Permit AUTH-2020xxx states that: "The fine particulate matter (PM_{10}) mass emission rate from the boiler stacks on the main site shall not exceed (X) kilograms per hour and shall not exceed (Y) kilograms per hour following the boiler upgrade.

Stack testing to assess the concentration of fine particulate (PM_{10}) particulate matter in the main boiler stacks shall be measured annually during the consent term. For the year that the boiler upgrade is completed, the annual stack test should delayed until the upgrade is completed and new plant is commissioned.

The concentration of total suspended particulate matter during the boiler stack tests shall also be estimated.

- *(a) Measurement of the discharge from the boiler(s) shall occur when the boiler(s) discharging into the main stack are operating at a rate of at least 50% of the maximum continuous rating.*
- *(b) Testing and analysis of samples as appropriate, shall be carried out by an organisation and by a laboratory accredited by International Accreditation New Zealand (IANZ) for the tests and analyses involved.*
- *(c) The method of sampling and analysis for fine particulate matter shall comply with US Environmental Protection Agency (USEPA) Method 201 or equivalent method as agreed upon in writing with the Consent Authority.*
- *(d) Results shall be adjusted to 0ºC, 101.3 kilopascals, and 12% carbon dioxide on a dry gas basis and as a mass emission expressed as kilograms per hour. The US Environmental Protection Agency (USEPA) Method 201 or equivalent method as agreed upon in writing with the Consent Authority shall also be used to estimate the concentration of total suspended particulate matter.*
- *(e) Volumetric flow of combustion gas, and gas temperature, during each particulate emission test shall be determined and recorded and results presented as a part of the particulate emission test report.*
- *(f) The oxygen or carbon dioxide concentration in combustion gases shall be continuously monitored and recorded during each particulate emission test and results shall be presented as a part of the particulate emission test report.*
- *(g) The following operating parameters of the boiler(s) during each particulate emission test shall be obtained and included in the testing report: furnace temperature, furnace back-end oxygen concentration (wet gas or dry gas basis identified), rate of firing (steaming rate) and any abnormal operation during the testing period.*
- *(h) A report summarising the results of the boiler emission testing and comparison with the limit specified in Condition X shall be provided to the Consent Authority within 15 working days of receipt of the emission testing results by the consent holder.*

The Environmental Manager is to liaise with the Engineering Manager and the stack testing agency (currently K2 Environmental) to ensure the stack testing is carried out as required. Where possible it should be carried out during the time the ambient monitoring is underway to enable an assessment of the boiler performance and possible contribution to the ambient monitoring especially in the event of elevated ambient results.

7. ODOUR EMISSIONS MANAGEMENT

Wastewater Treatment Plant

<u>Process Description</u>

Wastewater primary treatment occurs by the coarse solids being screened and utilised in an off-site independent compost operation.

Settled material such as sand and grit is continually removed by a dedicated sand and grit removal system attached to the wastewater treatment saveall. The sediment is taken out in conjunction with the screened coarse solids.

Wastewater is pumped from the savealls to the balance tanks, and pumped from the balance tank into the Dissolved Air Flotation (DAF) tanks where it is:

- Dosed with sulphuric acid
- Dosed with an anionic polymer
- Treated with dissolved air

The portion of the wastewater designated for phosphorous removal is then:

- Dosed with hydrated lime
- Dosed with an anionic polymer
- Treated with dissolved air

If wastewater is allowed to accumulate in any area and allowed to age or become anaerobic there is a risk of unpleasant odours developing.

<u>Odour Management</u>

Odour for the wastewater treatment plant is managed by ensuring the treatment plant is clean, well maintained and that wastewater is not held for a period of time that would allow it to become anaerobic and odorous.

Specific maintenance and mitigation measures to effectively manage odour from the wastewater treatment plant are as follows:

- Sumps, pumps, screens, general operation and the discharge are checked at least every 2 hours and issues recorded in a diary for action by relevant personnel.
- Regular checks of the sand and grit plant are carried out.
- The grit plant is cleaned approximately weekly.
- Transport of the collected sand and grit to an off-site location (in conjunction with the beef paunch content material) will occur daily during processing to minimise the risk of it becoming odorous.
- DAF tanks are routinely emptied and cleaned to minimise the build-up of solids in the bottom of the tanks. Approximately 3 tanks (of 12) are cleaned each week and this occurs during the night shift period to minimise any potential effect on neighbours.
- The balance tanks are cleaned when necessary; this is an infrequent occurrence due to the installation of a sand and grit removal system. If required, accumulated solids are removed by suction tanker, or dug out with a small tractor unit. The solids are transported off-site for composting. The solids are largely inorganic sand and grit and as such are not very odorous.
- Unexpected malfunctions are corrected promptly by the on-site maintenance team.
- During the shutdown period, all sumps, save-alls, balance tanks and DAF tanks are drained and cleaned for inspection.
- Routine maintenance of the treatment plant including pipe work, tanks, pumping and dosing systems occurs during scheduled plant shut-down periods.

The Wastewater Supervisor and the operators have the day to day responsibility for ensuring that the odour management procedures are effectively managed. The Environmental Manager has overall responsibility for the performance of the treatment plant. The Engineering Manager has the overall responsibility for ensuring that maintenance is carried out as scheduled or promptly as required.

Wastewater Solids Load Out

Process Description

The wastewater treatment flotation process creates an organic solids layer on each tank which is continually scraped to holding tanks as an integral part of the wastewater treatment process. Wastewater treatment solids are dewatered through a decanter and then sent to an off-site composting operation.

In the event that the composting operation is unable to take the dewatered solids, the sludge can be disposed of by an external contractor to farmland largely in Eastern and Northern Southland. This activity is authorised by Consent No 207295. Alternatively it can be transported to the Alliance Lorneville Plant to be processed through their wastewater treatment ponds. If the wastewater solids are allowed to become anaerobic there is a risk of offensive odours escaping during storage and loadout.

Odour Management

Specific maintenance and mitigation measures to effectively manage odour from the wastewater solids load out process are as follows:

- The dewatered DAF solids are discharged into a parked trailer, which when full, is transported offsite to an external composting operation. If the trailer is to be moved from its loading position, it is to have the covers pulled at all times to keep the product dry, as there is a risk of adverse odour if the material got wet.
- The trailer should be cleaned via hosing with water.
- In the event that the DAF sludge is not able to be dewatered, the material is removed for discharge every production day and on no occasion is it allowed to accumulate for more than 24 hours prior to discharge.
- The solids tank and associated pump and pipe work is cleaned out every off-season.
- Inspections and maintenance are carried out as required.

