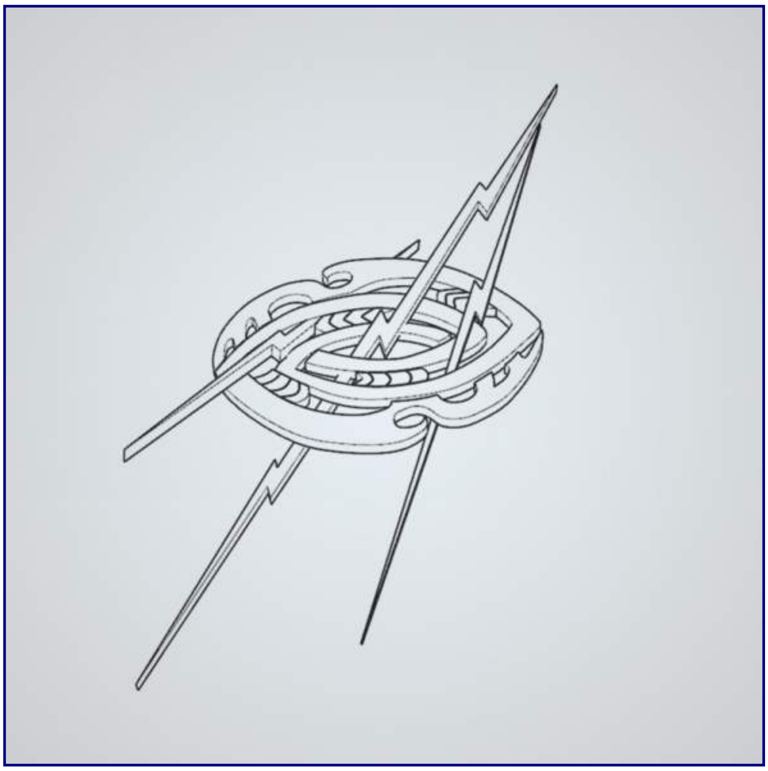
APPENDIX P

AIR QUALITY ASSESSMENT

GLOBAL CONTRACTING SOLUTIONS LTD

ASSESSMENT OF THE EFFECTS OF DISCHARGES TO AIR FROM AN RDF ENERGY PLANT



Technical Report
3263.02R001
November 2021

TBC Terry Brady Consulting Ltd
Air Quality and Air Pollution Science

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LIST OF ABBREVIATIONS

µg	One millionth of a gram
$\mu g\ m^{-3}$	A concentration of one microgram in one cubic metre of air
µm	Micron. One millionth of a metre
2,3,7,8-TCDD	2,3,7,8 tetrachlorodibenzo-p-Dioxin
AAQG	Ambient air quality guideline
$Am^3\ sec^{-1}$	Actual flow rate at operating temperature
CALMET	The meteorological model for CALPUFF
CALPUFF	A diagnostic computer model for predicting the dispersion of contaminants
CO	Carbon monoxide
CV	Calorific Value. The heat available from a fuel
DSI	Duct sorbent injection
FF	Fabric filter
fg	Femtogram. One thousandth of one millionth millionth
HCl	Hydrogen chloride
HF	Hydrogen fluoride
HHV	Higher heating value. The gross heat released during combustion
K	Temperature in degrees K (= °C + 273)
$kg\ hr^{-1}$	Mass rate in kilograms per hour
kW	kilowatt
LHV	Lower heating value. The nett heat released during combustion
LOD	Limit of detection
$m\ sec^{-1}$	Velocity in metres per second
MCR	Maximum continuous rating
MfE	Ministry for the Environment
mg	one thousandth of a gram
$mg\ m^{-3}$	A concentration of one milligram in one cubic metre of air
MJ	One million Joules
$MJ\ kg^{-1}$	One million Joules per kilogram
MSW	Municipal solid waste
MW	Megawatt
NES	National Environmental Standard
$Nm^3\ sec^{-1}$	Flow rate normalised to NTP
NO_2	Nitrogen dioxide
NOx	Total nitrogen oxides
NTP	Normalised temperature and pressure 0°C, 1 atmosphere pressure
O_3	Ozone

OEHHA	Office of Environmental Health Hazard Assessment, California
OLM	Ozone limiting method
PCDD	Polychlorinated di-benzo dioxin
PCDF	Polychlorinated di-benzo furan
pg	Picogram. One millionth millionth of a gram
PM_{10}	Particles less that 10 microns in diameter
$PM_{2.5}$	Particles less that 2.5 microns in diameter
ppm	A concentration of one part per million by volume
RDF	Refuse derived fuel
SO_2	Sulphur dioxide
TAPM	A prognostic meteorological and dispersion model developed by CSIRO
TEF	Toxic equivalence factor
TEQ	Toxic equivalence mass
TEQ m^{-3}	Concentration of toxic equivalence per cubic metre of air
TSP	Total suspended particulate
USEPA	United States Environmental Protection Agency
WHO	World Health Organisation
WRC	Waikato Regional Council

1 INTRODUCTION

Global Contracting Solutions Ltd. (GCS) propose to construct and operate a waste to energy plant at 401 Racecourse Rd in Te Awamutu. The plant will produce a refined fuel from municipal solid waste (MSW) that is commonly referred to as Refuse Derived Fuel (RDF), and this will be used to power two steam turbines to generate up to 15 MW of electricity to be fed into the National Grid. However the turbines will have the capacity to generate 20 MW of electricity if the plant is expanded in the future.

1.1 THE SITE

The proposed site is located in a rural/industrial setting at the northwestern end of Te Awamutu, is shown with blue border in Figure 1-1 and is zoned Specialised Dairy Industrial) in the operative Waipa District Plan. The existing racecourse to the east and northeast of the proposed site is zoned deferred residential and would therefore be considered sensitive to discharges to air. Likewise areas to the south are residential but immediately to the south and southwest are industrial.

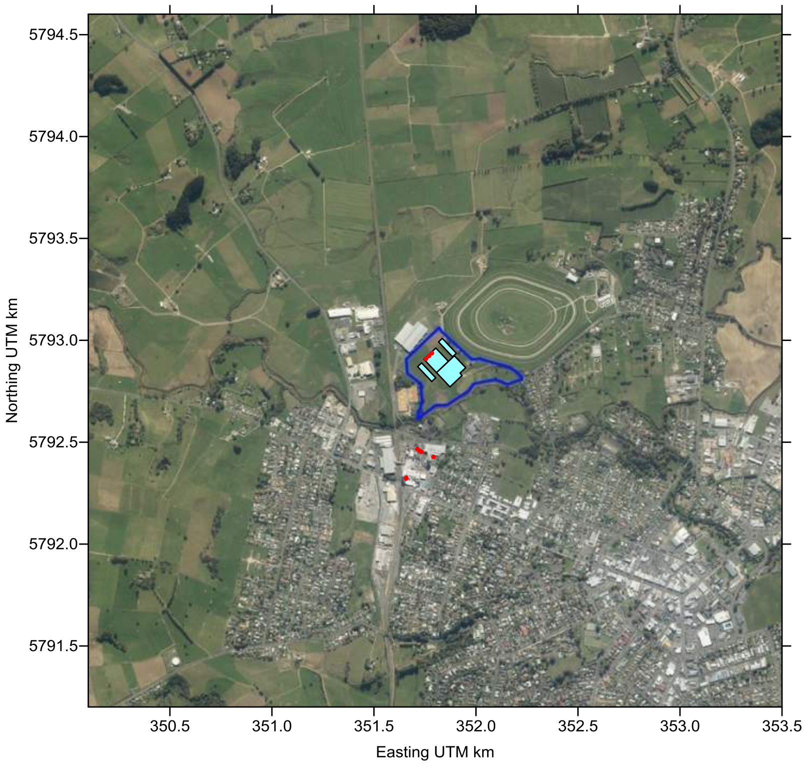

Figure 1-1 Site location The site is shown in blue outline with the discharge stacks, including those for nearby Fonterra, in red.

For the purposes of this assessment, the discharges to air e.g. particulate and trace gases are assessed equally in all land use zones as the assessment criteria do not differentiate between them.

With regard to potential odour discharges lower amenity would be expected in the industrial zone compared to the residential and rural zone, although residential zones that directly abut industrial zones should also expect to experience a somewhat lower amenity.

However in this instance all the zones are very close and both odour and dust control is required to meet the expectations of the most sensitive land uses, i.e. the existing residential and proposed/deferred residential zones that are close to the proposed site.

A conservative approach has been taken assuming the racecourse will be developed to where it abuts the subject site. This is however unlikely and in accordance with regional planning direction around separation of potentially incompatible land uses it is much more likely that a substantial setback will be imposed on residential development from the subject site.

1.1.1 Climate

No suitable local meteorological data is available for the Te Awamutu site, but as described in more detail in Section 4.1 a data set has been developed using the CALMET and TAPM models incorporating data from Hamilton Airport, the Metservice Waikeria station and plus data from an Agresearch station in Tokanui[1]. A wind rose for Te Awamutu generated by the CALMET is shown in Figure 1-2.

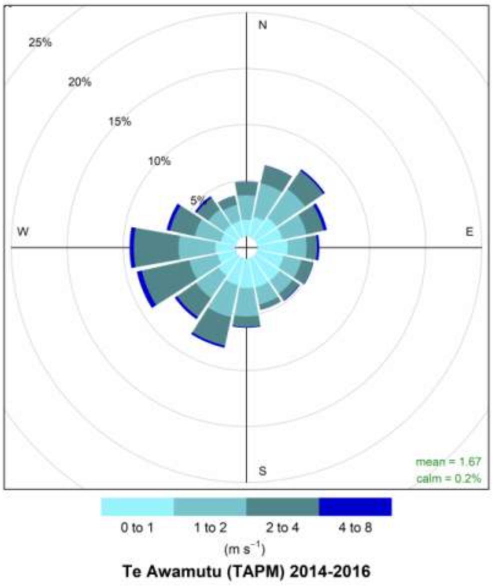

Figure 1-2. Wind Rose for Te Awamutu. A comparison with nearby meteorological stations is provided in Appendix D

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[1] Data kindly provided by Ag Research

The windrose is expected to be representative of Te Awamutu, and, not unexpectedly, shows a combination of features that are apparent in the Hamilton airport, Waikeria and Tokanui sites with the normally expected predominant winds from the west and southwest and to a lesser extent the northeast. The windrose also shows that there are no areas that are more likely to be affected by potential discharges than others as a result of direction specific weather.

1.2 STATUTORY REQUIREMENTS

The discharges to air in the Waikato Region are controlled under the existing Regional Plan that is administered by the Waikato Regional Council (WRC), and the Regulation 17 of the Resource Management Act (the Act) imposes additional controls on the WRC relating to the granting of discharge to air consents.

1.2.1 Waikato Regional Plan

The rules that control the discharges of contaminants to air in the Plan are set out in Chapter 6 of the operative Regional Plan, and the relevant rules are Rules 6.1.9.2 and 6.1.12.

> ***6.1.9.2 Discretionary Activity Rule – General Rule***
>
> *Except as provided for in any other rule in this Plan, the discharge of contaminants into air from:*
>
> *1. Any process or activity that is on an industrial or trade premises and is not*
>
> *permitted by or does not comply with Rules 6.1.9.1, 6.1.10.1 to 6.1.19.1; or*
>
> *2. A mobile source or premises that are not industrial or trade premises, and does not comply with Rules 6.1.9.1, 6.1.10.1 to 6.1.19.1*
>
> *is a* ***discretionary activity*** *(requiring resource consent).*

Rule 6.1.9.2 (1) specifically requires resource consent for activities that do not comply with Rules 6.1.9.1, 6.1.10.1 to 6.1.19.1, and in particular, Rule 6.1.12.1.

> ***6.1.12.1 Permitted Activity Rule – Combustion of Fuel for Heat Release***
>
> *The discharge of contaminants into air from burning the following fuels for the purpose of generating useful heat, steam, power or electricity:*
>
> *1. Natural gas and liquefied petroleum gas with a rate of heat release not exceeding* ***10*** *megawatts*

> *2. Wood and wood products (with the exception of wood that has been treated), paper and paper products with a rate of heat release not exceeding: i) five megawatts from activities lawfully established or authorised before the date of notification of this Plan ii) two megawatts from activities lawfully established or authorised after the date of notification of this Plan*
>
> *3. Diesel, kerosene, petroleum, coke, coal, charcoal, oil (excluding waste oil*) or non chlorinated alcohols with a rate of heat release not exceeding five megawatts*

There are two non-compliances of rule 6.1.12.1. Firstly the expected heat release is 22.8 MW per unit is greater than all the thresholds in clauses 1 to 3 for permitted activity status. Secondly, Rule 6.1.12.1 does not include the use of RDF as a fuel and Rule 6.1.9.2 therefore classes the discharges to as discretionary. A discharge to air consent will therefore be required.

In addition, it is also noted in the explanatory notes in the plan that the discharges from the combustion of refuse is specifically stated as being a discretionary activity as below.

> *Rule 6.1.9.2 provides for those discharges over which this Council wishes to retain control over through the resource consent process due to their potential adverse effects, but did not incorporate into a specific activity-based rule. In relation to industrial or trade premises, the discharges provided for under a discretionary activity rule includes, but is not restricted to, the following activities:*
>
> *a) Dry abrasive blasting not referred to in Rules 6.1.10.1, 6.1.10.2, 6.1.10.3 and 6.1.10.4.*
>
> *b) Combustion processes for fuel conversion not included in Rules 6.1.12.1 and 6.1.12.2.*
>
> *c) <u>Combustion processes involving fuel burning equipment, including flaring or incineration of trade wastes or refuse (including pathological waste incinerated at crematoria) not included in Rules 6.1.13.1 and 6.1.14.1.</u>*

While refuse is not defined in the plan, the normal interpretation would include RDF as refuse, since it is derived from it, and consent will be required for a discretionary activity.

1.2.2 Environmental Regulations and Guidelines

Regulation 17(1) of the Resource Management (National Environmental Standards for Air Quality)[2] Regulations 2004, limits the addition of PM_{10} into a *polluted air shed* to a maximum increment of 2.5 µg m^{-3}. However, Regulation 17(1) is not relevant to this assessment as Te Awamutu has not been gazetted as a "*polluted air shed*" for the purposes of the Regulation.

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[2] https://www.legislation.govt.nz/regulation/public/2004/0309/latest/DLM286835.html

Section 44B of the Act allows for Regional Councils to adopt more stringent guidelines or standards than the National Environmental Standards (NES's) and for some contaminants such as sulphur dioxide and nitrogen dioxide, the WRC has adopted additional guidelines that are not included in the NES's to determine compliance with the council policies and objectives. These are therefore included in this assessment and are set out in more detail in Section 5.8.

1.2.3 Policies and Objectives

Policies and objectives in the operative Regional Plan are intended to achieve integrated sustainable management of the natural and physical resources and are addressed in reports by Terra Consultants.

1.3 APPROACH TO THIS ASSESSMENT

The most suitable method of assessing the potential effects of the additional discharges from the activity is by way of computer dispersion models that can predict off-site levels of the contaminants, and these can then be compared to appropriate ambient air quality guidelines or standards that have been established to protect health and ecosystems.

For the majority of the contaminants comparison can be made with the NES's , New Zealand Ambient Air Quality Guidelines (NZAAQG), Waikato Regional Council AAQG's or alternative standards from other jurisdictions where none are available for New Zealand. Where compliance with these standards or guidelines is indicated, then it is generally accepted that the effects will be minimal. For discharges where there are no guidelines or standards, e.g. for fugitive odours, engineering solutions that have been proven to be successful in controlling the effects are adopted.

2 PROCESS DESCRIPTION

There are three principal parts to the process, namely reception of the raw materials into the facility, followed by preparation of the material into a refined RDF fuel that is suitable for combustion, and finally loading the RDF into the boiler to raise steam for use in the turbines that power electric generators.

2.1 RAW MATERIAL AND RECEPTION

The raw material feedstock will principally comprise municipal solid waste (MSW), plastics and pre-processed flock and tyres from GCS's metal recycling operations plus some additional material bought to the site by private contractors and the general public. Most of the material arriving at the site for will be pre-sorted and partially processed by GCS or other contractors so that it will be substantially free of putrescible and odorous material or greenwaste. This material is undesired for several reasons; not only for odour control but it also has a lower calorific value and higher moisture content which lowers the potential heat value of the fuel and performance of the operation.