The Wastewater Supervisor and the operators have the day to day responsibility for ensuring that the odour management procedures are effectively managed. The Environmental Manager has overall responsibility for the performance of the treatment plant and the solids collection and disposal. The Engineering Manager has the overall responsibility for ensuring that maintenance is carried out as scheduled or promptly as required.

Rendering Raw Material Load Out

Process Description

The process of rendering inedible and otherwise un-useable material into an end product of an animal feed by cooking, drying and processing into meat and bone meal is completed off-site. The raw product is pumped from the slaughter and boning departments to the loadout tank, situated at the North end of the plant opposite the cattle yards. From the rendering loadout tank the raw renderable material is loaded into trucks approximately four times a day and transported to the rendering facility at the Alliance Lorneville plant. If the product is allowed to age there is a risk of odours from the load out facility.

Odour Management

Specific maintenance and mitigation measures to effectively manage odour from the rendering raw material load out process are as follows:

- The product is loaded out approximately four times every 24 hours, depending on Plant production. It is never held for more than 24 hours.
- When there is a risk of odours (generally warm weather associated with off-peak kills) the material is stabilised by spraying the rendering product with a stabilising agent.
- The stabilising agent used is, a blend of organic acids with a specialised surfactant, to inhibit the growth of bacterial growth. The material is dosed at the rate recommended by the supplier who periodically checks the application.
- The raw material bin is cleaned daily.
- The transporting truck is cleaned at a minimum daily, usually after every load.
- Sump and pump are cleaned regularly.
- Loadout auger is maintained free of blockages to ensure no material is dropped on the ground.
- Sump pump is serviced during scheduled shut-downs.
- If the Alliance Lorneville plant is unable to receive raw material for rendering a contingency is in place that would see an external renderer receive the material
- Further mitigation via ventilation of head space air from the bin and treatment via a small-medium sized biofilter is recommended as a contingency to mitigate the potential effects of odour emissions from the bin.

It is the responsibility of the Environmental Manager to ensure that the odour management systems related to the rendering material loadout are effectively managed. The Engineering Manager has overall responsibility for the day to day operation and cleaning of the rendering load-out facility or it will be landfilled

Blood Processing

Process Description
During sticking on the slaughter board, blood is collected and 'blown' to the processing facility within the Wastewater Treatment plant. The fresh blood is either trucked off-site for processing elsewhere or dried onsite by being processed through a coagulator and decanter and the blood solids are dried in a steam jacketed drier. The dried solids are bagged for sale. The primary potential odour source from blood processing is via non-condensable gases released from the drying process. The key requirement to minimise odours from blood processing is to ensure only fresh blood is processed. Alternatively, the fresh blood is transported to the Lorneville Plant in 1000 litre IBC's for processing at the Lorneville site.

Odour Management
Specific maintenance and mitigation measures to effectively manage odour from blood processing are as follows:

- Routinely blood is processed the same day as it is collected from slaughter and no blood over 48 hours old is processed. If blood over 48 hours old is processed it must be stabilised with 0.3% sodium metabisulphate or another suitable stabilising agent
- The non-condensable gases ex the drier are directed into the boiler and discharged to atmosphere via the 30 metre stack.
- A full Clean In Place (CIP) clean occurs at the end of each processing day.
- Unexpected malfunctions are corrected promptly by the on-site maintenance team
- Routine maintenance of the blood plant including pipe work and tanks occurs during scheduled plant shut-down periods.

The Wastewater Supervisor and the operators have the day to day responsibility for ensuring that the odour management procedures are effectively managed. The Environmental Manager has overall responsibility for the performance of the blood processing plant. The Engineering Manager has the overall responsibility for ensuring that maintenance is carried out as scheduled or promptly as required.

Beef Yards

Process Description
The cattle yards have a capacity of approximately 700 - 800 to provide for a maximum daily slaughter tally of approximately 1000. As processing generally occurs over an 18 - 20 hour period, stock is generally received over approximately 15 hours. If the animal wastes are allowed to build up there is the potential for offensive odours.

Odour Management
Specific maintenance and mitigation measures to effectively manage odour from the beef yards are as follows:

- The yards are hosed down daily and the waste stream screened. The solid wastes from the yards are transported off site daily while processing to a composting operation.

The Cattle Yards Supervisor have the day to day responsibility for ensuring that the odour management procedures are effectively managed. The Production Manager has overall responsibility for the beef yard's operation. The Engineering Manager has the overall responsibility for ensuring that maintenance is carried out as scheduled or promptly as required.

8. ODOUR COMPLAINT RECORDS

Condition X of Discharge Permit AUTH-2020xxx states that: "There shall be no discharge of odour or particulate matter beyond the boundary of the site as a result of the exercise of this consent that is offensive or objectionable to the extent that it causes an adverse effect in the opinion of an authorised officer of the Consent Authority."

Odour complaints received against the plant shall be recorded in Infoleader PRO 117. Records shall include:

- The date and time of each compliant;
- Weather conditions (wind direction, wind speed and temperature);
- Location of the complaint;
- Nature and intensity of the odour; and
- The action (if any) taken in response to the complaint. *Note: action is not required to be taken over every complaint but does require that the decision be recorded.*

By the 31 October each year a copy of odour complaints received shall be supplied to Environment Southland for the previous period from 1 October to 30 September.

9. INCIDENT RESPONSE PROCEDURE

In the event of a confirmed odour from the site, either resulting from a complaint or from an internal observation the Environmental Manager should carry out a full investigation to determine, if possible, the cause of the odour. Particular attention should be given to identifying if the detailed odour management requirements listed in the above sections are being properly enacted. Any deficiency in these procedures should be rectified immediately.

If a mechanical issue has caused the odour then the Environmental Manager is to liaise with the Engineering Manager to ensure the issue is rectified as soon as practicable. If practicable the activity should cease until appropriate corrective actions are put in place.

Verification of the corrective actions put in place should be carried out in the period following their implementation to ensure they remain effective.

The actions taken in response to an odour event are to be recorded on Infoleader Form PRO 117.

10. CONTINGENCY RESPONSE

In the event of mechanical or electrical or other problems that provide for continuing operation of processes and/or timely shutting down of processes as the case may be, to ensure conditions of Discharge Permit AUTH-20xxxx are not breached, the plant has implemented where possible contingency plans in order to minimise the risks.