There will be two reception areas for material, one on the upper level and another one on the lower level. A simple schematic is shown in Figure 2-1.

Material arriving via the upper level will have controlled door access into the initial manoeuvring area where it will be inspected to ensure that it is free from putrescible, odorous, greenwaste material or prohibited items such as batteries, gas bottles, liquids etc. Loads that contain these materials will be either fully or partially rejected and the reject material will be required to be removed from the site. Initially this will be by the individual presenting the material and latterly, the Paewira plant will provide enclosed bin methods for handling material that is unidentified at the inspection stage

Once inside the manoeuvring area the outer doors will close, and vehicles will reverse through an interior door to then tip material into the recycling plant building.

The two-door system provides an air lock that prevents any tipped material in the recycled area being of wind-blown and discharged through the main doors. This will essentially eliminate fugitive emissions of particulate and any slight residual odour which is not expected to be present due to the pre-sorting and screening of the raw materials.

Material arriving via the lower level will be in vehicles from the GCS's own operations as well as contract operators that supply the partially pre processed material such as flock or shredded tyres. Vehicles will traverse the entry road, down a private ramp and unload into the bunker through a controlled-door access.

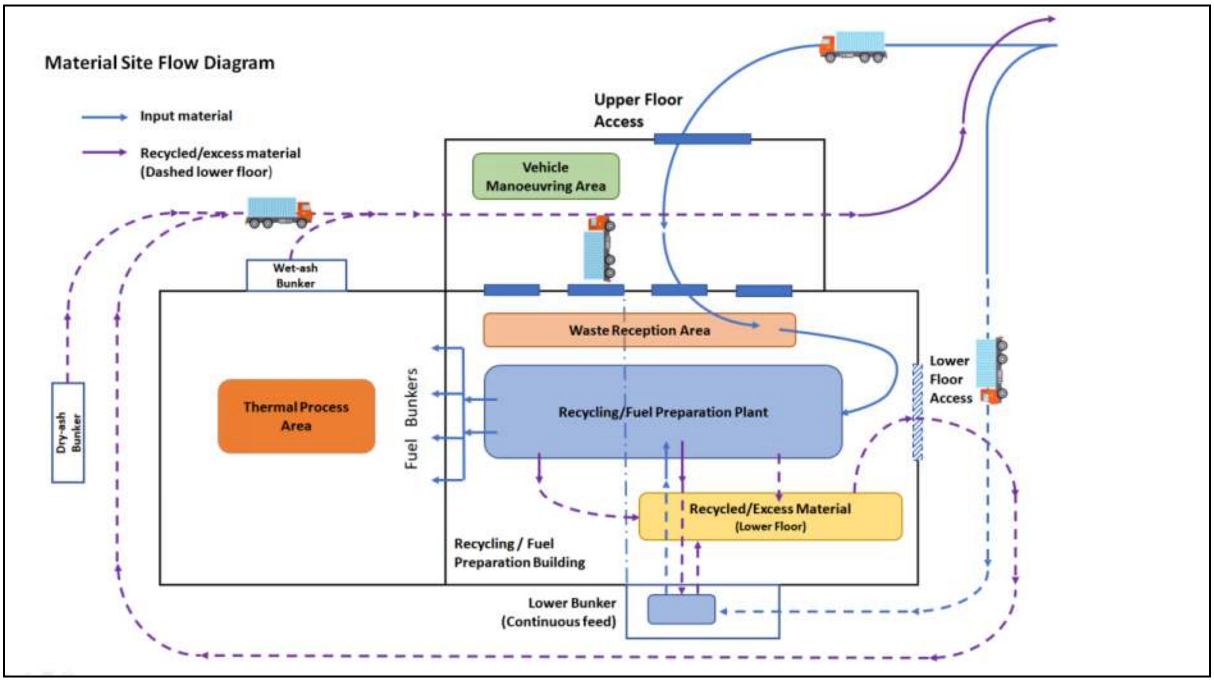

Figure 2-1. Vehicle access layout.

The pre-prepared material entering the lower floor part of the process will have minimal dust or odour potential and double doors are not necessary for dust control. Public access or non contracted vehicles will not be permitted in this area.

2.2 FUEL PREPARATION

Raw material arriving at the reception area is loaded into a hopper that directly feed into a coarse shredder that reduces the size to about 10 to 150mm depending on the material. The shredders operate at very low speed generally between 50 to 75 RPM and do not generate dust. After shredding it passes into a magnetic separator that automatically removes ferrous material, e.g. steel and iron, followed by screens that remove large items that are conveyed to the lower floor for manual inspection and sorting. These operations do not generate odour nor significant dust as the equipment used for these processes are enclosed.

The screened material then enters an air classifier (also called a windsifter) that removes heavy material such as stones and glass as well as some ferrous material that may have not been picked up in the previous magnetic sorter. The classifier works by gravity separation after the material is introduced into a continuous air stream. Heavy material including glass, ceramics, stones etc that falls out of the airstream is rejected and conveyed to the lower level for further manual sorting into recyclables or waste that is sent off-site for disposal. Most of the air stream in the separators is recycled through the machine but a portion is diverted to a fabric filter prior to discharge back into the workspace. This creates a partial vacuum inside the separator so that fresh air is continuously drawn in preventing dust and light material being discharged into the workspace.

The windsifter fabric filter is specified to control dust to less than 0.1 mg m^{-3} which is suitable for workplace environments that is limited to 3 mg m^{-3} for respirable dust[3] as an 8-Hr average.

After air separation, the material passes through another magnetic separator to remove any residual ferrous material and then finally through an eddy-current separator that removes non-ferrous metals such as aluminium, brass and copper etc. There is no dust generation from these operations as the material is not physically disturbed by the equipment as it passes through. Finally the finished RDF material is conveyed to the fuel bunkers in the thermal section of the building that houses the boilers and air pollution control equipment.

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[3] Workplace exposure standards and biological exposure indices EDITION 12-1. 2020 ISBN: 978-1-98-852748-2

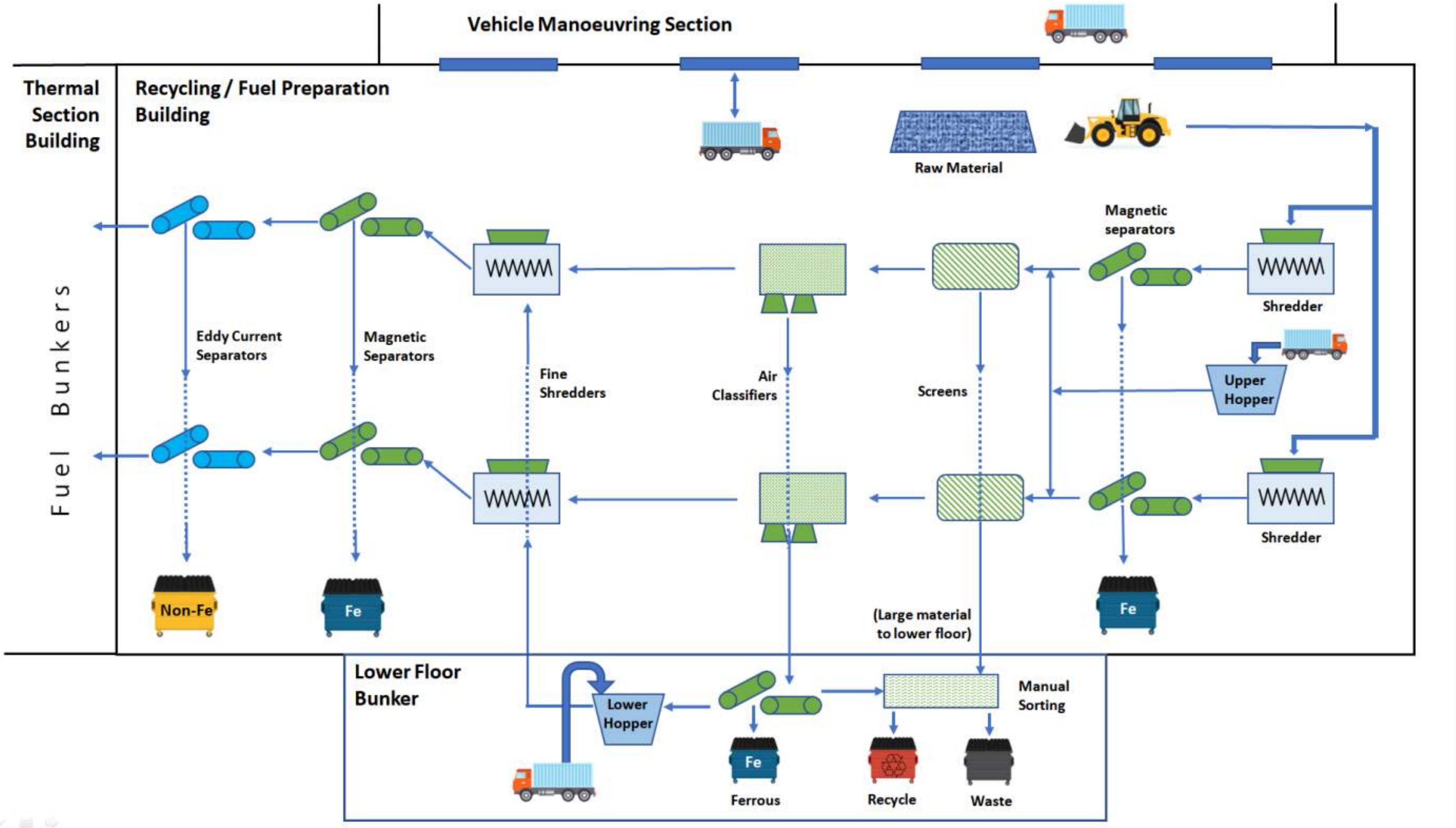

Figure 2-2. Simplified fuel processing.

2.3 THERMAL SYSTEM

A simple schematic of the post-combustion flue gas cleaning system is shown in Figure 2-3 and the individual items are discussed below. A more detailed diagram is provided in Appendix A that shows the fuel loading via a gantry claw grab.

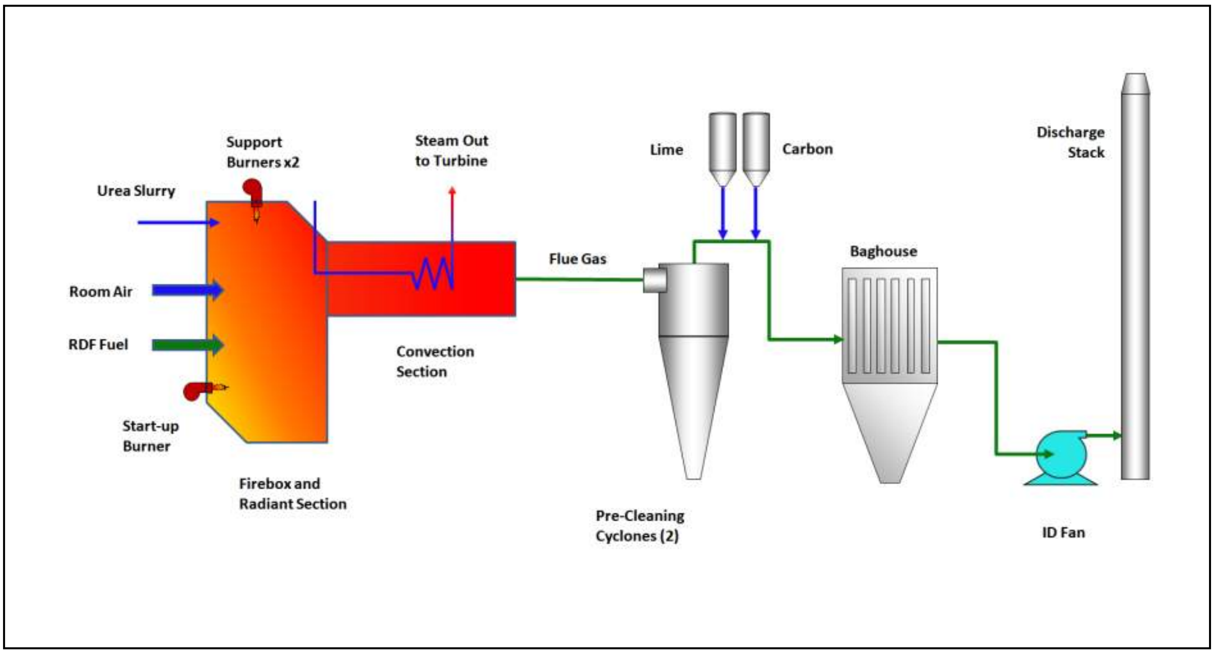

Figure 2-3. Simplified thermal section including flue gas cleaning

The thermal system consists of three parallel combustion and energy recovery lines burning RDF to produce superheated steam that is used to drive two steam turbines for heat and power production. There is capacity in the facility for the addition of a fourth line at some point in the future, for which consent would be separately sought. This assessment is based on three lines only

During start-up, combustion of the initial refuse charges is assisted with a 2 MW diesel package burner that is switched off once the combustion is self supporting and the firebox attains a stable temperature of 850 °C.

In addition to the start-up burner each unit is also equipped with two 6.25 MW supplementary diesel fired burners that can also be used during start up preheating or for short times when the calorific value (CV) of the RDF fuel temporarily drops below about 9 MJ kg^{-1}.

The reason for the supplementary firing in these low CV instances, rather than simply allowing the steam production and turbines to wind down, is that the steam turbines usually have a warm-up and warm-down period but more importantly they are required to operate at a fixed speed when driving the generator. Operating the boilers at a reduced load because of a temporary lowering of heat value in the fuel is therefore not an option. However, extended operation on supplementary firing is discouraged by the high price of using diesel and the costs of operation would not be recovered from the energy to be gained from selling the electricity.

2.4 FLUE GAS CLEANING

Combustion flue gases are passed through a four stage flue gas cleaning process that comprises the following items:

- Selective Non-Catalytic Reduction (SNCR)
- Sulphur Dioxide (SO_2) and other acid gases removal
- High molecular weight hydrocarbon and heavy metal removal
- Particulate removal

2.4.1 Selective Non-Catalytic Reduction (SNCR)

Nitrogen oxides (NOx) are removed in the SNCR process by the addition of a urea slurry into the firebox that reduces[4] the NO to inert nitrogen N_2 and lowers the total NOx emission by about 30%. Any small amounts of urea solids that exit the firebox are collected in the particulate removal filter.

2.4.2 Sulphur Dioxide (SO_2) and other acid gases removal

Sulphur dioxide and other acid gases that include hydrogen chloride (HCl) and hydrogen fluoride (HF) are absorbed using in-duct injection of hydrated lime ($Ca(OH)_2$) that reduces SO_2 by a factor of about 80% as well as some of the nitrogen dioxide (NO_2). This is referred to a dry sorbent injection (DSI). HCl and HF are also reduced to a level that meets the current emission limits for waste combustion in Germany[5].

2.4.3 High molecular weight hydrocarbon and heavy metal removal

Activated carbon is also added as an in-duct injection to remove higher molecular weight hydrocarbons e.g. dioxins and furans (PCDD/PCDF's) as well as heavy metals including mercury (Hg).

---

[4] The reverse of oxidation

[5] Directive 2010/75/eu of the European Parliament and of the Council of 24 November 2010.

2.4.4 Particulate removal

Particulate material in the flue gases, including fine particulate that is discussed in more detail in Section 3.2, is firstly removed in twin high-efficiency pre-cleaning cyclones that remove large particles using centrifugal action followed by high performance fabric filters in a reverse pulsejet baghouse. A proposed particulate emission concentration of 15 mg m^{-3} represents better performance than that which is normally applied to fabric filter controlled discharges.

The baghouses will be fitted with broken bag detectors that will warn if there is bag leakage or failure. These will be alarmed and logged in the process data logging system. In the event that an alarm is triggered and found to be genuine the appropriate RDF furnace will be shut down until the baghouse is repaired as soon as is practicable.

2.5 ASH REMOVAL

Ash is removed from underneath and at the end of the grate using a wet ash collection system that eliminates fugitive dust.

3 DISCHARGES TO AIR

Discharges to air arise primarily from the RDF boilers that comprise the normal products of combustion plus trace amounts of metals that arise from both biomass components and other components of the fuel such as reclaimed tyres and flock. In addition to the main discharges from the boilers there is a very low potential for the discharge of odour from the RDF reception and processing part of the operation, but this will be controlled to the extent that no significant odour is expected to be discharged.

The discharges to air that are considered in this assessment include:

- Particulate PM and PM_{10}
- Sulphur Dioxide SO_2
- Nitrogen Oxides NOx
- Carbon Monoxide CO
- Trace elements
- Dioxins and Furans
- Dust
- Odour

These discussed in more detail in Sections 3.2 to 3.11.

3.1 BOILER OPERATION

The rate of flue gas and contaminant discharges are dependent on quantity of fuel burned that is in turn determined by the both the overall boiler efficiency[6] and the calorific (CV) value of the fuel that can typically vary between 10 to 15 MJ kg^{-1} on an "*as fired*" Lower Heating Value (LHV) basis.

Normal operation, specified by the manufacturer is for a fuel LHV of 12 MJ kg^{-1} and a lower limit that would be normally expected of 10 MJ kg^{-1}. While in theory the LHV can go as low as 9 MJ kg^{-1} this would indicate the worst case scenario that would require remedial action at the fuel preparation stage. This not considered to be normal, and the use of lower LHV fuel runs the risk of needing supplementary diesel firing that is also not desirable.

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[6] Total of the combustion and thermal efficiencies

For this assessment an analysis based on experience at other existing installations was carried out by the manufacturer to determine the operational scenario that could give rise to the most probable maximum fuel consumption and therefore higher flue gas flow rates and emissions, as well as the nominal values. It was determined that operation with fuel having a LHV of 10 MJ kg and a relatively low overall boiler efficiency was considered the worst case that could reasonably be expected.

The discharge parameters used in the assessment for each boiler are shown in Table 3-1, and are based on the each of the three units operating at 100% MCR, a LHV of 10 MJ kg^{-1} and a very low boiler overall efficiency[7] of 72%. Further details provided in Appendix B also show the lower discharge rates and exit velocity for normal conditions with 12 MJ kg^{-1} rated fuel. However for this assessment, the lower rated fuel and low efficiency is used to ensure that the emissions and therefore the potential off-site effects are not under-estimated.

Table 3-1
Discharge Parameters per Boiler Used for Assessment

Parameter	Value	Units
Stack Height	38	m
Exit Diameter ID	1150	mm
Fuel LHV	10	MJ kg^{-1}
Flue Gas O_2	6	%
Heat Release	23.3	MW
Fuel Consumption	8385	kg hr^{-1}
Exit Temperature	175	°C
Flue Gas Flow Rate (actual)	62580	Am^3 sec^{-1}
Flue Gas Flow Rate (at NTP)	31122	Nm^3 sec^{-1}
Exit Velocity	16.7	m sec^{-1}

Flue gas flow rates are determined from the fuel ultimate analysis provided by the boiler manufacturer that are based on the expected MSW composition. The residual O_2 in the flue gases is normally controlled to 6% and this has therefore been chosen as the reference level for specifying emission concentrations in the flue gases.

Under normal operation, the actual flue gas temperature is expected to be closer to 180 °C but may dip at times depending on the load, the heating value of the fuel and excess air ratio in the final flue gas.

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[7] Boiler efficiency would normally be expected to be close to 80% or better.

The use of a lower temperature in the off-site model predictions will slightly over-estimate the potential effects due to lower plume buoyancy.

Each boiler stack will terminate at least 3 metres above the top of the main processing building (35 m) that includes the boilers and flue gas cleaning equipment (cyclones, and baghouses). The stack locations are shown in Figure 3-1 together with the six discharges from the Fonterra facility (not all are visible as they are very close to each other) to the south of the site as described in a recent assessment report by Tonkin and Taylor[8]. A More detailed plot is provided in Appendix C.

Figure 3-1 Stack Discharge Locations Coordinates are Universal Trans Mercator (UTM).

3.2 PM$_{10}$ AND PM$_{2.5}$ EMISSIONS

Total particulate discharges (TSP) have been provided by the manufacturer's specification for the proposed plant that meets the emission standards for waste combustion in Germany. However the fractions of either PM$_{10}$ or PM$_{2.5}$ are not available.

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[8] Tonkin and Taylor Ltd 22 April 2020. Application to change condition of Air Discharge Permit 119187 - Fonterra Te Awamutu

The USEPA emission factors for various combustion sources that are provided in the AP-42 emission factor documentation[9] include refuse (MSW) combustion, but also does not include a particle size distribution for total particulate emissions. The closest alternative that would be similar is that for fabric filter controlled woodwaste combustion that cites PM_{10} as 74% of total particulate (TSP) and $PM_{2.5}$ as 65% that are similar to many other fabric filter controlled discharges including the USEPA factors for coal combustion[10]. The European Environment Agency Guidebook[11] 2019 lists an emission factor of for PM_{10} as 74% of TSP and 50% for $PM_{2.5}$ that is then used to calculate the emission according to the control system.

The manufacturer has specified the maximum total particulate (TSP) emission concentration of 10 mg Nm^{-3} (dry gas 11% O_2) in the exit flue gases that is based on the current German limits for waste fired boilers that equates to 15 mg Nm^{-3} (dry gas 6% O_2).

While it is expected that the PM_{10} and $PM_{2.5}$ fractions in the discharge will be less than 100% it has been assumed for this assessment that all the particulate is $PM_{10}/PM_{2.5}$ so that there is no under-estimation of the potential effects.

3.3 SULPHUR DIOXIDE EMISSIONS

Sulphur dioxide is generated from the combustion of sulphur containing compound in the fuel such as rubber. The proposed system will absorb much of the SO_2, using the dry sorbent injection that reduces the concentration from about 540 mg Nm^{-3} to a level of no more than 75 mg Nm^{-3} (dry gas 6% O_2).

3.4 NITROGEN OXIDES EMISSIONS

Nitrogen oxides are generated in every combustion system and the primary source is the recombination of nitrogen and oxygen in the flame front and post combustion zones. The use of lime to control sulphur dioxide also results in a reduction in nitrogen oxides and the rates of discharge are based on the proposed emission concentrations listed in Table 3-2 where NO_2 is assumed[12] to be 5% of the total NOx.

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[9] https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-fifth-edition-volume-i-chapter-1-external-0

[10] epa.gov/sites/production/files/2020-09/documents/1.1_bituminous_and_subbituminous_coal_combustion.pdf

[11] European Environment Agency NFR 5.C.1.a SNAP 090201 Incineration of domestic or municipal wastes (without energy recovery) Version Guidebook 2019 https://www.eea.europa.eu/ds_resolveuid/4B1PO97HGU

[12] Ministry for the Environment. 2016. *Good Practice Guide for Assessing Discharges to Air from Industry.* Wellington: Ministry for the Environment.

3.5 HYDROGEN CHLORIDE

Hydrogen chloride (HCl) is generated in small quantities in the combustion process due primarily to the presence of salts and chlorine-containing components of the fuel, e.g wood, plastics etc. The emission rate is that guaranteed by the manufacturer based on the German emission limits.

3.6 HYDROGEN FLUORIDE

Similarly to HCl, hydrogen fluoride (HF) is generated in small amounts from salts and fluorine-containing material. The emission rate is that guaranteed by the manufacturer based on the German emission limits.

3.7 CARBON MONOXIDE EMISSIONS

Carbon monoxide is formed in small quantities in well tuned combustion systems, and the levels in the flue gases in the proposed boilers are expected to be no more than 50 mg Nm^{-3} (dry gas 11% O_2) or 75 mg Nm^{-3} (dry gas 6% O_2) as specified by the manufacturer.

3.8 TRACE METALS

The USEPA emission factors for MSW combustion[13] using dry sorbent injection and fabric filter control (DSI/FF) are similar to or less than those for wood combustion using fabric filters[14] except for mercury that is higher for MSW combustion. Assessments for trace metals not usually carried out for the low levels of discharges from wood combustion and therefore only mercury is considered to be potentially significant for this application.

The discharge rate of mercury is taken from the manufacturers guarantee based on the German maximum emission limits for waste combustion.

3.9 DIOXINS AND FURANS

All solid fuel combustion systems will discharge dioxins and furans (PCDD/PCDFs), as do domestic fires, school boilers, and motor vehicles and barbecues. The formation of dioxins in combustion processes depends primarily on four factors; the fuel being burned, the chlorine content of the fuel (if it is above about 2%), the temperature of combustion and the amount of excess air used in the combustor.

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[13] https://www.epa.gov/sites/production/files/2020-10/documents/c02s01.pdf

[14] https://www.epa.gov/sites/p1.6_wood_residue_combustion_in_boilers.pdf

Discharge rates for PCDD/PCDF's are taken from the USEPA DSI/FF controlled emission factors for RDF combustion that are given as a mass rate of emission which are converted to the more commonly used unit of Toxic Equivalent Quotient I-TEQ using a 1:50 ratio given in the USEPA document *Locating and Estimating Air Emissions from Sources of Dioxins and Furans*[15].

However the I-TEQ unit has now been superseded by the WHO-TEQ that is 10% higher[16] than the I-TEQ. The listed USEPA emission rates for RDF combustion have therefore been increased by 10% for this assessment. From here on, the levels of PCDD/PCDF's in WHO-TEQ units will simply be referred to as TEQ.

3.10 DUST

The main potential sources of dust and light airborne material are:

- Unloading raw material in the loading bay
- Loadout of screened material rejects
- Firebox ash handling
- Cyclone and bagfilter dust collection
- Lime, carbon and urea silo filling

All of these activities will be carried out within the main building that will operate under a negative pressure that is developed due to each of the boilers drawing approximately 12 m^3 sec^{-1} of air through the building. Combined with the tilt slab construction, rapid open/close doors the negative pressure generated within the building will be sufficient to contain all dust and airborne material.

However to maintain good housekeeping and a dust free environment in the building the standard dust control systems will be employed as below.

3.10.1 UNLOADING RAW MATERIAL IN THE LOADING BAY

As described in sections 2.1 and 2.2 dust and particulate discharges will be prevented by the use of a double door air lock system that prevents unloaded material being transferred from the processing area to the outside. In addition, the building will be kept under negative pressure due to the large amount of air that is drawn into the boilers at a rate of about 12 m^3 sec^{-1} per boiler making a total of 36 m^3 sec^{-1}.

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[15] EPA-454/R-97-003 Locating And Estimating Air Emissions From Sources Of Dioxins And Furans. Office of Air Quality Planning And Standards Office of Air And Radiation U.S. Environmental Protection Agency Research Triangle Park, North Carolina 27711 May 1997 https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=2000WMMG.TXT

[16] WHO Consultation May 25-29 1998, Geneva, Switzerland EXECUTIVE SUMMARY Assessment of the health risk of dioxins: re-evaluation of the Tolerable Daily Intake (TDI)

3.10.2 Loadout of screened material rejects

All reject and recycle material that is sent off site for disposal will be transported in covered trucks or bins to prevent particulate or dust discharges.

3.10.3 Firebox ash handling

Ash is collected using a wet ash sluice beneath the grates and conveyed to the wastewater handling system as a slurry. There will be no potential for dust generation from the ash.

3.10.4 Cyclone and Bagfilter dust collection

All baghouses will be fitted with temperature and pressure transmitters installed on the inlet and outlet ducts, broken bag detectors, differential pressure transmitter installed across the filter that is alarmed and logged in the data acquisition system and a hopper level switch that is alarmed to warn that it is approaching full.

Dust is discharged from the baghouse hopper to a covered skip via a rotary valve and shute that exits inside the skip so that there is no significant dust. Overfilling of the skip is possible but daily inspections will minimise it.

Finally, the baghouses and cyclones will be housed within the main building, virtually eliminating the potential for dust discharge.

3.10.5 Lime, carbon and urea silo filling

All silos will be fitted with quick coupling for truck connection and pneumatic gate valves for loading. They will include overpressure/under-pressure safety valves, overpressure/under-pressure rupture disks, high and low level switches to shut off the feed when tripped and extraction using rotary valve or reversible screws. Each silo will also include a roof mounted fabric filter to eliminate dust discharges during filling. Dust discharges from the silos is expected to be minimal.

As with the baghouses and cyclones, the silos will be housed within the main building eliminating the potential for dust discharge.

3.11 ODOUR

As described in section 2.1 most of the raw material will be pre-sorted to eliminate putrescible material and will have no odour. Additional checks will be made in the vehicle management area, and loads will be inspected for putrescible or odorous material and rejected if necessary. Combined with the negative pressure in the building and double door isolation, there is very little potential for odour discharge from the proposed operation. There will be no odour from the stack discharges as the combustion of material at temperatures of 850 °C or more in the presence of excess O_2 completely destroys odour.

3.12 SUPPLEMENTARY DIESEL FIRING

Discharges to air from firing on the supplementary burners are considerably less than for RDF. Appendix B shows a comparison of the principal species that are discharged for diesel that are on average about 1/6th of those for RDF. The effects assessment carried out for RDF firing is therefore adequate for assessing the times when the supplementary burners are used.

3.13 DISCHARGES TO AIR SUMMARY

A summary of the discharges to air that are used in this assessment is provided in Table 3-2. These are regarded as conservative due to the assumptions or low fuel heating value, low boiler efficiency and discharges at the maximum rate listed. Normal operation is expected to result in lower values than those listed.

Table 3-2
Emission Data per Unit

	Concentration mg Nm^{-3} Dry Gas 11% O_2	Concentration mg Nm^{-3} Dry Gas 6% O_2	Emission Rate kg hr^{-1}
Particulate TSP	10	15	0.47
Particulate PM_{10}	10	15	0.47
Particulate $PM_{2.5}$	10	15	0.47
Sulphur Dioxide SO_2	50	75	2.33
Nitrogen Oxides NOx as NO_2	150	225	7.00
Nitrogen Dioxide NO_2	7.5	11	0.35
Hydrogen Chloride HCl	10	15	0.47
Hydrogen Fluoride HF	1	1.5	0.05
Mercury Hg	0.03	0.045	0.0014
Carbon Monoxide CO	50	75	2.33
Dioxins and Furans PCDD/PCDF's	4.82E-14	7.23E-14	2.25E-09

Full details of the model inputs including those used for the Fonterra plant are provided in Appendix F.

4 MODEL DESCRIPTION

The assessment has been carried out using a standard dispersion modeling technique. The model chosen in this instance was CALPUFF although a simpler model would also have been suitable in this instance since the terrain in the near to intermediate dispersion field is relatively flat and the maximum predictions for regulatory purposes are dominated by building downwash effects that are determined using PRIME. However in this case, recent assessments[8, 53] that have been carried out for the nearby Fonterra dairy factory discharges were carried out using CALPUFF, and using this model ensures that the cumulative effects of both the proposed RDF plant and Fonterra are directly compatible. CALPUFF v 7.2.1 (Level 150618) was used for this assessment.

The CALPUFF modelling system comprises two modules. The first module CALMET is a meteorological model that takes local data and produces a data set for the second module CALPUFF that is a Lagrangian dispersion model that predicts the downwind concentrations of contaminants that are discharged into the atmosphere. The main advantage with CALPUFF over more simple models and the USEPA model AERMOD is that the plumes from a discharge follow and track the local terrain more realistically.

The model uses the emission rates for the species described in Section 3, and the building configuration together with detailed meteorological data to predict downwind concentrations that can be compared to the relevant ambient air quality standards or guidelines.

4.1 METEOROLOGICAL DATA

There is no meteorological data that is readily available for Te Awamutu, and the closest NIWA or Metservice stations are those at Hamilton Airport 15 km to the north, and Waikeria, 10 km to the south which only has data from 2016. However Ag Research in Ruakura has supplied TBC with 2014 to 2016 meteorological data for Tokanui about 8 km to the south.

CALMET date sets for the years 2014 to 2016 were prepared for this assessment as these are the only years for which WRC has carried out ambient air quality measurements in Te Awamutu for PM_{10} particulate that are suitable for inclusion as background levels. The background levels are used in the CALPUFF models to determine the cumulative air quality effects of the industrial sources when combined with the existing contributions from local motor vehicles and domestic fires etc. More details of the existing background air quality are provided in Section 5.