Blood processing: if the blood processing plant were to have a major mechanical failure that could not rectified within a timely manner then steps would be taken to transfer the raw blood to the Lorneville Plant for further processing.

Rendering: if there was a major failure with the Rendering Plant at Lorneville and they were not able to take product from the Mataura Plant, arrangements should be made with Keep it Clean in Dunedin to remove and process the raw rendering material from the Mataura Plant in a timely manner or arrange for it to be landfilled.

Wastewater solids decanter: if there is a mechanical failure with the wastewater solids decanter, relevant consents are in place to enable wastewater solids to be loaded out via a slurry tanker and either spread onto farmland or treated through the Lorneville Plant wastewater treatment ponds.

Boiler operations, processing building ventilation air, minor refrigeration losses and water vapour discharges from site processes: risks of a consent breach being caused mechanical/electrical or other issue for the aforementioned processes are minimised by routine off-season maintenance, boiler certifications and in the event of major breakdown, processing would be stopped until the issue was able to be fixed.

11. DOCUMENT PROCEDURES

Review

This plan is to be reviewed at least on an annual basis, and it may be amended at any time. If/when the Plan is amended; the consent holder shall forward a copy of the amended version to the Consent Authority within fifteen (15) working days following the amendment.

Document Record updates

Date	Rev	Section	Changes

12. REFERENCES

Environment Southland Discharge Permit AUTH-20158002
Resource Management Act 1991 (RMA)
National Environmental Standards for Air Quality (NESAQ)
Ambient Air Quality Guidelines (MfE/MoH) (AAQG)
Regional Air Quality Plan 2016
MfE Good Practice Guide for Assessing and Managing Odour in NZ
Assessment of Environmental Effects (TDL)
Statistics New Zealand 2018

GOLDER

golder.com

D

APPENDIX D

Brown, Copeland & Co Ltd

Renewal of Resource Consents to Enable Continued Operation of The Alliance Group Limited's Mataura meat Processing plant: Assessment of Economic Benefits

May 2019

FINAL

RENEWAL OF RESOURCE CONSENTS TO ENABLE CONTINUED OPERATION OF THE ALLIANCE GROUP LIMITED'S MATAURA MEAT PROCESSING PLANT

ASSESSMENT OF ECONOMIC BENEFITS

Mike Copeland
Brown, Copeland & Co Ltd

31 May, 2019

1. INTRODUCTION

Background

1.1 The Alliance Group Limited (Alliance) is a co-operative owned and supplied by 4,340 shareholder farmers, who supply more than 85% of the livestock processed at its five plants located in the South Island and two in the North Island.[1] The Mataura plant, which accounts for approximately 17% of Alliance's processing capacity, is located in the Gore District, about 50 kilometres north-east of Invercargill. In 2017/18[2], the plant processed approximately 143,000 cattle into meat, offal, hides and other products. Livestock were purchased mostly from Southland, Otago and Canterbury farmers. In addition the plant spent around $12 million per annum on goods and services supplied by local Southland businesses (e.g. Ajax Building, Tullochs Transport, Greenbriar (coal supply) and J Harper Contracting). The plant paid $22 million per annum in wages and salaries to fulltime salaried staff and seasonal staff – at the peak of the season there are 500 employees at the plant.

1.2 Alliance currently holds eight resource consents issued by the Southland Regional Council (Environment Southland) and one issued by the Gore District Council. These resource consents enable the operation of the Mataura plant and authorise discharges to air, land and water, and the taking of water. Alliance is seeking renewal of three resource consents due to expire on 6 December, 2019 and one due to expire on 15 December, 2020 to enable the continued operation of its Mataura meat processing plant for a further 35 years.

Report Objective

1.3 The objective of this report is to assess the Gore District and Southland regional economic effects of the continued operation of the Mataura plant. The report will form part of the Assessment of Environmental Effects to be lodged in relation to the consents renewal applications.

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[1] The plants are located at Stoke (Nelson), Smithfield (Timaru), Pukeuri (North Otago), Mataura (Southland), Lorneville (Southland), Levin (Horowhenua) and Dannevirke (Hawkes Bay).

[2] I.e. the year ending 30 September, 2018.

Report Format

1.4 This report is divided into 5 parts (in addition to this introductory section). These are:

(a) The background to the Mataura plant operations;

(b) A consideration of the relevance of economic effects under the Resource Management Act (RMA);

(c) A description of the Gore District and Southland regional economies;

(d) The economic benefits from consent renewals; and

(e) Some overall conclusions.

2. BACKGROUND TO THE MATAURA PLANT'S OPERATIONS[3]

2.1 Meat exports of $7.4 billion for the calendar year 2018 were New Zealand's second largest commodity[4] exports by value behind dairy products ($14.7 billion[5]) and ahead of forest products ($6.6 billion), fruit ($3.2 million) and fish ($1.6 billion). In 2018, meat and edible offal and raw hides and skins ($0.4 billion) made up 13.6% of the value of New Zealand's commodity export trade, second only to dairy product exports which made up 25.6%.[6]

2.2 Trade enables New Zealand to specialise in the production of certain products in which New Zealand has a comparative advantage enabling production surplus to domestic consumption to be exported. The production of meat and other animal products is an area in which New Zealand has comparative advantage. Exports of these products provide foreign exchange, enabling New Zealand to finance the purchase of competitively priced imported goods and services. The alternative model of "fortress New Zealand"[7] would see higher priced goods and services, reduced choice in the range of goods and services available in New Zealand and

[3] Material in this section provided by Alliance, unless stated otherwise.
[4] A distinction is made between "commodity trade" or "merchandise trade" and total trade. Commodity trade relates to the exporting and importing of goods only, whereas total trade includes the exporting and importing of both goods and services.
[5] Includes eggs and honey.
[6] Trade statistics from Statistics New Zealand NZ Stat.
[7] I.e. a situation where New Zealand's trade with the rest of the world is constrained and it is not possible for New Zealand to specialize in the production of those goods and services in which it has a comparative advantage, nor access cheaper goods and services from overseas.

a less efficient use of our physical and natural resources. This would result in lower incomes and a lower standard of living for New Zealanders.