CALMET meteorological data was prepared by meteorologist Neil Gimson of NRG Science NZ, Wellington, that included data from Hamilton Airport, Waikeria meteorological station and the Ag Research Tokanui research farm with a grid resolution of 200m. A full description of the CALMET modelling used is provided in Appendix D.

4.2 MODEL CONFIGURATION

When stack discharges are located on or close to large buildings, there is an effect called building downwash where, at times, some of the discharge plume is bought down closer to the ground by the turbulence created in the lee of the building. Building influences were included in the model using the PRIME option to account for building downwash effects. A schematic view of the buildings included in the correction algorithms is provided in Appendix E.

Note that some of the final ancillary buildings may change slightly from those depicted but BPIP ignores them, even though they are included in the BPIP input, providing that they are less than 35m tall.

Dispersion parameters were determined using the internally calculated micro-meteorology dispersion coefficient option as recommended by Scire and Barclay[17], and all other model parameters were set to default. The full suite of model input configuration files can be made available on request[18]. The discharges were modeled assuming a constant emission rate 24/7 for 365 days. Receptors were defined with a 50m grid resolution.

4.2.1 Meteorological Data Choice

Although meteorological data was prepared for 2016 it was not used as there was only limited data for background PM_{10} levels that are used to assess the cumulative effects.

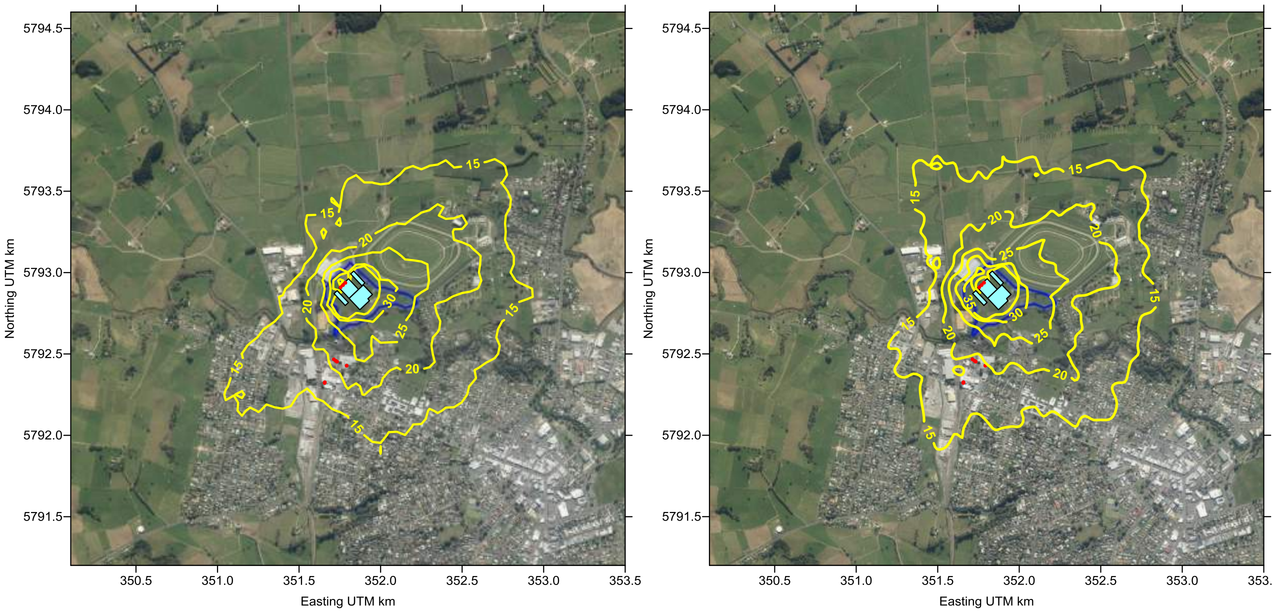

Figure 4-1. 99.9%ile 1-Hr predictions for SO_2 Left panel; predictions for 2014, right panel predictions for 2015

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[17] Generic Guidance and Optimum Model Settings for the CALPUFF Modeling System for Inclusion into the ‘Approved Methods for the Modeling and Assessments of Air Pollutants in NSW, Australia’ March 2011 Prepared For: NSW Office of Environment and Heritage, Sydney Australia Prepared By: Jennifer Barclay and Joe Scire Atmospheric Studies Group TRC Environmental Corporation 650 Suffolk Street, Wannalancit Mills Lowell, MA 01854 USA

[18] For non-regulatory parties, TBC and GCS reserve the right to provide or withhold this data.

CALPUFF was run for sulphur dioxide hourly predictions for the years 2014, 2015 to determine the most appropriate data for assessment purposes. Figure 4-1 shows the two plots for hourly SO_2 that are very similar but slightly higher in the residential zone to the south and southwest for the year 2014. Note also that in line with standard assessment guidelines[19], the 99.9th percentile is considered to be representative of the maximum prediction for hourly averages. For averaging times greater than one hour, the model maximum (100th %ile) is used.

The 2015 year was also dominated by strong La Nina conditions[20] and a comparison of the ambient PM_{10} levels in Section 5.1.1 shows that the ambient levels measured for 2014 are about 5% higher than for 2015.

Therefore it was considered that the use of 2014 model results were most appropriate and should not under-estimate the potential effects.

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[19] Ministry for the Environment New Zealand Good Practice Guide for Atmospheric Dispersion Modelling. ISBN: 0-478-18941-9 ME number: 522. 2004

[20] http://www.bom.gov.au/climate/enso/soi/

5 AIR QUALITY AND STANDARDS

The following subsections describe, in general terms, the potential health effects of the discharges from the boilers and the National Environmental Standards (NES's) or other appropriate guidelines that are set to prevent those effects.

The actual off site levels discharges to air from the boilers that are predicted by dispersion models are then compared to those standards to assess the expected potential effects from this proposal.

5.1 PARTICULATE MATTER

Particulate in air is often referred to as suspended particulate matter (SPM) Health effects of SPM in humans depend on particle size and concentration, and can fluctuate with daily fluctuations in PM_{10} or $PM_{2.5}$ levels. PM_{10} material refers to particles in the air that are less than 10 microns in aerodynamic diameter and $PM_{2.5}$ has a diameter of less than 2.5 microns[21]. $PM_{2.5}$ is as subset of PM_{10}.

PM_{10} particulate is the fraction of SPM that is inhaled and can reach the upper parts of the respiratory system. By comparison $PM_{2.5}$ can reach deep into the alveoli of the lungs, and it is now becoming apparent that PM_{10} is not necessarily a reliable indicator of potential health effects compared to $PM_{2.5.}$

People most susceptible to the effects of particles include the elderly; those with existing respiratory disease such as asthma, chronic obstructive pulmonary disease and bronchitis; those with cardiovascular disease; those with infections such as pneumonia; and children. Again the evidence emerging is that the health effects are actually associated with $PM_{2.5}$ rather than PM_{10}.

In this application the relevant standard for comparing ambient levels with is the New Zealand National Environmental Standard for (NES) PM_{10}.

As there is currently no NES for $PM_{2.5}$ nor Council guidelines for $PM_{2.5}$, but the MfE proposed NES is likely to be adopted shortly and has therefore been included in this assessment as if it was in force.

Regulation 17(1) of the RMA, limits the addition of PM_{10} into a polluted air shed to a maximum increment of 2.5 $\mu g\ m^{-3}$. However as noted in Section 1.2.2 Regulation 17(a) is not relevant to this application.

5.1.1 Existing Levels in Te Awamutu

Ambient air levels of PM_{10} for Te Awamutu were measured by the Waikato Regional Council during the years 2013 to 2016 PM_{10} monitoring program in Te Awamutu at the location shown in Appendix G, but the most complete data is for the 2014 and 2015 years.

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[21] By comparison, the average human hair has a diameter of about 50 microns

Figure 5-1 shows the 24 hour average levels of PM_{10} for the years 2014 and 2015 that are typically between 15 to 20 µg m^{-3} for a 24 hour average that were, on average, higher for 2014 at an average of 12.3 compared to 2015 that had an average of 11.7.

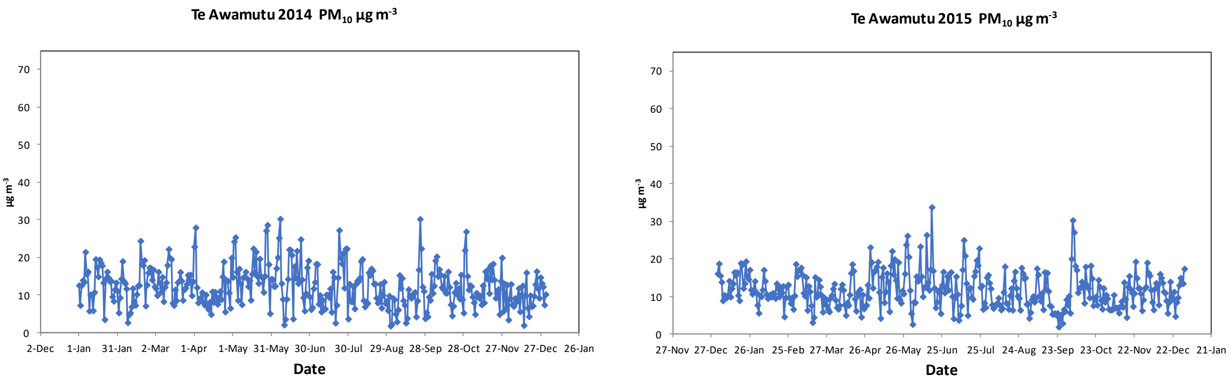

Figure 5-1. Ambient 24-Hr PM_{10} levels µg m^{-3} Left panel 2014 and right panel 2015

While the monitoring site location was intended to represent the overall ambient air quality of the greater Te Awamutu area, it is not without the risk of abnormally high values that can be caused by nearby domestic burning (both for heating or rubbish disposal) and dust from road sweeping or grass cutting close to the sampling equipment.

Discussions with WRC staff[22] revealed that the PM_{10} data had only limited quality assurance and that the anomalies noted above should be removed. For use as background data, to assess the cumulative effects, hourly data is required, and a number of abnormal recordings were therefore removed from the dataset. For example where the PM_{10} levels were stable at say 10 to 20 µg m^{-3} and a reading of say 200 was recorded for 1 hour in the middle of the day with wind blowing from the residential zone, returning abruptly to 10 to 20 at midday, is clearly not valid as an indicator of background levels. In addition, a small number of negative values due to instrument drift when the levels were close to zero were replaced with values of 2 µg m^{-3}. The raw and corrected background data files can be provided on request[23].

$PM_{2.5}$ levels were assumed to be 60% of PM_{10} in accordance with guidance from the Auckland Council[24].

5.2 SULPHUR DIOXIDE

SO_2 is highly soluble in the aqueous surfaces of the respiratory airways and short-term exposures can affect the respiratory system. Those with asthma, particularly children, can be sensitive to these effects. The effects of SO_2 have been well studied for both short and long term effects, and the ambient air quality standards and guidelines include limits for both short and long term averages are

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[22] J Caldwell. Waikato Regional Council, Pers Comm. April 2021.

[23] For non-regulatory parties, TBC and GCS reserve the right to provide or withhold this data.

[24] Use of background air quality data in resource consent applications. Auckland Council guideline document, GD2014/01

set to prevent adverse effects in the most sensitive subsets of the population. Existing levels of SO_2 in Te Awamutu are expected to be very low.

5.3 NITROGEN OXIDES

There are two main nitrogen oxide species that are discharged from virtually every combustion source including motor vehicles, domestic wood and coal burners, BBQ's etc. These are nitric oxide (NO) and nitrogen dioxide (NO_2). Of these, only NO_2 is considered to be of any importance when assessing short term effects close to the source. Most combustion discharges[25] have more than 95% of the nitrogen oxides present as NO and this is assumed in this assessment. However NO does transform into NO_2 depending on the availability of ultraviolet light from sunlight, and the ambient levels of ozone.

Exposure to nitrogen dioxide (NO_2) has been shown to cause reversible effects on lung function and airway responsiveness. Recent epidemiological studies[26] have shown an association between ambient NO_2 exposure and increases in daily mortality and hospital admissions for respiratory disease. NO_2 has also been shown to potentiate the effects of exposure to other known irritants, such as ozone and respirable particles and it may cause an increase in airway responsiveness in asthmatic individuals for levels in the range of 400–600 $\mu g\ m^{-3}$.

Existing levels of NO_2 in Te Awamutu are expected to be low, although there is potential for the discharges from the Fonterra facility to be additive to those from the proposed RDF boilers.

Background levels of NO_2 have been reported at about 18 $\mu g\ m^{-3}$ for a 30-day average[27] that is indicative of 1-Hr levels of 67 $\mu g\ m^{-3}$ but the location of the monitoring site was adjacent to the roundabout on State Highway 3 at the intersection of Cambridge Rd. This means that the data is only representative of vehicle emissions adjacent to the road, not Te Awamutu in general and even less likely to be representative of the proposed site that is almost in a rural setting. In the absence of other local data, the default background levels for regional sites recommended by the Auckland Council[28] are adopted and are shown in Table 5-1.

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[25] Emission Factor Documentation for |AP-42 section 1.3, Fuel Oil Combustion. Contract No. 68-DO-0120 U.S. Environmental Protection Agency Research Triangle Park, NC 27711 April 1993, and Cato, G.A., et al., Field Testing: Application of Combustion Modifications To Control Pollutant Emissions from Industrial Boilers - Phase II, EPA-600/2-76-086a, U.S. Environmental Protection Agency, Washington, DC, April 1976.

[26] WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide Global update 2005. Summary of risk assessment. WHO/SDE/PHE/OEH/06.02

[27] Ambient Air Quality (nitrogen dioxide) Monitoring Network. Annual Report 2007 - 2012. New Zealand Transport Agency. Wellington. ISBN 978-0-478-40793-8

[28] Use of Background Air Quality Data in Resource Consent Applications July 2014 Guideline Document 2014/01 Auckland Council Guideline Document 2014/01 ISBN 978-1-927302-46-0 (PDF)

Table 5-1
Nitrogen Oxide Background Levels

Averaging Time	Concentration µg m^{-3}
1 Hr	41
24-Hr	16
Annual	4

5.4 HYDROGEN CHLORIDE AND FLUORIDE

These are both acid gases that at high concentrations can have adverse respiratory effects. As with SO_2, those with asthma, particularly children, can be sensitive to these effects. Background levels are expected to be low.

5.5 MERCURY

Exposure to high levels of mercury can result in respiratory system and central nervous system damage. Long term exposure (chronic effects) include memory deficit, speech problems, blurred vision as well as cardiovascular and kidney damage[29].

It is discharged from a variety of combustion sources, including virgin wood[30] and is present naturally in the ambient air. The concentration in ambient air varies considerably depending on the location and is between 0.02 and 0.05 µg m^{-3} (20 to 50 ng m^{-3}) and is due to the natural out-gassing of the earth's crust at a rate of about 50,000 tonnes per year[31].

Samples of mercury vapour taken in a "clean site" at Baring Head, near Wellington, obtained concentrations of 0.5 to 1.3 ng m^{-3} as a 7-day average, with a mean of 0.73 ng m^{-3}. More recent but limited mercury monitoring has been undertaken in Ngawha and Rotorua using techniques that provide shorter averaging times. Results in Ngawha ranged from 2.8 to 21 ng m^{-3} for averaging times of 5 to 8-hours. In Rotorua levels were from < 0.6 to 1.5 ng m^{-3} (0.0015 µg m^{-3}) in suburban areas and up to 20 ng m^{-3} (0.02 µg m^{-3}) near areas of geothermal activity (Whakarewarewa) for 4 and 8-hour averages[32].

Background levels of mercury in Te Awamutu are expected to be very low and much less than those measured in Rotorua and Ngawha.

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[29] OEHHA TSD for Non-cancer RELs December 2008 (Updated July 2014) Appendix D. Individual Acute, 8-Hour, and Chronic Reference Exposure Level Summaries .https://oehha.ca.gov/media/downloads/crnr/appendixd1final.pdf. Accessed 30 Oct 2018

[30] https://www.epa.gov/sites/p1.6_wood_residue_combustion_in_boilers.pdf

[31] Environmental Health Criteria 1. WHO Geneva 1976

[32] Ministry for the Environment. Health Effects of Eleven Hazardous Air Contaminants and Recommended Evaluation Criteria, Air Quality Technical Report No 13. MfE Oct 2000.

5.6 CARBON MONOXIDE CO

Carbon monoxide is an odourless and colourless gas that replaces oxygen in the blood stream by converting normal haemoglobin to carboxy-haemoglobin. The following information is reproduced from the MfE Ambient Air Quality Guideline[33].

> *CO is a trace constituent of the atmosphere, with background levels normally ranging between*[34] *0.01 and 0.2 mg/m*^{3}*. When inhaled, CO combines with haemoglobin (Hb), the blood's oxygen-carrying protein, to form COHb. In this state the Hb is unable to carry oxygen (O2). It takes about 4 to 12 hours for CO concentrations in the blood to reach equilibrium with the CO concentration in air, so any fluctuations in the ambient CO concentrations are only slowly reflected in the COHb levels in humans.*
>
> *High exposures to CO can cause acute poisoning, with coma and collapse occurring at COHb levels of over 40%. Ambient exposures to CO are several orders of magnitude lower than those associated with acute poisoning.*
>
> *Adverse cardiovascular effects of CO inhalation include decreased O2 uptake and decreased work capacity. Those with angina may suffer decreased exercise capacity at onset of angina, and increased duration of angina. Adverse neurobehavioural effects of CO include a decrease in vigilance, visual perception, manual dexterity, ability to learn and perform complex sensorimotor tasks in healthy individuals, and reduced birth weight in non-smoking mothers.*

The NES for carbon monoxide is 10 mg m^{-3} for an 8 hour exposure. Existing levels of CO are expected to be low in the vicinity of the proposed site but are likely to increase close to highly trafficked roads.

5.7 DIOXINS AND FURANS

These are poly-chlorinated di-benzo dioxins (PCDD's) and poly-chlorinated di-benzo furans (PCDF's), and collectively these are often referred as PCDD/PCDF's.

Long environmental exposure causes a range of toxicity, including immunotoxicity, developmental and neurodevelopmental effects, and effects on thyroid and steroid hormones and reproductive function. The most sensitive life stage is considered to be the fetus or neonate. These substances are not genotoxic carcinogens and it is considered that the mechanism of carcinogenesis, involving the aryl hydrocarbon receptor, means that there is a threshold for carcinogenicity. Tolerable intake guidance based on non-cancer endpoints is considered protective for carcinogenicity.[35]

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[33] Ambient Air Quality Guidelines 2002 Update. Air Quality Report No 32 Prepared by the Ministry for the Environment and the Ministry of Health. ISBN: 0-478-24064-3.

[34] 10 to 200 µg m^{-3}

[35] World Health Organisation 2010. http://www.who.int/ipcs/features/dioxins.pdf.

There is no data on the levels of dioxins in Te Awamutu, but they are likely to be low and similar to or less than Auckland since the ambient levels of $PM_{10,}$ that is an indicator of dioxin levels[36], are similar to those in Auckand[37].

The existing ambient levels of dioxin in the Auckland area[38] are between 16.5 and 40.8 fg TEQ m^{-3} (including half LOD values) for 20 day averages[39], with the higher levels being recorded during both during the heating season and during summer. In Masterton the levels ranged from 6.73 to 158 fg TEQ m^{-3}, and the levels measured at a relatively pristine site at Baring Head in Wellington ranged between 1.21 and 7.48 fg TEQ m^{-3} (including half LOD values) for a 20 day average. The higher levels for Masterton are attributed to domestic wood burning during winter.

There are also no ambient air quality standards or guidelines for dioxins in New Zealand but Japan and Ontario (Canada) do have standards and these are adopted for this assessment.

An alternative method for assessment is to compare long term exposure and risk according to the USEPA unit risk[40] for cancer of 3.3×10^{-5} $(pg\ m^{-3})^{-1}$, for the single 2,3,7,8-TCDD congener where the risk relates to a risk of 1E-6 i.e. no risk.

Because 2,3,7,8-TCDD is assigned a TEQ value of 1.0, and the TEQ sum that includes acute, chronic and carcinogenicity effects[41] for all the congeners in the discharge is derived from the TEF-weighted sum, a reasonable estimate of the total risk can be derived from the use of the total TEQ and the unit risk for 2.3.7.8-TCDD. Essentially this will provide a TEF weighed risk of all the congeners.

The total risk for all congeners can then be calculated from the annual average off-site predictions for total PCDD/PCDF's.

5.8 STANDARDS AND GUIDELINES

The relevant standards and guidelines for the discharges assessed are shown in Table 5-2 and are the minimum requirements that outdoor air quality should meet in order to guarantee a set level of protection for human health and the environment. The phrase ‘set level of protection’ is used quite deliberately – it does not mean that all adverse health impacts will be avoided. This is because some pollutants (e.g., PM_{10}) are deemed to not have a safe threshold under which no adverse health impacts are experienced. However for PM_{10} the NES allows one exceedance per year of the 50 µg m^{-3} level for a 24 hour average whereas the World Health Organisation allows for three exceedances of the same level.

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[36] McCauley, M. Ambient concentrations of polycyclic aromatic hydrocarbons and dioxins/furans in Christchurch - 2003/2004 Environment Canterbury Report No. R05/14 ISBN 1-86937-568-8 June 2005

[37] For example, see https://www.lawa.org.nz/explore-data/auckland-region/air-quality/

[38] Organochlorines in New Zealand. Ambient Concentrations of selected organochlorines in ambient air. Ministry for the Environment. 1999. Values for Auckland City are used rather than the industrial site at Otahuhu.

[39] 1 fg is a femtogram or 1/1000th of 1 million millionth of a gram (1E-15g)

[40] https://www.epa.gov/sites/production/files/2016-09/documents/2-3-7-8-tetrachlorodibenzo-p-dioxin.pdf

[41] CCMS, Committee on the Challenges of Modern Society. Pilot Study on International Information Exchange on Dioxins and Related Compounds. North Atlantic Treaty Organization (NATO). Committee on the Challenges of Modern Society (CCMS) Report Number 178 (1988).

Table 5-2
Ambient Air Quality Standards and Guidelines

	Averaging Time	Value µg.m^{-3}	Status	Reference
Particulate PM_{10}	24 Hr Annual	50 20	NES NES	NES[42] NES
Particulate $PM_{2.5}$	24 Hr Annual	25 10	Guideline Guideline	NES proposed NES proposed
Sulphur Dioxide SO_2	1 Hr	350 120	NES Guideline	NES WRC-AAQG
Nitrogen Dioxide NO_2	1 Hr 24 HR Annual	200 100 30	NES Guideline Guideline	NES WRC-AAQG WRC-AAQG
Hydrogen Chloride HCl	1 Hr	140		NSW EPA[43]
Hydrogen Fluoride HF*	1 Hr Annual	240 14	REL REL	OEHHA[44] OEHHA
Mercury Hg	1 Hr 1 Hr 8 Hr Annual	0.6 1 - 10 0.06 0.33	REL MRL REL Guideline	OEHHA ATSDR[45] OEHHA ibid MfE[46]
Carbon Monoxide CO	8-Hr	10 mg m^{-3}	NES	NES
PCDD/PCDF	Annual 24-Hr	600 fg-TEQ m^{-3} 100 fg-TEQ m^{-3}	Standard AAQC	Japan[47] Ontario[48]
*NZ Guidelines for HF range from 24 hrs to 90 days and are designed for protection of vegetation and are discussed in more detail in Section 6.5				

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[42] Resource Management (National Environmental Standards for Air Quality) Regulations 2004 (SR 2004/309) Regulations name: amended, on 1 June 2011, by regulation 4(2) of the Resource Management (National Environmental Standards for Air Quality) Amendment Regulations 2011 (SR 2011/103).

[43] https://www.epa.nsw.gov.au/-/media/epa/corporate-site/resources/air/approved-methods-for-modelling-and-assessment-of-air-pollutants-in-nsw-160666.pdf 2016

[44] Californian Office Of Environmental Health Hazard Assessment Air Toxics Hot Spots Program Appendices Guidance Manual for Preparation of Health Risk Assessments February 2015. Appendix L. Consolidated Table Of OEHHA/ARB Approved Risk Assessment Health Values .https://oehha.ca.gov/media/downloads/crnr/appendixd1final.pdf. Accessed 30 Oct 2018

[45] Chemical-Specific Health Consultation for Joint EPA/ATSDR National Mercury Cleanup Policy Workgroup Action Levels For Elemental Mercury Spills March 22, 2012 https://www.atsdr.cdc.gov/emergency_response/Action_Levels_for_Elemental_Mercury_Spills_2012.pdf accessed 6 Nov 2021

[46] Ambient Air Quality Guidelines 2002 Update. Air Quality Report No 32 Prepared by the Ministry for the Environment and the Ministry of Health Wellington, New Zealand ISBN: 0-478-24064-3 ME number: 438

[47] https://www.env.go.jp/en/air/aq/aq.html, accessed 30 Oct 2018

[48] Ontario's Ambient Air Quality Criteria (AAQC). Standards Development Branch Ontario Ministry Of The Environment April 2012 Pibs # 6570e01

Relevant Waikato Regional Council Regional Ambient Air Quality Guidelines (WRC-AAQG) are also included, and where there is no New Zealand NES or guideline an appropriate guideline from other appropriate jurisdictions is shown.

The OEHHA Reference Exposure Level (REL) "*is the concentration level at or below which no adverse non-cancer health effects are anticipated for the specified exposure duration. RELs are based on the most sensitive, relevant, adverse health effect reported in the medical and toxicological literature. RELs are designed to protect the most sensitive individuals in the population by the inclusion of factors that account for uncertainties as well as individual differences in human susceptibility to chemical exposures. The factors used in the calculation of RELs are meant to err on the side of public health protection in order to avoid underestimation of non-cancer hazards. Exceeding the REL does not automatically indicate an adverse health impact. However, increasing concentrations above the REL value increases the likelihood that the health effect will occur*"[49].

The OEHH RELs are therefore considered to be conservative guidelines especially for short term exposures where it is extremely unlikely that persons attending the Beauchamp funeral home would remain either on site, or in the areas of predicted maximum exposure, for the time period that the REL value relates to.

For mercury the ASTDR the Minimal Risk Level (MRL) is an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse non-cancer health effects over a specified duration of exposure.

There are no New Zealand ambient air quality standards or guidelines for dioxins, and at the present time there are no WHO, European nor USA standards. However, Japan has an annual air quality standard of 0.6 pg-TEQ m^{-3} i.e. 600 fg-TEQ m^{-3} while Ontario[50] (Canada) has a much more stringent 24-hour ambient air quality criteria (AAQC) of 0.1 pg-TEQ m^{-3} i.e. 100 fg TEQ m^{-3}. . The Ontario AAQC is for a 24 hour average, and is not a modeling or point of impingement standard but "*If the AAQC is met, then no adverse effects are expected over continuous lifetime exposure*"[51].

In everyday terms for use in this assessment, the data in Table 5-2 represent the maximum allowable levels that would be allowed based on the predictions of the CALPUFF model. While the levels are not a target to pollute up to, they represent the best available tool for assessing the effects on health.

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[49] Air Toxics Hot Spots Program Risk Assessment Guidelines The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments. Office of Environmental Health Hazard Assessment California Environmental Protection Agency February 2015

[50] Ontario's Ambient Air Quality Criteria Standards Development Branch Ontario Ministry Of The Environment April 2012 Pibs # 6570e01

[51] Interpretation of 24-hour sampling data: Development of 24-hour ambient air quality criteria and their use in Ontario. Denis Jugloff, Ph.D. Human Toxicology & Air Standards Section Standards Development Branch Ontario Ministry of the Environment Toronto, ON, Canada. https://www.tera.org/Alliance for Risk/Workshop/WS6/OMOE_Jugloff_Final.pdf

6 EFFECTS ASSESSMENT

The following sections describe the potential off-site effects that are generated by the CALPUFF model and are based on the assumption that all three boilers will be operating at 100% MCR for 24 hours per day 7 days per week for 52 weeks per annum. It is also assumed that the discharges from the three boilers will be at the maximum emission rate for each species in Table 3-2 with low heating value fuel and low boiler efficiency. In reality this is unlikely as the usual operating point for industrial heat plant is about 75% MCR, and it is even more unlikely that all three units will be always be simultaneously operating at a low boiler efficiency with a low heating value fuel. Finally, experience shows that the actual in-service emission rates of discharges will be typically between 25 to 50% of those shown in Table 3-2 which are proposed as consent limits.

This means that the potential effects, as detailed below, can be regarded as over-estimates and conservative predictions.

6.1 PARTICULATE MATTER PM_{10} AND $PM_{2.5}$

For the purposes of this assessment, all the particulate discharged from the boilers is assumed to be PM_{10} and this is also assumed to be $PM_{2.5}$ material. In practice most boiler discharges have typically only about 75% of the total particulate as PM_{10} and of this about 80% is $PM_{2.5}$. The discharges from fabric filters to reduce particulate discharges can also have similar size fractions[52]. In addition to the conservatism noted above this assumption further ensures that the potential PM_{10} and $PM_{2.5}$ effects are not under-estimated.

6.1.1 24 Hour PM_{10} Predictions

Maximum PM_{10} or $PM_{2.5}$ predictions for 2010 are shown in Figure **6-1** for 3 boilers operating at 100% MCR and no existing background added. It is assumed that all the PM_{10} is also $PM_{2.5}$.

The highest levels are in the immediate vicinity of the plant with a maximum of about 7 µg m^{-3} (in red) close to the Paewira boundary that is unlikely to be occupied by future by either industrial buildings or residential houses.

For areas that are occupied or likely to be occupied in the future, the maximum predicted PM_{10} contribution from the RDF plant are between 2 and 4 µg m^{-3} for a 24-Hr average and can be compared to the NES of 50 µg m^{-3}.

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[52] C, Noll, G. Kalkoff W.D, Baumbach, G. Dreiseidler, A. PM_{10}, $PM_{2.5}$ and $PM_{1.0}$ Emissions from industrial plants—Results from measurement programmes in Germany Ehrlich,. Atmospheric Environment 41 (2007) 6236–6254

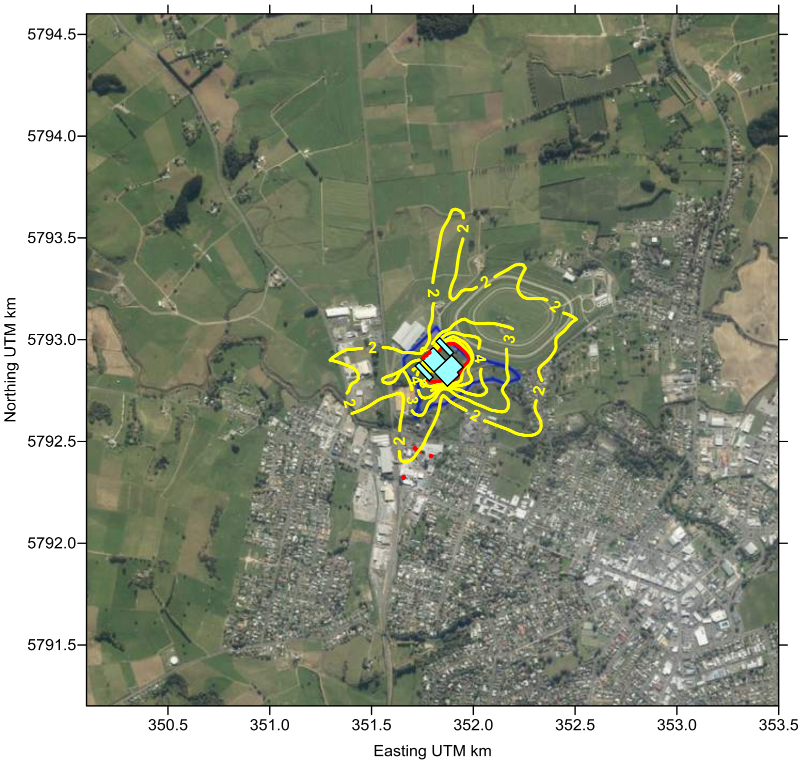

Figure 6-1 Maximum 24-hr PM_{10}/$PM_{2.5}$ µg m^{-3} for RDF Plant only. Excluding background

6.1.2 24-Hr Cumulative Effects

The Fonterra plant to the south of the RDF plant is also a significant PM_{10} source as well as low level residential home heating and motor vehicle sources. The contribution from Fonterra is shown Figure 6-2 and has been modelled using the data provided in the Tonkin and Taylor (T&T) report[8] for a change to consent conditions for a wood-fired boiler. The model predictions shown are slightly lower in some directions than those reported in the T&T report that used only broad scale synoptic meteorological data in the TAPM model with no local surface stations. However, they are very similar to those reported in the 2008 Golder Associates report[53] that used actual on site meteorological data.