2.3 Alliance's total revenues in 2017/18 were $1.8 billion, of which $1.6 billion (89%) were from export earnings. It employs 4,650 fulltime salaried staff and seasonal employees and pays $235 million per annum in wages and salaries. Of Alliance's 4,340 shareholders on the Share Register at 30 September 2018, over a third were in Southland. The shareholders are a mix of family owned farms and corporate entities.

2.4 The Mataura meat processing plant was established in 1893 and processes cattle. The plant provides Alliance with its only processing capacity for cattle within the Southland region and any reduction in the plant's capacity to process cattle would see this livestock processed outside the region.

2.5 The latest estimate (December 2018) for the Mataura plant's insured value is $225 million and much of this value is sunk – i.e. it could not be recovered if the plant was forced to downsize, close or be relocated.

2.6 Stock for the plant is largely sourced locally. In 2017/18, approximately 143,000 cattle were processed at the plant, with a relatively even split between Southland and Otago/Canterbury. Approximately 230 twenty foot equivalent unit (TEU) containers of meat and meat products were shipped from the plant through SouthPort in 2017/18.

2.7 Alliance has analysed the advantages of retaining processing capacity at the Mataura plant relative to other potential new sites and/or the expansion of other existing plants. The key advantages are:

(a) The continued use of existing plant and equipment having significant sunk costs;

(b) Sufficient livestock production in the immediate area and wider surrounding catchment;

(c) Optimised location from the perspective of livestock and processed products' transportation;

(d) The proximity of a trained and experienced workforce;

(e) The proximity of supplier businesses with appropriate expertise and experience;

(f) The proximity of both road and rail networks for plant inputs and outputs;

(g) The availability of sufficient water supply from the Mataura River to enable livestock processing operations;

(h) The ability to discharge treated meat processing waste to the Mataura River and treated wastewater solids to land;

(i) The ability to minimise and mitigate adverse environmental effects for neighbours and the wider community;

(j) Few incompatible adjacent or nearby land uses;

(k) The site is large enough for any future expansion; and

(l) Economies of scale and scope as compared to relocating processing capacity to a number of alternative sites.

2.8 Consent renewals will enable Alliance and its supplier shareholders to continue to benefit from these economic advantages of the plant. Closure or downsizing of the plant due to consents not being renewed or being renewed with more stringent conditions would result in efficiency losses from reduced utilisation of existing assets, higher costs and reduced returns for Alliance's farmer shareholders. In addition there will be economic costs for the broader Gore and Southland communities. These are covered later in this report.

3. ECONOMICS AND THE RMA

Community Economic Wellbeing

3.1 Economic considerations are intertwined with the concept of the sustainable management of natural and physical resources, which is embodied in the RMA. In particular, Part 2 section 5(2) refers to enabling "*people and communities to provide for their … economic ... well being*" as a part of the meaning of "*sustainable management*", the promotion of which is the purpose of the RMA.

3.2 As well as indicating the relevance of economic effects in considerations under the RMA, this section also refers to *"people and communities"* (emphasis added), which highlights that in assessing the impacts of a proposal it is the impacts on the community and not just the applicant or particular individuals or organisations, that must be taken into account. This is underpinned by the definition of *"environment"* which also extends to include people and communities.

3.3 The continued operation of the Mataura plant enables the residents and businesses of Gore and the Southland region to provide for their social and economic wellbeing by retaining employment, incomes and expenditure within the local economy.

Economic Efficiency

3.4 Part 2 section 7(b) of the RMA notes that in achieving the purpose of the Act, all persons *"shall have particular regard to ... the efficient use and development of natural and physical resources"* which include the economic concept of efficiency[8]. Economic efficiency can be defined as:

> *"the effectiveness of resource allocation in the economy as a whole such that outputs of goods and services fully reflect consumer preferences for these goods and services as well as individual goods and services being produced at minimum cost through appropriate mixes of factor inputs".* [9]

3.5 More generally economic efficiency can be considered in terms of:

- Maximising the value of outputs divided by the cost of inputs;
- Maximising the value of outputs for a given cost of inputs;
- Minimising the cost of inputs for a given value of outputs;
- Improving the utilisation of existing assets; and
- Minimising waste.

3.6 The continued operation of Alliance's Mataura plant is consistent with the efficient use of resources, especially in regard to the ongoing use of significant existing assets, transport cost savings and the economies of scale in production available at the plant.

[8] See, for example, in *Marlborough Ridge Ltd v Marlborough District Council* [1998] NZRMA 73, the Court noted that all aspects of efficiency are "*economic*" by definition because economics is about the use of resources generally.
[9] Pass, Christopher and Lowes, Bryan, 1993, *Collins Dictionary of Economics* (2nd edition), Harper Collins, page 148.

Value of Investment to the Existing Consent Holder

3.7 Part 6, section 104 (2A) of the RMA requires the consent authority when considering a renewal of an existing consent to *"have regard to the value of the investment of the existing consent holder."* The value to Alliance of its investment in the Mataura plant can be considered in terms of either the insured value of the plant ($225 million) or the foregone future earnings of the plant if it was forced to close. By both of these measures, the value of the Mataura plant is significant to the existing consents' holder.

Viewpoint

3.8 An essential first step in carrying out an evaluation of the positive and negative economic effects of the granting of consent renewals is to define the appropriate viewpoint that is to be adopted. This helps to define which economic effects are relevant to the analysis. Typically a district (or city) or wider regional viewpoint is adopted and sometimes even a nationwide viewpoint might be considered appropriate.

3.9 The Mataura processing plant is located in the Gore District, which is part of the Southland region. Therefore in this report the economic effects are considered in relation to the Gore District and the Southland region.

3.10 There are also private or financial benefits associated with the granting of consent renewals. Generally these benefits are not relevant under the RMA and the main focus of this report is therefore on the wider economic effects on parties other than Alliance and its customers. Economists refer to such effects as "externalities"[10].

3.11 However, Alliance is owned by its farmer shareholders and financial benefits to Alliance impact on the *"economic (and social) well being"* of these farmer shareholders including those within the local community – i.e. the Southland region. Increased returns to (or reduced costs for) farmer shareholders in Southland will flow through to increased expenditure, employment and incomes within the Gore and Southland economies, as a consequence of increased

[10] Defined as the side effects of the production or use of a good or service, which affects third parties, other than just the buyer and seller.

disposable income for local farmer shareholders. Also financial benefits to Alliance are relevant with respect to the *"efficient use and development of natural and physical resources"* and New Zealand's export competitiveness, given the Mataura plant's significant scale and the importance of meat and meat product exports to the New Zealand economy.