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[53] Golder Associates 2008. Resource Consent Application and Assessment of Effects on the Environment. Report Number: FONTE-TAW-004 / 087813063

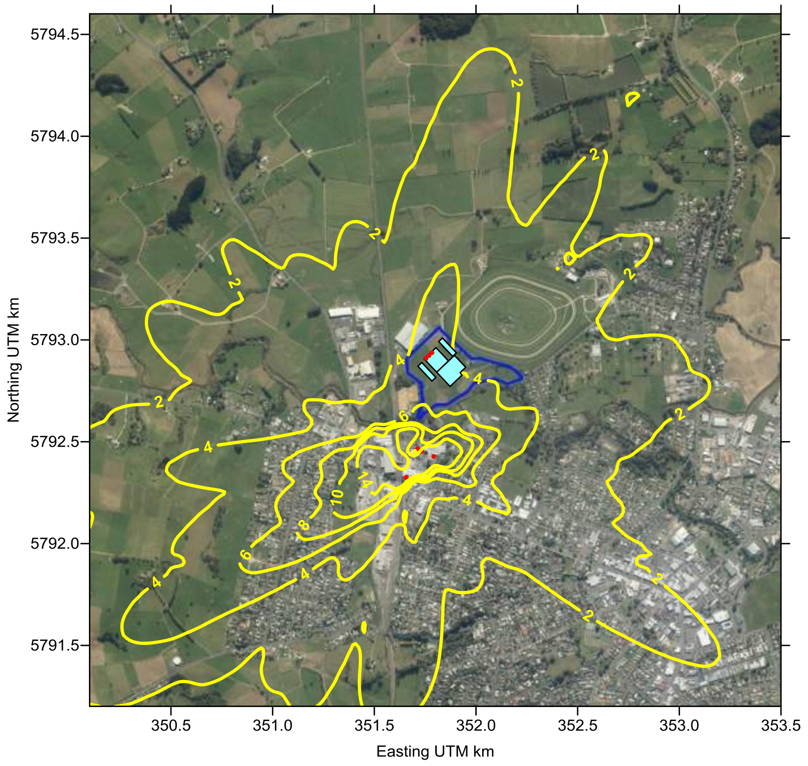

Figure 6-2 Maximum 24-hr PM_{10} µg m^{-3} for Fonterra only.Excluding background

The combined effects of PM_{10} discharges from both the RDF plant and Fonterra sources plus the assumed background from domestic home heating and motor vehicle sources are shown in Figure 6-3.

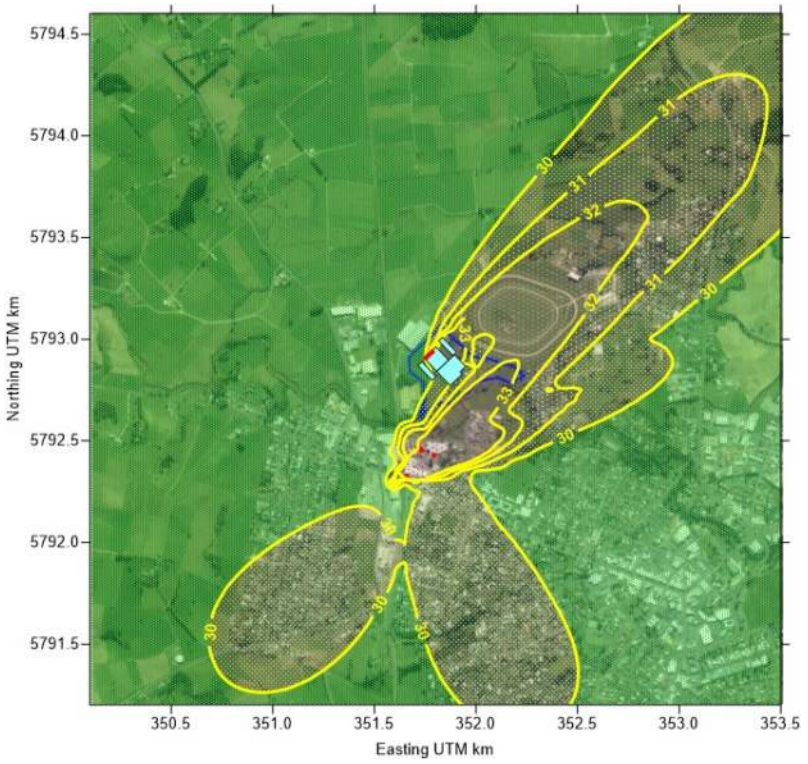

Figure 6-3 Maximum Cumulative 24-hr PM_{10} µg m^{-3}. Combined RDF sources plus Fonterra and background. The green shaded area is a constant 30 µg m^{-3}.

The existing ambient level of 30 µg m^{-3} (green filled) is primarily from existing domestic sources and motor vehicles and the yellow filled areas represents the contributions from the RDF plant and Fonterra of between 1 and 3 µg m^{-3}. It can also be inferred that for this scenario the contributions from the RDF plant and Fonterra during times of elevated PM_{10} are small. Note that the 30 µg m^{-3} background level for this location will be an over-estimation as described in Section 5.1.1 since the data was collected in central Te-Awamutu and levels on the outskirts of the town are expected to be considerably lower.

The combined effects can be compared to NES of 50 µg m^{-3} and the effects are considered no more than minor.

6.1.3 Annual PM_{10} Predictions

Annual PM_{10} predictions for the RDF plant alone are shown in Figure 6-4 and off-site levels are very low at between 0.2 and 0.6 µg m^{-3}.

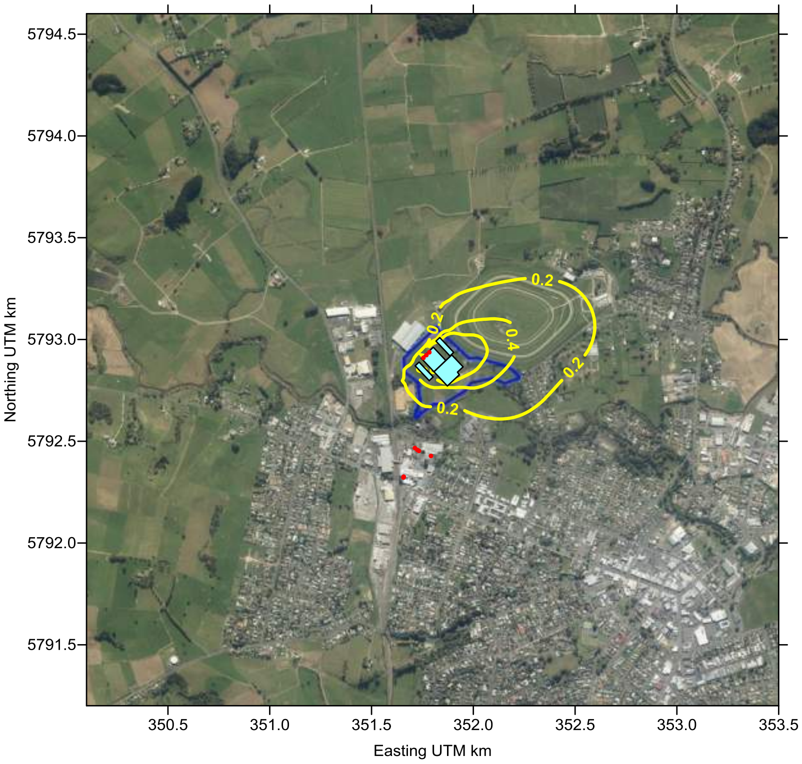

Figure 6-4 Annual PM_{10} µg m^{-3} for RDF plant onlyExcluding background

6.1.4 Annual Cumulative Effects

The cumulative PM_{10} predictions that include both the RDF plant and Fonterra sources plus those from domestic home heating and motor vehicle sources are shown in Figure 6-5, and are completely dominated by the existing background contributions from domestic home heating and motor vehicles that account for about 13 µg m^{-3} (green filled areas).

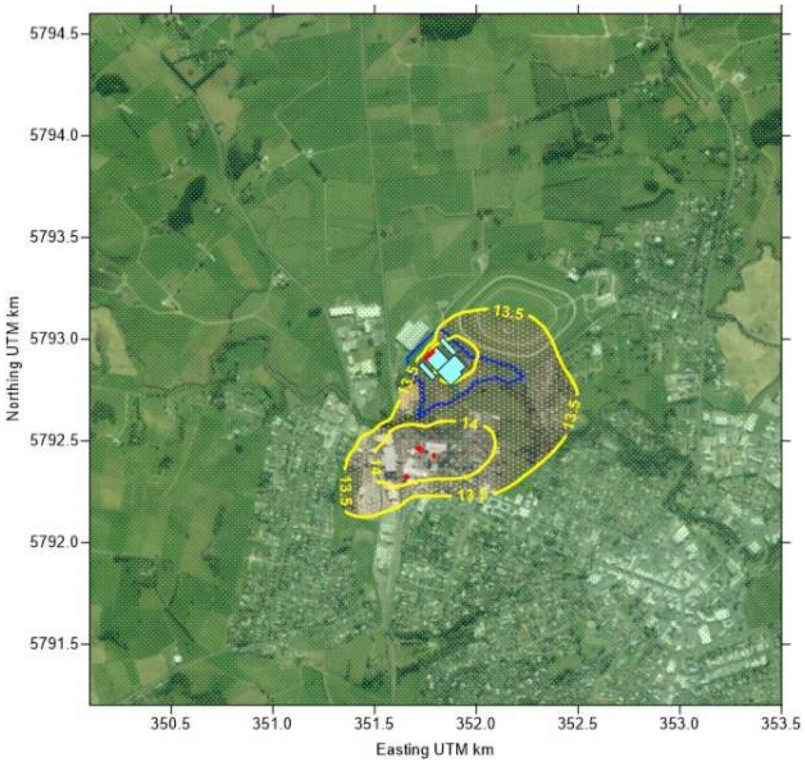

Figure 6-5 Annual Cumulative PM_{10} µg m^{-3}Including Fonterra plus background

The levels shown in Figure 6-5 can be directly compared to the NES value of 25 µg m^{-3}, although as noted above, the assumed background is not likely to be uniform across the whole of Te-Awamutu, and would be expected to be considerably lower close to both the RDF and Fonterra plants. The annual PM_{10} predicted effects from the RDF plant are considered no more than minor.

6.1.5 24-Hr $PM_{2.5}$ Predictions

24-hr $PM_{2.5}$ levels from the RDF plant alone are shown in Figure 6-6 with the highest off site levels to the east about 2 to 4 µg m^{-3}.

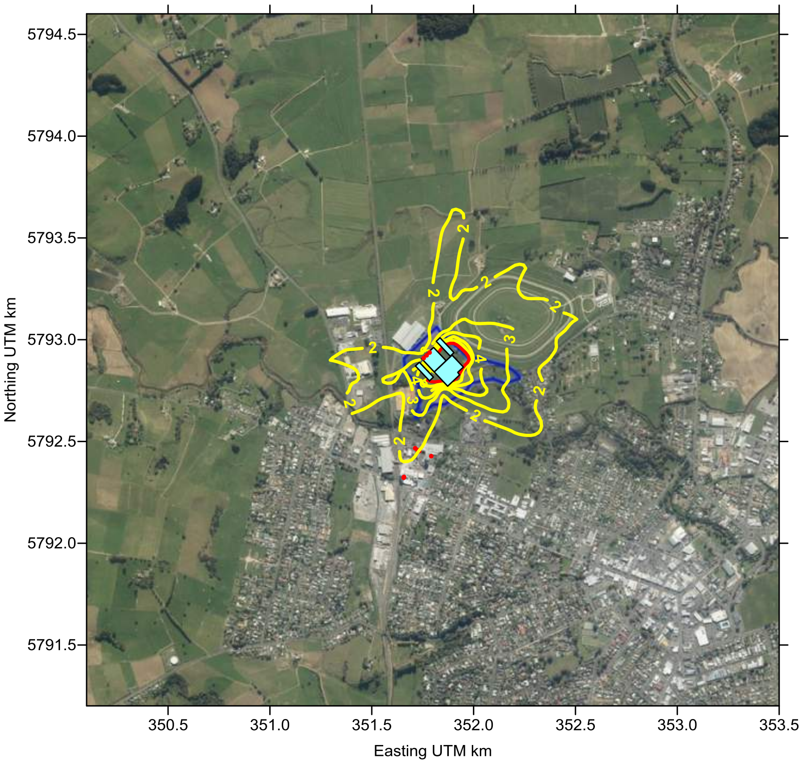

Figure 6-6 Maximum 24-hr $PM_{2.5}$ µg m^{-3}RDF plant only excluding background

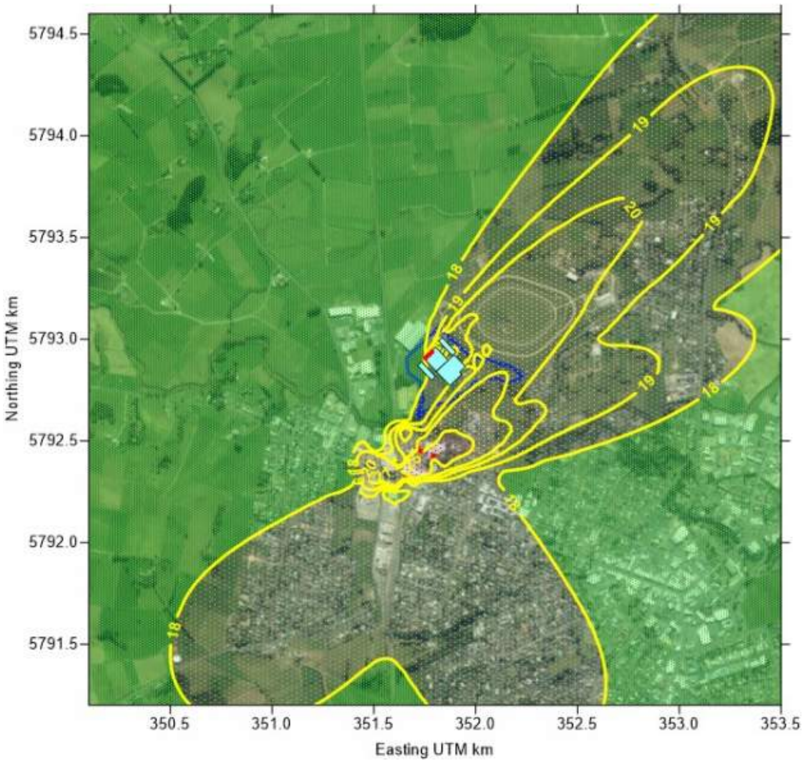

Figure 6-7 Maximum Cumulative 24-hr $PM_{2.5}$ µg m^{-3} RDF plant plus Fonterra and background. Isopleths 1 µg m^{-3}

The combined $PM_{2.5}$ levels including the contributions from Fonterra and the existing background from domestic heating and motor vehicles for 24-hr averages are shown in Figure 6-7 and can be compared to the proposed NES of 25 µg m^{-3}. Note that the largest component is from the existing background that is likely to be over-estimated for the same reasons noted for PM_{10}.

6.1.6 Annual $PM_{2.5}$ Predictions

Annual average $PM_{2.5}$ levels are shown in that are dominated by the existing background of about 8 µg m^{-3}, and the contribution from the RDF plant is only about 0.2 to 0.6 µg m^{-3} for off-site locations as shown in where all the PM_{10} is assumed to be $PM_{2.5}$.

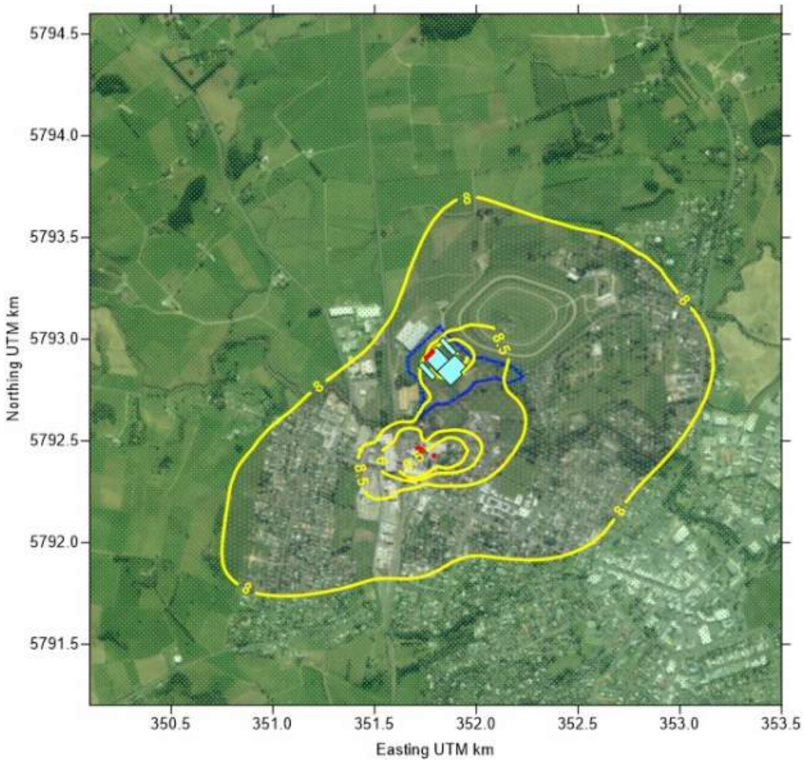

Figure 6-8 Annual Cumulative $PM_{2.5}$ µg m^{-3}RDF plant plus Fonterra and background. Isopleths 0.5 µg m^{-3}

These values can be compared to the proposed NES of 10 µg m^{-3} for an annual average. However in New Zealand the NES are provided for in the Act and the current values have legal status over both proposed NES's and guidelines. This means that although the proposed NES for $PM_{2.5}$ has no legal status at the present time, in the event that it becomes part of the Regulations, the discharges from the RDF plant will comply with the standard.

6.2 SULPHUR DIOXIDE

Maximum 1-hour sulphur dioxide levels are shown in Figure 6-9 and should be compared to the NES of 350 $\mu g\ m^{-3}$ for 1-hour average. The predicted levels are no more than 1/10th of the guideline. The 24-hr averages also shown in Figure 6-9 are well below the WRC-AAQG of 120 μg^{-3}. The potential effects are considered to be no more than minor.

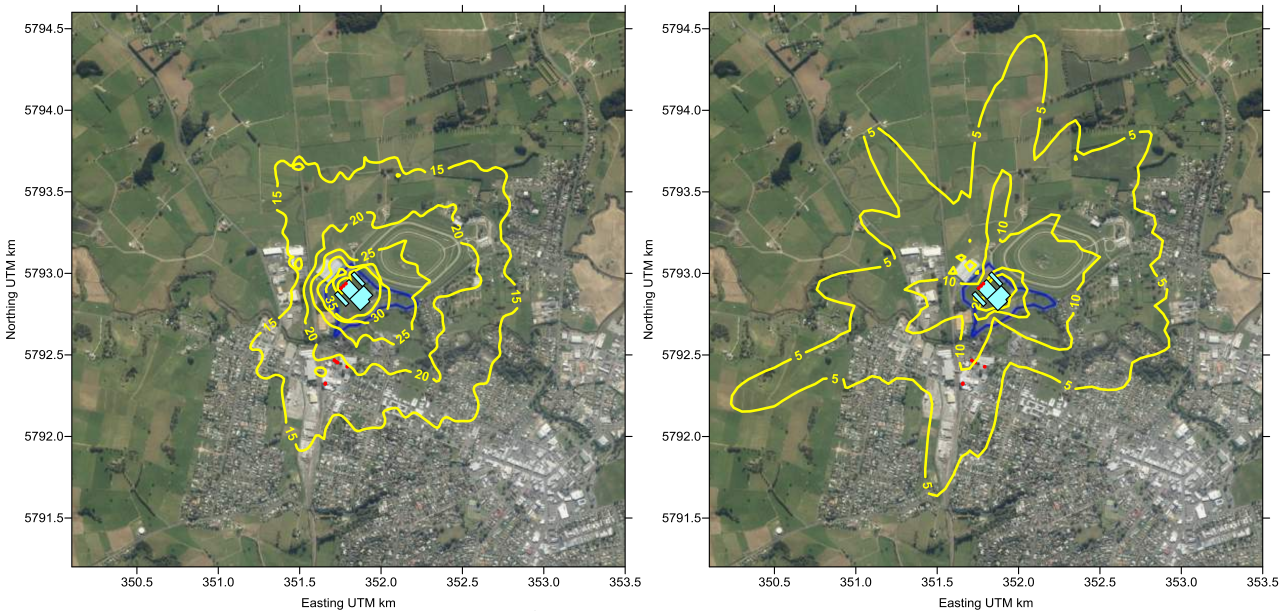

Figure 6-9. Predicted sulphur dioxide $\mu g\ m^{-3}$ Left panel, 99.9%ile 1-hr level. Right panel, maximum 24-hr averages.

6.3 NITROGEN OXIDES

Nitrogen oxides have been modelled for total NOx as NO_2, and the NO_2 component is then estimated using the ozone limiting method (OLM) adjusted to account for an assumed 5% NO_2 in the discharges[12] instead of the more commonly assumed and conservative[54] 10%.

The modified OLM is as described by equation (1), and details of the modified method are provided in Appendix H.

$$[NO_2] = 72 + [NOx]_{tot} \text{ x } 5\% \qquad (1)$$

The OLM method as described in the MfE guide uses a single assumed concentration of ozone (O_3) from Baring Point in Wellington to estimate the conversion of NO to NO_2. However the hourly average is not applicable to use for longer term such as 24-hr and annual averages. Longer term average values for O_3 this assessment were taken from the 2014 Auckland monitoring data set at Patumahoe that is set in a rural environment and is considered to be more representative of the proposed site. Note that the peak hourly Patumahoe O_3 is the came as the 35ppb from Baring Head used in the MfE OLM calculation so there is no under-estimation of the short term effects when

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[54] Ministry for the Environment Wellington, New Zealand *Good Practice Guide for Atmospheric Dispersion Modelling* 2004. ISBN: 0-478-18941-9

compared to the MfE guidance. The predicted 1-hr maxima as the 99.9th %ile are shown in Figure 6-10.

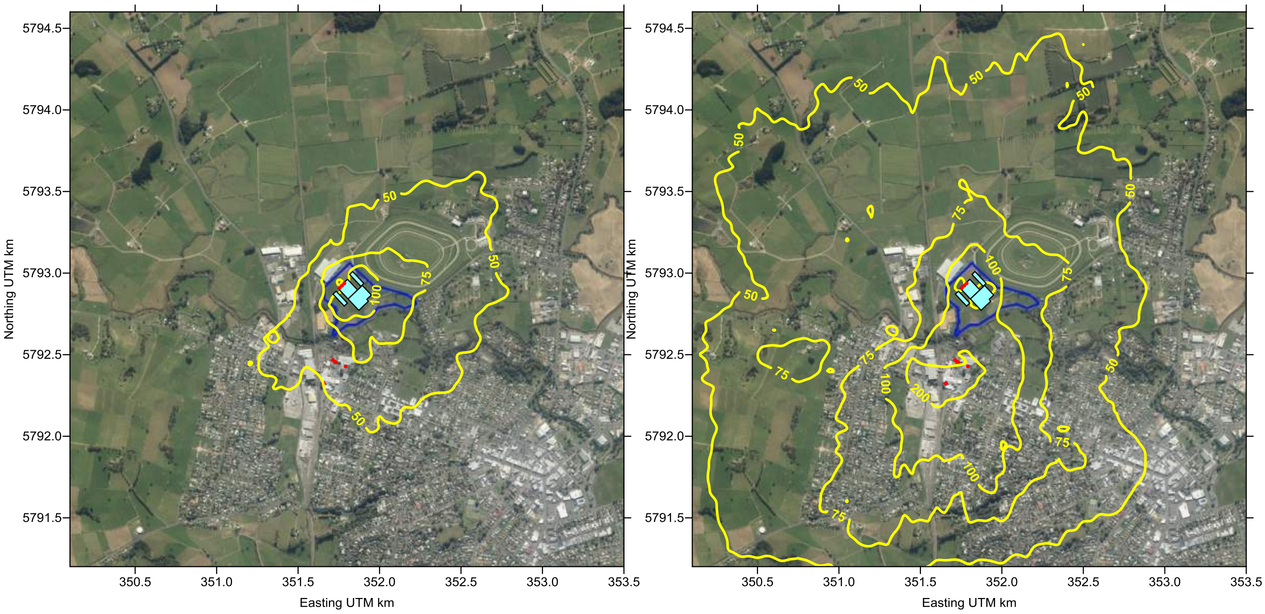

Figure 6-10. 99.9%ile Predicted 1-hr Nitrogen Oxides µg m^{-3} (NOx as NO_2). Left panel, RDF plant only. Right panel RDF plant plus Fonterra.

For locations close to the RDF plant, NOx is between 75 µg m^{-3} to 100 giving an estimated NO_2 level of 76 to 77 µg m^{-3}. For locations closer to the Fonterra plant the total NOx is between 100 and 200 µg m^{-3} giving an estimated NO_2 of between 77 and 82 µg m^{-3}.

The addition of the assumed background of 41 µg m^{-3} results in total NO_2 of 117 to 118 µg m^{-3} close to the RDF plant and 118 to 123 closer to the Fonterra plant that can be compared to the NES of 200 µg m^{-3}. No adverse effects are expected from the discharge of nitrogen oxides.

In addition to the NES limits, the WRC also has a 24-hr guideline of 100 µg m^{-3} and an annual guideline of 30 µg m^{-3} for NO_2 and total NOx predictions for these time averages are shown in Figure 6-11.

For 24-hr averages the OLM method for determining NO_2 levels is revised as in equation (2) that uses a 24 hour average background ozone that is set out in more detail in Appendix H.

$$[NO_2] = 68 + [NOx]_{tot} \times 5\% \qquad (2)$$

For a 24-hr total NOx of 50 to 75 µg m^{-3} close to the RDF plant, the NO_2 concentration can be estimated to be 50 to 72 µg m^{-3}. For locations closer to the Fonterra plant the total NOx of 100 to 150 µg m^{-3} yields a predicted NO_2 level of 73 to 76 µg m^{-3}.

The addition of the assumed 24-hr background of 16 µg m^{-3} results in a total NO_2 of 66 to 88 µg m^{-3} close to the RDF plant and 89 to 92 µg m^{-3} closer to the Fonterra plant.

Figure 6-11. Maximum long term Nitrogen Oxides µg m^{-3} (NOx as NO_2) for the RDF plus Fonterra plants. Left panel, 24-hr averages. Right panel annual averages.

These are less than the WRC guideline of 100, and as the estimates are considered to be conservative, no adverse effects are expected.

For annual averages the highest off-site predicted total NOx is about 15 µg m^{-3} that is less than the lower limit of 44 µg m^{-3} where it is all assumed to be converted to NO_2 (see Appendix H). Therefore the total NO_2 is determined to be 15 µg m^{-3} plus the assumed annual background of 4 µg m^{-3} results in 19 µg m^{-3} for locations very close to the both the RDF and Fonterra plant boundaries but much less for more distant locations. This is less than the WRC guideline of 30 µg m^{-3} and the effects are considered to be no more than minor.

6.4 HYDROGEN CHLORIDE

The level of Hydrogen Chloride (HCl) discharge is low with a stack concentration of 15 mg Nm^{-3} (dry gas 6% O_2), and the off-site levels can be determined from the 99.9%ile sulphur dioxide plot in Figure 6-9. Taking a sulphur dioxide discharge concentration of 75 mg Nm^{-3} (dry gas 6% O_2) and a maximum off-site level of 30 µg m^{-3} close to the RDF plant boundary the pro-rated hydrogen chloride level will be 6 µg m^{-3} and can be compared to the NSW modelling criterion of 140 µg m^{-3} not to be exceeded. The potential effects are considered to be no more than minor and no adverse effects are expected.

6.5 HYDROGEN FLUORIDE

Similalrly to hydrogen chloride, off-site levels of hydrogen fluoride can be determined from the 99.9%ile sulphur dioxide plot in Figure 6-9. For a stack concentration of 1.5 mg Nm^{-3} (dry gas 6% O_2) and a sulphur dioxide discharge concentration of 75 mg Nm^{-3} (dry gas 6% O_2), with a maximum off-site level of 30 µg m^{-3} close to the RDF plant boundary the hydrogen fluoride level will be 0.6 µg m^{-3} that is orders of magnitude less than the OEHHA REL of 240 µg m^{-3} based on health effects.

However New Zealand also has guidelines for HF that are based on the protection of vegetation not health, and these are shown in Table 6-1 where special land use is not defined by the MfE but is taken to include sensitive forest areas or horticultural areas for example. The surrounding land use would be considered general land use.

Table 6-1
New Zealand Guidelines for Fluoride (HF)

Contaminant and land use	Critical level µg m^{-3}	Averaging period
Special land use	1.8	12-hour
	1.5	24-hour
	0.8	7-day
	0.4	30-day
	0.25	90-day
General land use	3.7	12-hour
	2.9	24-hour
	1.7	7-day
	0.84	30-day
	0.5	90-day
Conservation areas	0.1	90-day

Figure 6-12. Fluoride levels in µg m^{-3} Left panel is for 12-hr averages. Right panel is for 90-day averages

The maximum 12-hour average HF levels are shown in Figure 6-12 that range from 0.2 to 0.5 µg m^{-3} and are all already less than or equal to the guidelines for all the longer time averages for general land use, (excepting the 90-day averages). Since any plots of the longer time averages would show significantly lower values than the 12-hour averages there is no need to plot those results.

The predicted 90-day averages are shown in the right panel of Figure 6-12 that shows levels between 0.05 and 0.1 µg m^{-3} which is compliant with the most stringent maximum for sensitive conservation land use of 0.1. Given that the land use close to the proposed RDF is predominantly industrial and rural with a potential residential zone to the east, the discharge of fluoride from the plant is not expected to cause adverse effects and the effects are minor.

6.6 MERCURY

The predicted 1 hour mercury levels are shown in Figure 6-13 with maximum off site levels ranging between 0.01 and 0.015 µg m^{-3} and can be compared to the OEHHA REL of 0.6 µg m^{-3} that is a "*concentration at which no adverse noncancer health effects are anticipated even in sensitive members of the general population, with infrequent one hour exposures*"[49].

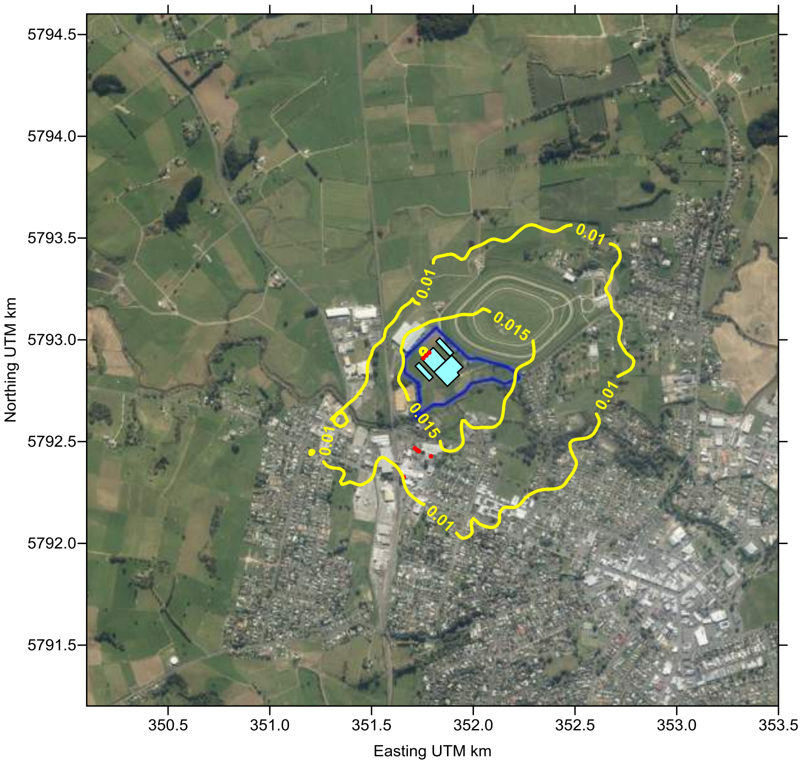

Figure 6-13. Maximum 1-hr Mercury levels µg m^{-3}

The short term effects of both the off-site and on-site locations can therefore be considered to be no more than minor. The maximum predicted 8-hour mercury levels are shown in Figure 6-14 and can be compared to the OEHHA REL of 0.06 µg m^{-3}. The maximum occurs on the site and off-site levels are predicted to be no more than about 0.01 to 0.015 µg m^{-3} and when compared to the REL of 0.06 are considered to be no more than minor.