4. BACKGROUND TO GORE DISTRICT AND SOUTHLAND REGION'S ECONOMIES[11]

4.1 Statistics New Zealand's June 2018 population estimate for Gore District is 12,500. In 2010 population in the District was estimated to be 12,400, implying growth of 0.8% over the period 2010 to 2018, as compared to growth of 12.3% for New Zealand as whole. Statistics New Zealand's 'medium' population projections[12] have Gore District's population decreasing to 11,450 in 2043 – i.e. an average rate of decline of 0.4% per annum over the period 2018-43, compared to an average rate of growth for New Zealand of 0.8% per annum.

4.2 Statistics New Zealand's June 2018 population estimate for the Southland region is 99,100. In 2010 population in the region was 94,700. The region's population over the period 2010 to 2018 has grown by 4.6%. Statistics New Zealand's 'medium' population projections have the region's population decreasing to 99,000 in 2043 – i.e. an average rate of decline of 0.01% per annum over the period 2018-43.

4.3 Employment data highlight the importance of the agricultural sector to the Gore District. In February 2018, 1,300 jobs (20.0%) of the District's 6,500 jobs were in the agricultural, forestry and fishing sector with agriculture and agriculture support services contributing 1,117 of these jobs or 17.2% of total employment in the District. Manufacturing contributed 960 jobs (14.8% of total jobs in the District)) with meat and meat products manufacturing contributing 610 of these jobs. Other significant sources of employment within the Gore District are retail trade (960 or 14.8% of total employment), health and social assistance (500 jobs, or 7.7% of

[11] Data in this section from Statistics New Zealand NZ Stat.
[12] Statistics New Zealand prepare three sets of projections – high, medium and low – according to natural population change (i.e. the net effect of birth and death rate assumptions) and net migration assumptions. These projections do not explicitly incorporate assumptions about different rates of economic development.

total employment), healthcare and social services (500 jobs or 7.7% of total employment), and education and training (450 or 6.9% of total employment).

4.4 For the Southland region in February, 2018 there were 49,400 jobs. Agriculture, forestry and fishing with 8,370 jobs (16.9% of total employment) and manufacturing with 8,000 jobs (16.2% of total employment) are the two largest sectors. Within agriculture, forestry and fishing, agriculture and agriculture support services accounts for around 7,141 or 85.3% of these jobs including 2,750 in dairy farming and 2,200 in sheep, beef cattle and grain farming. Within manufacturing, there are 4,750 jobs in food product manufacturing including 3,600 jobs in meat and meat products manufacturing and 630 jobs in dairy products manufacturing. Other important sources of employment for the Southland region are retail trade (5,100 jobs or 10.3% of total regional employment), health and social assistance (4,750 jobs or 9.6% of total regional employment), accommodation and food services (3,450 jobs or 7.0% of total regional employment) and education and training (3,350 jobs or 6.8% of total regional employment). However these service sectors are to a large extent "driven" by the economic activity generated by the so called "economic drivers" of the region – principally agriculture and agricultural product processing and the Tiwai point aluminium smelter. Taken together agriculture, food product manufacturing and the Tiwai Point aluminium smelter directly account for about 27% of total employment in the region. With the inclusion of the flow on, or "multiplier" effects, (see next section of this report), these industries generate around 48% of total employment in the region.

5. ECONOMIC BENEFITS FROM CONSENT RENEWALS

Maintaining Economic Activity within the District and Regional Economies[13]

5.1 The Mataura meat processing plant employs up to 500 full time salaried staff and seasonal workers at the peak. This equates to 340 full time equivalent staff (FTEs). Alliance's Mataura plant pays out $22 million in wages and salaries per annum and spends an estimated additional $12.3 million per annum in the Southland region on goods and services. Goods and services to the plant provided by local firms include transport, engineering, plumbing, electrical and

[13] Unless stated otherwise data in this section provided by Alliance.

security contractors; packaging suppliers; utilities (electricity and telecommunications); providers of medical services and supplies (doctors, physiotherapists, drug testers and other healthcare service suppliers); professional service suppliers; and providers of laboratory equipment and materials, clothing, fuels, knives and food.

5.2 These are the direct economic impacts for the Southland region's economy from the plant's operation.[14]

5.3 However in addition to these direct economic impacts there are indirect impacts arising from:

a. The effects on suppliers of goods and services provided to the plant from within the region (i.e. the "forward and backward linkage" effects); and

b. The supply of goods and services from within the region to employees at the plant and to those engaged in supplying goods and services to the plant (i.e. the "induced" effects). For example, there will be additional jobs and incomes for employees of supermarkets, restaurants and bars as a consequence of the additional expenditure by employees directly employed at the plant.

5.4 Multipliers can be estimated to gauge the size of these indirect effects. The size of the multipliers is a function of the extent to which an area's economy is self-sufficient in the provision of a full range of goods and services and the area's proximity to alternative sources of supply. Multipliers typically fall in the range of 1.5 to 2.0 and taking the mid-point of this range (i.e. 1.75) implies total impacts (i.e. direct plus indirect impacts) of:

- 595 FTE jobs for local Southland residents; and
- $38.5 million per annum in wages and salaries for local Southland residents.

[14] No account is taken in this section of the direct and indirect economic impacts of cattle farming within the region. Cattle farming will in general not be affected by whether the resource consents are renewed – i.e. livestock produced within the region are assumed to be diverted to other meat processing plants if consents are not renewed. However to the extent the non-renewal of consents or stricter consent conditions add costs to meat processing, farmers will be impacted as a consequence of lower payments for livestock.

5.5 The Gore District and Invercargill City are the areas of the region that benefit most from the additional economic activity generated by the ongoing operation of the Mataura plant.

Economic Benefits from Increased Economic Activity

5.6 As indicators of levels of economic activity, economic impacts in terms of increased expenditure, incomes and employment within the local economy are not in themselves measures of improvements in economic welfare or economic wellbeing. However, there are economic welfare enhancing benefits associated with increased levels of economic activity. These relate to one or more of:

a. Increased economies of scale: Businesses and public sector agencies are able to provide increased amounts of outputs with lower unit costs, hence increasing profitability or lowering prices;

b. Increased competition: Increases in the demand for goods and services allow a greater number of providers of goods and services in markets and there are efficiency benefits from increased levels of competition;

c. Reduced unemployment and underemployment[15] of resources: To the extent resources (including labour) would be otherwise unemployed or underemployed, higher levels of economic activity can bring efficiency benefits when there is a reduction in unemployment and underemployment. The extent of such gains is of course a function of the extent of underutilized resources within the local economy at the time and the match of resource requirements and those resources unemployed or underemployed within the local economy; and

d. Increased quality of central government provided services: Sometimes the quality of services provided by central government such as education and health care are a function of population levels and the breadth and quality of such services in a community is higher with higher levels of economic activity, particularly to the extent they lead to or maintain higher levels of population.

[15] Underemployment differs from unemployment in that resources are employed but not at their maximum worth; e.g. in the case of labour, it can be employed at a higher skill and/or productivity level, reflected in higher wage rates.

5.7 The Mataura meat processing plant gives the Gore District greater critical mass and as a consequence the residents and businesses within the District benefit from economies of scale, greater competition, increased resource utilisation and better central government provided services. This is also true for the Southland region, although to a lesser extent given the economic activity generated by the plant is proportionately less for the region as compared to the Gore District.

Economic Efficiency Benefits from Optimising Plant Location

5.8 There are a number of economic efficiency benefits from Alliance obtaining consents to enable the continued operation of the Mataura plant at its current site. These have been listed earlier in section 2 of this report and include the continued use of existing plant and equipment with an insured value of $225 million,[16] the minimisation of transport costs (and carbon footprint) for livestock and finished product dispatch, the availability of a trained and experienced workforce and businesses with appropriate expertise and experience within close proximity of the plant, and economies of scale and scope as compared to re-locating processing capability to a number of alternative sites.

5.9 The Mataura plant provides Alliance with its cattle processing capacity in Southland and farmers would need to truck cattle out of the region for processing if the Mataura plant's processing capacity for cattle was reduced. There is insufficient capacity at other plants within the region to handle cattle processed at the Mataura plant. This would add to farmers' costs, reduce their disposable incomes and reduce spending in the Gore District and elsewhere within the region.

5.10 Alliance is seeking renewal of consents for a minimum period of 35 years. There are also economic efficiency benefits associated with consents being renewed for a longer term as compared to short term (e.g. 10 year) consent renewals. Longer term consent renewals not only save more frequent consent renewal costs, but also provide greater certainty for investment in and management of the plant.

[16] In addition to the economic efficiency benefits from the continued use of plant and equipment having an insured value of $225 million, Alliance's significant investment in the Mataura plant is also relevant in terms of Part 6, section 104 (2A) of the RMA, which requires regard to be given to value of the investment of the existing consent holder.

5.11 Maintaining these economic efficiency benefits is consistent with *"the efficient use and development of natural and physical resources"* (Part 2, section 7(b) of the RMA) as well as enabling *"people and communities to provide for their economic and social wellbeing"* (Part 2, section 5(2) of the RMA).

Greater Economic Resilience for the Gore District and the Southland Region

5.12 As discussed earlier in this report, both the Southland region and the Gore District are significantly dependent upon the agricultural sector, especially sheep and beef cattle and dairy farming. Therefore the Mataura plant helps provide greater diversity and balance to the two economies. Although it involves the processing of livestock, having livestock processing manufacturing capacity within the region provides employment opportunities and incomes less dependent upon returns to the agricultural sector. This makes the Gore District and Southland economies more resilient to agricultural commodity price cycles.

Rates Income to the Gore District Council and Environment Southland

5.13 The Mataura plant pays $238,000 per annum in rates to the Gore District Council and Environment Southland.The plant also pays out $13,000 per annum in consent fees. Whilst these payments are for services provided by the Councils and from which Alliance and its employees benefit, economies of scale mean that should the Councils lose this income, the range and quality of services provided by the Councils would diminish and/or payments by other ratepayers in the District and region would need to increase.

Community Sponsorship Programmes

5.14 In recognition of the important role the community plays in helping Alliance realise its potential, the company provides financial support to a number of initiatives at the community and national level. In the year to 30 September, 2018 the Mataura plant made grants totalling around $11,000 to various community organisations.

6. CONCLUSIONS

6.1 The granting of consents enabling the continued operation of the Mataura meat processing plant will maintain the economic wellbeing of people and communities within the Gore District and the Southland region by:

(i) Maintaining significant direct and indirect employment opportunities for local residents;
(ii) Maintaining significant direct and indirect wages and salaries for local residents;
(iii) Maintaining significant levels of direct and indirect expenditure with local businesses;
(iv) Maintaining population and economic activity levels within local communities thereby maintaining the breadth and quality level of services available to local residents and businesses;
(v) Providing greater employment choice for local residents;and
(vi) Continuing Alliance contributions to local community activities, in its role as a responsible employer and "good corporate citizen".

6.2 The granting of consents sought for the Mataura plant will maintain resource use efficiency by enabling:

(i) The continued use of existing plant and equipment with significant sunk costs;
(ii) The minimisation of transport costs for livestock and finished product dispatch;
(iii) The continued utilisation of a trained and experienced workforce and businesses with appropriate expertise and experience within close proximity of the plant;
(iv) The continued benefits from economies of scale and scope as compared to re-locating processing capability to a number of alternative sites; and
(v) The maintenance of population and economic activity levels (or "critical mass") in the Gore District and the Southland region, thereby providing economies of scale and competition in the local provision of goods and services.

6.3 The Mataura plant has an insured value estimated at $225 million. Therefore its value to Alliance (the existing consents' holder) is very significant.

E

APPENDIX E

Consultation Summary Document

MATAURA PROCESSING PLANT – RESOURCE CONSENT APPLICATIONS TO DISCHARGE CONTAMINANTS AND ODOUR TO AIR

Overview

Alliance Group Limited (Alliance) owns and operates the Mataura Meat Processing Plant (the Plant) on the true right bank of the Mataura River in the Mataura township.

Alliance is a farmer owned cooperative and the Plant is a vital component of Southland's agricultural sector – processing stock from the region. It is also a vital component of the local and regional economy, employing approximately 500 people in the peak of the season and contributing approximately $164 million per year to the economy (mostly in livestock payments) and approximately $30 million per year for wages and salaries for the 2018/2019 season.

The Plant currently operates under 10 resource consents issued by Southland Regional Council (Environment Southland) and/or Gore District Council (District Council). The resource consents authorising the discharge of contaminants and odour to air expire in December 2020. Alliance will be lodging applications for replacement consents in September. Alliance lodged applications to replace the resource consents authorising the Plant's take and use of water from the Mataura River, and discharge of treated wastewater and cooling water to the Mataura River in 2019, and those applications are currently being processed.

The continued operation of the Plant is completely reliant on securing replacement resource consents to authorise these key activities.

The Plant's Discharges to Air

There are two main discharges to air at the Mataura Plant which need to be authorised by resource consents:

- Discharge of the products of combustion from the Plant's two operative boilers (with an additional back-up boiler) which are used to provide steam and heat for the Plant's operation; and
- Discharges of odour from production activities.

Boiler Discharges

Existing activities

The Plant currently operates two boilers onsite:

- A 9,400 kW Babcock and Wilcox spreader stoker boiler at the main Plant (the Main Boiler); and
- A small 923 kw Boag spreader stoker boiler at the hide salting plant.

There is also a backup spreader stoker boiler (3,800 kW) to the Main Boiler.

Alliance commissioned Golder Associates (Golder) to review ambient air quality in Mataura, and the contribution of emissions from the Plant's boilers to that air quality. Golder identified ambient levels of fine respirable particulate matter (PM_{10} / $PM_{2.5}$) as the key issue for ambient air quality in Mataura and the key issue for the boiler discharge. Golder identified no other air quality parameters of concern in Mataura.

Ambient PM_{10} monitoring programmes by Environment Southland and Alliance have previously indicated the Mataura airshed complies with the National Environmental Standards (**NESAQ**) for PM_{10}. However, to inform these consent applications and the long-term plan for thermal plant onsite Golder conducted additional monitoring of ambient PM_{10} and $PM_{2.5}$ between March and early July in 2018. The Golder monitoring data, shown in Figure 1, indicates that ambient concentrations of PM_{10} and $PM_{2.5}$ are significantly elevated in the Township. It confirmed PM_{10} concentrations comply with the NESAQ limit, but that on occasion $PM_{2.5}$ breaches the relevant World Health Organisation (**WHO**) guideline which Ministry for the Environment (**MfE**) has foreshadowed will be incorporated in the NESAQ soon.[1]

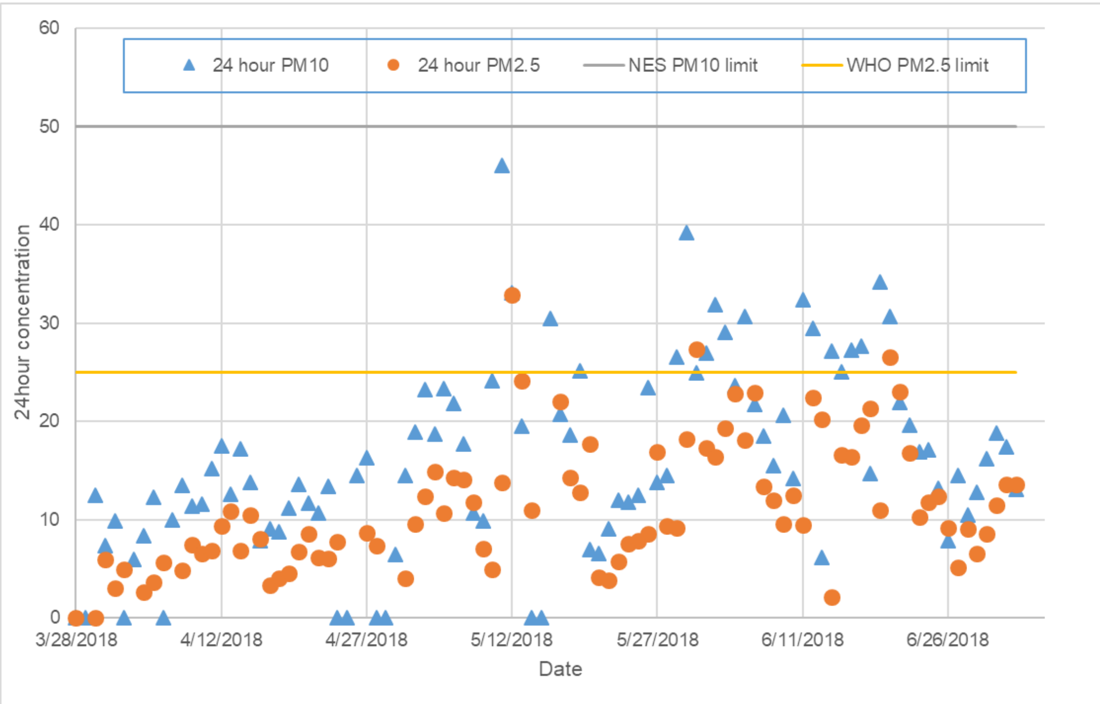

Figure 1: **Results of fine particulate monitoring in Mataura (measured close to the Southern Boundary of the Plant).**

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[1] Golder also completed monitoring at an elevated position on Hillview Crescent. No air quality issues were identified at that elevated location, with PM10 and PM2.5 concentrations measured well below the relevant guideline levels.

As part of its work Golder completed an analysis of relative contribution of different activities to the elevated particulate concentrations, including analysis of monitoring data and ambient air quality modelling. Key findings of the Golder assessment are:

- Ambient particulate levels in Mataura may be causing more than minor effects on the health of residents.
- For the most part elevated PM_{10} and $PM_{2.5}$ concentrations in Mataura occur on cold still days, and domestic fires are the dominant cause of those elevated concentrations. Good context to this is provided in the results of the ambient air quality modelling conducted by Golder which shows in these cold still conditions:
  - Ambient PM_{10} (Plant + background) at the residential dwelling in Mataura most impacted by the Plant's boilers would be 82% of the NESAQ, but the contribution of the Main boiler to those ambient PM_{10} concentrations would only be in the order of 5.5% of the NESAQ in these conditions; and
  - Ambient $PM_{2.5}$ (Plant + background) at the dwelling would be in the order of 120% of the relevant WHO guideline, but the contribution of the Main boiler to those ambient $PM_{2.5}$ concentrations would only be in the order of 8% of the WHO guideline in these conditions.
- In other meteorological conditions (i.e. not cold and still) the Plant's Main boiler can, on occasion, significantly increase ambient PM_{10} and $PM_{2.5}$ concentrations in Mataura. Thereby increasing the total number of days in the year when ambient levels of fine particulate in Mataura are high and air quality is degraded. Of relevance here, is that the Golder report identifies the Main Boiler as the likely cause of one of the exceedances of the 24 hour $PM_{2.5}$ WHO guideline recorded on the Plant's southern boundary during Golder's ambient monitoring programme in 2018 (see Figure 1 above). The Golder modelling also shows the Main Boiler can cause the most elevated $PM_{2.5}$ concentrations in an area to the east of the Plant, which may, on occasion, approach, or exceed the WHO guideline, when combining with existing background levels of $PM_{2.5}$.
- The hide salting plant produces minimal air quality effects within the rural area of Mataura and that it has no substantive cumulative impact upon air quality effects caused by the Main Boiler.

Alliance acknowledges ambient particulate levels in Mataura are elevated to concerning levels, the Main Boiler is a significant contributor to ambient PM_{10} and $PM_{2.5}$ levels in Mataura at times, and the emissions control technology on the Main boiler can be improved, so it commissioned DETA consulting to identify options for the company to do its part in reducing ambient levels of respirable particulate matter in Mataura's ambient air.

Proposed options

Two viable options were identified by DETA consulting and Alliance:

- Installing a new bag house filter on the Plant's Main boiler (Option 1); or

- Decommissioning the Plant's main boiler and replacing it with a new 8 MW biomass fired boiler (BFB) (Option 2).[2]

Both options contain best practice emissions control technology for fine particulate matter and would **reduce the particulate emission rate from the Main Boiler by approximately 85%**.

Golder has modelled the effects of the Plant operating following upgrade of its Main Boiler with the two options above. The key findings of the Golder modelling are:

- In cold still conditions, when the background quality is poorest, ambient air quality would remain degraded in Mataura due to the impact of domestic fires, but the contribution of the Main Boiler in those ambient concentrations would be reduced and minimal. For example, in these conditions at the most impacted residential dwelling in Mataura the modelling predicts:
  - Ambient PM_{10} (Plant + background) at the dwelling would be in the order of 77% of the NESAQ for both the baghouse and BFB upgrade option and remain elevated, but the contribution of the Main boiler to those ambient PM_{10} concentrations would only be in the order of 0.5% (or less) of the NESAQ; and
  - Ambient $PM_{2.5}$ (Plant + background) at the dwelling would be in the order of 113% of the relevant WHO standard for both the baghouse and BFB upgrade option, but the contribution of the Main boiler to those ambient $PM_{2.5}$ concentrations would only be in the order of 1% (or less) of the WHO guideline.
- In other meteorological conditions the Main Boiler would no longer cause elevated particulate levels in Mataura. For example, in the meteorological conditions the Main Boiler is predicted to cause its highest level of impact, at the most impacted residential dwelling in Mataura (located east of the Plant):
  - Ambient PM_{10} (Plant + background) at the dwelling would be in the order of 33% of the NESAQ for both the baghouse and BFB upgrade option and comply with that standard, with the Main boiler only contributing PM_{10} concentrations in the order of 5% (or less) of the NESAQ in these conditions; and
  - Ambient $PM_{2.5}$ (Plant + background) at the dwelling would be in the order of 42% of the relevant WHO guideline for both the baghouse and BFB upgrade option, with the Main boiler only contributing $PM_{2.5}$ concentrations in the order of 10% (or less) of the WHO guideline in these conditions.

Alliance will be making applications for replacement consents on the basis that it will implement one of the two upgrade options identified by Golder early in the consent term and do its part to improve ambient air quality in Mataura.

Both upgrade options would require significant capital investment (approximately $5 million for Option 1 and $8.8 million for Option 2), and when combined with the capital investment Alliance has committed to spending on the Plant's wastewater system in the next 10 – 15 years, Alliance's total

[2] The BFB could be fired by woodchips or a combination of woodchips and wastewater solids from the Plant.

spend on improving the environmental performance of the Plant will be approximately $18.9 million to $23.7 million. Alliance will be seeking a 35 year term of consent to enable the requisite financial investment to be justified and secured over an appropriate timeframe.

Odour

Alliance acknowledges that odour effects are still of concern to some members of the local community. In turn, to inform these consent applications Alliance commissioned Golder to conduct a thorough review of the odour generated by the Plant and the mechanisms implemented to reduce that odour, and to identify opportunities to further reduce the levels of odour generated.

The Golder assessment was undertaken in accordance with The Ministry for the Environment's '*Good Practice Guide for Assessing and Managing Odour in New Zealand*' (MfE, 2016). It included an analysis of the historical complaints record for the site, a comprehensive 3 month odour diary programme (completed between 15 November 2019 and 22 February 2020 which involved community members who had previously complained about odour from the Plant), a site visit and review of emission control systems by Golder personnel, and application of expert knowledge of odour generating processes for sites of this kind.

Key findings of the Golder assessment are:

- There was a spike in complaints following installation of the new DAF solids decanter in August 2017, and a subsequent reduction in those complaints after Alliance reconfigured the Plant so that the most of the emissions from the DAF solids decanter were captured and ducted to the Main boiler;
- Alliance has continued to receive odour complaints in the period since the 2017 spike albeit at a lower level (up to 2 – 3 per month);
- These odour complaints, and the odour events recorded during the odour diary programme, are typically associated with the same meteorological conditions (light wind conditions) and likely to be caused by the same sources;
- While the odour effects of the Plant are likely to have reduced in recent years, the site may still be producing an excessive frequency of recognisable odour, which has more than minor potential effects for some individuals;
- Remaining odours associated with the DAF solids decanting activity is likely to be the key source of existing odour effects beyond the site boundary; and
- Two other sources of odour at the site associated with the storage and loadout of compost solids and rendering by products also likely contribute to the existing level of odour effects beyond the site boundary.

In turn Golder recommended that:

- Emissions from the DAF solids decanter centrate drain be extracted and treated using a biofilter to further reduce the odour associated with the DAF decanter process;

- Modification of the screened solids (compost solids) storage system, and removal of compost solids from site on a daily rather than the current less regular basis;
- Modification of the by-products storage and load out system, including additional ventilation and use of a biofilter to capture and treat odour emissions; and
- The Odour Management Plan be updated.

With successful implementation of these additional odour mitigation measures Golder concluded that the potential for off-site exposure to any short term unpleasant odour to be minor or less.

Alliance will include these process improvements as part of its applications.