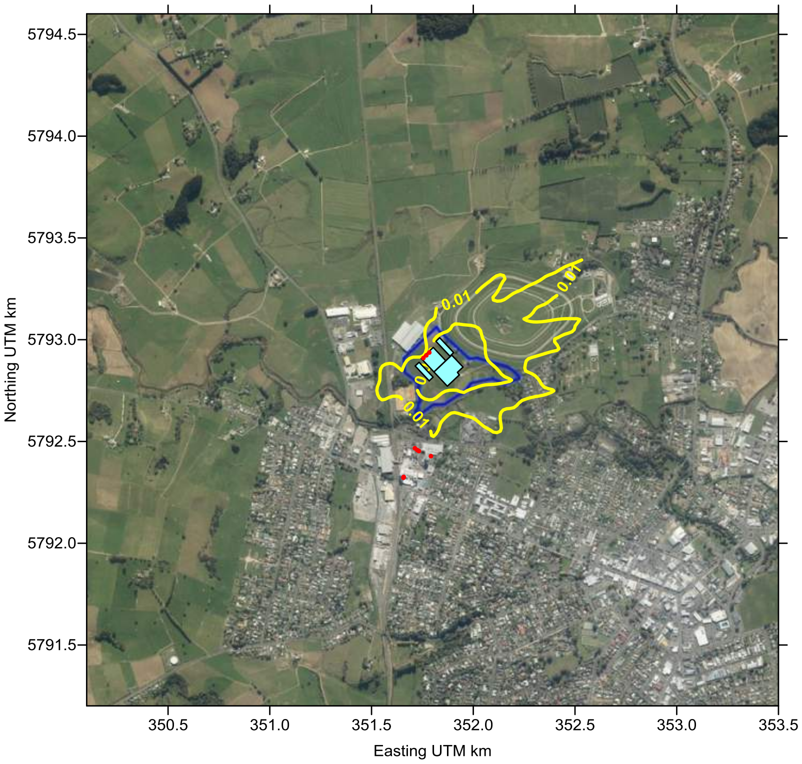

Figure 6-14. Maximum 8-hr Mercury predictions µg m^{-3}

Annual off site predicted mercury levels are shown in Figure 6-15 are in the range of 0.0005 to 0.002 to µg m^{-3} and should be compared the New Zealand NES for mercury in the ambient air of 0.33 µg m^{-3} for inorganic mercury as an annual average.

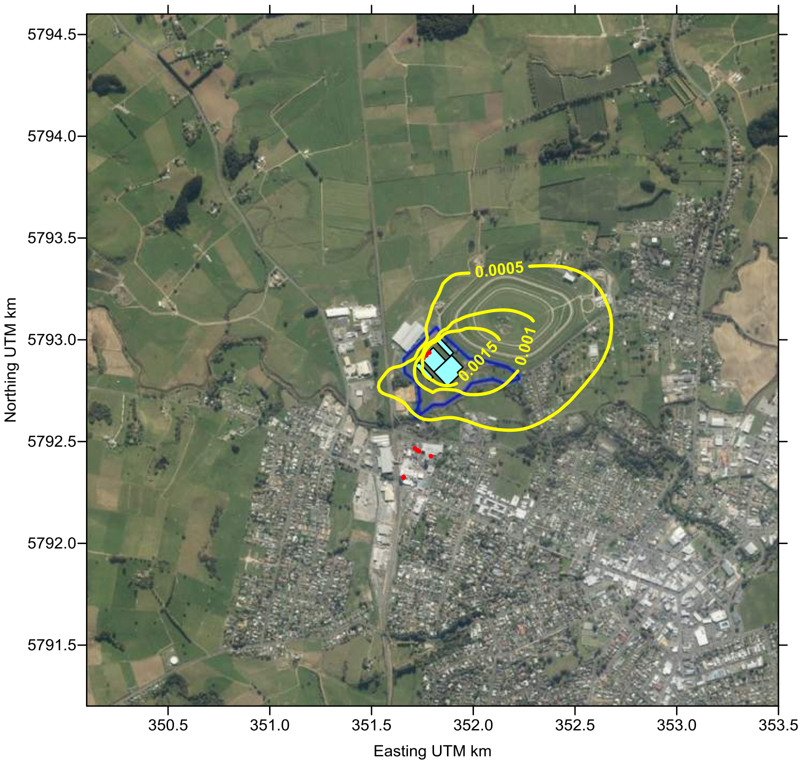

Figure 6-15. Annual Mercury predictions µg m^{-3}.

The predictions can also be compared to the more stringent OEHHA REL of 0.03 µg m^{-3}, and are also considered to be low by comparison, although the New Zealand NES takes precedence over other standards or guidelines. The effects are less than minor.

6.7 CARBON MONOXIDE

The predicted 8-hr CO concentrations are shown in Figure 6-16 with maximum off site levels ranging between 0.01 and 0.025 mg m^{-3} and can be compared to the NES value of 10 mg m^{-3} for an 8-hr average. Note that only the predictions for the RDF plant are shown as they are so low that cumulative effects from both existing ambient levels (expected to be also low) and Fonterra are not considered relevant.

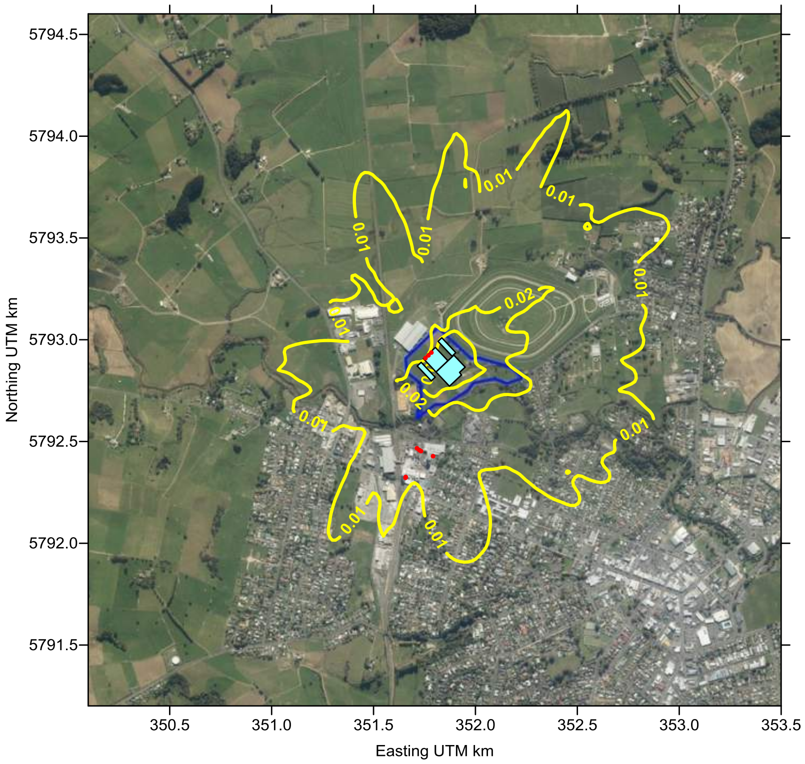

Figure 6-16.Maximum 8-hr carbon monoxide predictions mg m^{-3}RDF Plant only

The potential effects of CO discharges from the proposed RDF plant are less than minor.

6.8 DIOXINS AND FURANS

Predicted levels of PCDD/PCDF's are shown in Figure 6-17 in femtograms[55] of TEQ per cubic metre, with 24-hr levels between 5 and 20 fg TEQ m^{-3}, and annual levels between 0.5 and 2.5 fg TEQ m^{-3}.

The ambient levels of PCDD/PCDD's in New Zealand are directly proportional[56] to the total suspended particulate (TSP) in the air and by implication PM$_{10}$. As with the assessment for PM$_{10}$, the

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[55] One femtogram is 10^{-15} or one thousandth of one million millionth of a gram

background levels of PCDD/PCDF's will be lower at the edges of the township than in the centre and the cumulative effects will be less than stated.

There is no data for existing background levels of PCDD/PCDF's in Te Awamutu but the highest levels[57] for Auckland were 40.8 fg TEQ $m^{-3}$and for Hamilton 234 fg TEQ $m^{-3}$for 20 day averages. The median values were 27.5 and 17.1 and the means 28.1 and 53.6 respectively. It is not reasonable to use a maximum value as a baseline background and a nominal 60 fg TEQ m^{-3} has been assumed for a 24 hour average, that is close to the Hamilton mean and the Auckland maximum. However it is still likely to be too high as the site is semi-rural.

Figure 6-17 Predicted PCDD/PCDF levels fg m^{-3}. Left panel is 24 hr average, right panel is annual average. Both are for the RDF plant only

If the worst case maximum background level of 60 fg TEQ m^{-3} is assumed, the cumulative total is estimated to be between 65 and 90 fg TEQ m^{-3} which is well below the Japanese annual ambient standard of 600 fg TEQ m^{-3} and less than the Ontario AAQC of 100 TEQ m^{-3}.

For annual average the actual mean background level for Hamilton of 53.6 fg TEQ m^{-3} can be used, and adding the maximum annual off-site contribution of about 3 fg TEQ m^{-3} from Figure 6-17 (left panel) the total annual level is estimated to be 56.6 fg TEQ m^{-3} (56.6 $x10^{-3}$ pg TEQ m^{-3}). However these estimates are conservative as the Hamilton data will over-estimate the levels for this semi-rural site.

A more realistic assessment can be made using the USEPA risk unit risk of $3.3x10^{-5}$ (pg $m^{-3})^{-1}$ as discussed in Section 5.7, and an annual average of 56.6 $x10^{-3}$ pg TEQ m^{-3} a lifetime risk of 1.8 x 10^{-6} is

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[56] Ministry for the Environment. Ambient concentrations of polycyclic aromatic hydrocarbons and dioxins/furans in Christchurch - 2003/2004 Report No. R05/14 ISBN 1-86937-568-8.

[57] Organochlorines in New Zealand: Ambient concentrations of selected Organochlorines. Ministry for the Environment PO Box 10-362 Wellington NZ. ISBN 0 478 09033. 1999

obtained. However the USEPA[58] also requires an additional factor of 1.6 for established carcinogens, so this conservatively[59] increases the estimated risk to 3 x 10^{-6} which can be compared to the USEPA upper limit of 100 x 10^{-6} or the more commonly used acceptable risk of 10 x 10^{-6}. The potential effects are considered to be no more than minor.

Note that 94% of this risk is from the assumed existing background levels not from the proposed RDF plant.

6.9 VISUAL EFFECTS

At a maximum particulate concentration of 15 mg Nm^{-3} (dry gas 6% O_2) there should be no visible plume from the boiler stacks under normal operating conditions and the discharge should be clear. However at times during cold weather and high relative humidity a visible water vapour plume that forms after discharge may be evident.

A stack opacity monitor will be fitted to each of the boiler stacks to monitor for possible smoke emissions. A maximum opacity of 20% is proposed that is more stringent than the historical limit of 40% applied to most boilers, but is appropriate for modern solid fuel boilers with better combustion control systems. This limit is normally excluded for short times during startup from cold and during soot blowing, but in this case the boilers will employ mechanical cleaning so the traditional soot blowing is not required. However the exclusion will still apply for startup.

Boiler steam drum traditional blowdown is often accompanied by a visible steam plume close to boiler plants that use intermittent blowdown to manage mineral content of the steam feedwater. The proposed boilers will use a continuous blowdown method that does not create a visible steam plume.

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[58] e.g. https://www.epa.gov/national-air-toxics-assessment

[59] Not all PCDD/PCDF's are established carcinogens

7 MONITORING

Process monitoring on the proposed plant will include a number of monitors and sensors that are intended to optimise the combustion system and to alert the operators of actual or potential failure of control equipment.

7.1 STACKS

Each of the discharge stacks will be fitted with a smoke opaciity meter to warn of visible smoke discharges. In line with newer solid fuel boilers a limit of 20% opacity is considered to be appropriate with exemptions for start up operations when the opacity may exceed 20% for short periods of time.

A stack test will be carried out within the first 12 months after comissioning and in accordance with a monitoring schedule to be determined in negotiation with the WRC. The tests will include flue gas concentrations and emisison rates for PM_{10}, $PM_{2.5}$, SO_2, HCl, and HF. The expected levels of NOx and PCDD/PCDF's are sufficiently low that testing is not considered necessary.

7.2 COMBUSTION

The boilers wil be fitted with a standard combustion control and monitoring system that both optimises the fuel burning and minimises dischargs to air. The relevant monitoring includes temperatures, pressures and fuel consumption rate and residual oxygen level in the flue gases, as well as the operating conditions of a large number of fans and pumps, grate motors, conveyors etc. that are logged on the data acquisition system.

7.3 BAGHOUSE

The baghouse will be monitored for pressure drop to detect bag blinding, tribo-elecric sensors to detect broken, worn or detached bags and temperature to detect fire. All the monitors will be alarmed. In the event of a baghouse fault the boiler will be shut down as soon as is practicable. In the event of fire, the boiler will be shut down immediately.

The baghouse including the pulsejet cleaning system will be inspected annually for bag condition as well as structural integrity.

7.4 CYCLONES

The cyclones wil be fitted with level sensors to detect any blockages in the bottom exits due, for example, to a faulty or blocked rotary valve. These will be alarmed, but no shut down is necessary as the baghouse is capable of maintaining its performance for short times with a high inlet loading if the cyclones become full and cease removing coarse particulate. Servicing should take place as soon as practicable.

7.5 LIME AND CARBON SILOS

These will have high and low level switches to shut off the feed when tripped and extraction using rotary valve or reversible screws. The status of the switches will be monitored on the plant control system with alarms.

7.6 MONITORING SUMMARY

A Summary of the relevant monitoring is provided in Table 7-1.

Table 7-1
Selected Monitoring Systems

Item	Reason	Monitoring	Threshold	Alarmed
Stacks	Smoke and opacity Annual compliance	Opacity Meter In stack sampling for PM_{10}, $PM_{2.5}$, SO_2, HCl, and HF	20%	Yes na
Fuel Consumption	Maintain correct combustion	Weighing	na	Yes
Oxygen level	Maintain correct combustion	O_2 sensor	na	na
Lime and carbon silos	Over-filling	High/low sensors	High/low	Yes
Baghouse	Broken, worn or dislodged bags Blocked bags Over-temperature or fire Blocked exit	Tribo-electric broken bag detector Differential pressure monitor Inlet and Outlet temperature Hopper Level switch	15 mg m^{-3} High	Yes Yes Yes Yes
Cyclones	Blocked exit	Level detectors	na	Yes

8 CONCLUSIONS

The proposed Paerewa facility will take a variety of raw materials that include municipal solid waste, tyres and flock and convert it into a refined RDF fuel for use in three boilers to raise steam that will be used to produce electricity from steam-turbine driven generators.

The discharges to air from the RDF fired boilers have been assessed using traditional computer based dispersion models. The model chosen for this assessment is CALPUFF that uses local or derived local meteorological data together with the maximum expected rates of discharge of a number of species to determine the potential off site levels. In this assessment a meteorological data set was prepared for Te Awamutu using nearby meteorological stations.

A conservative approach to the modelling was adopted by assuming a low calorific fuel that results in more fuel being burned than would actually occur with normal operation. The models also assumed all three boilers were operating at 100% MCR 24/7 for 365 days per year - again a conservative assumption. Finally the emission rates of all contaminants were assumed to be at the proposed emission limit that is usually about two to three times higher than the rates that occur in practice.

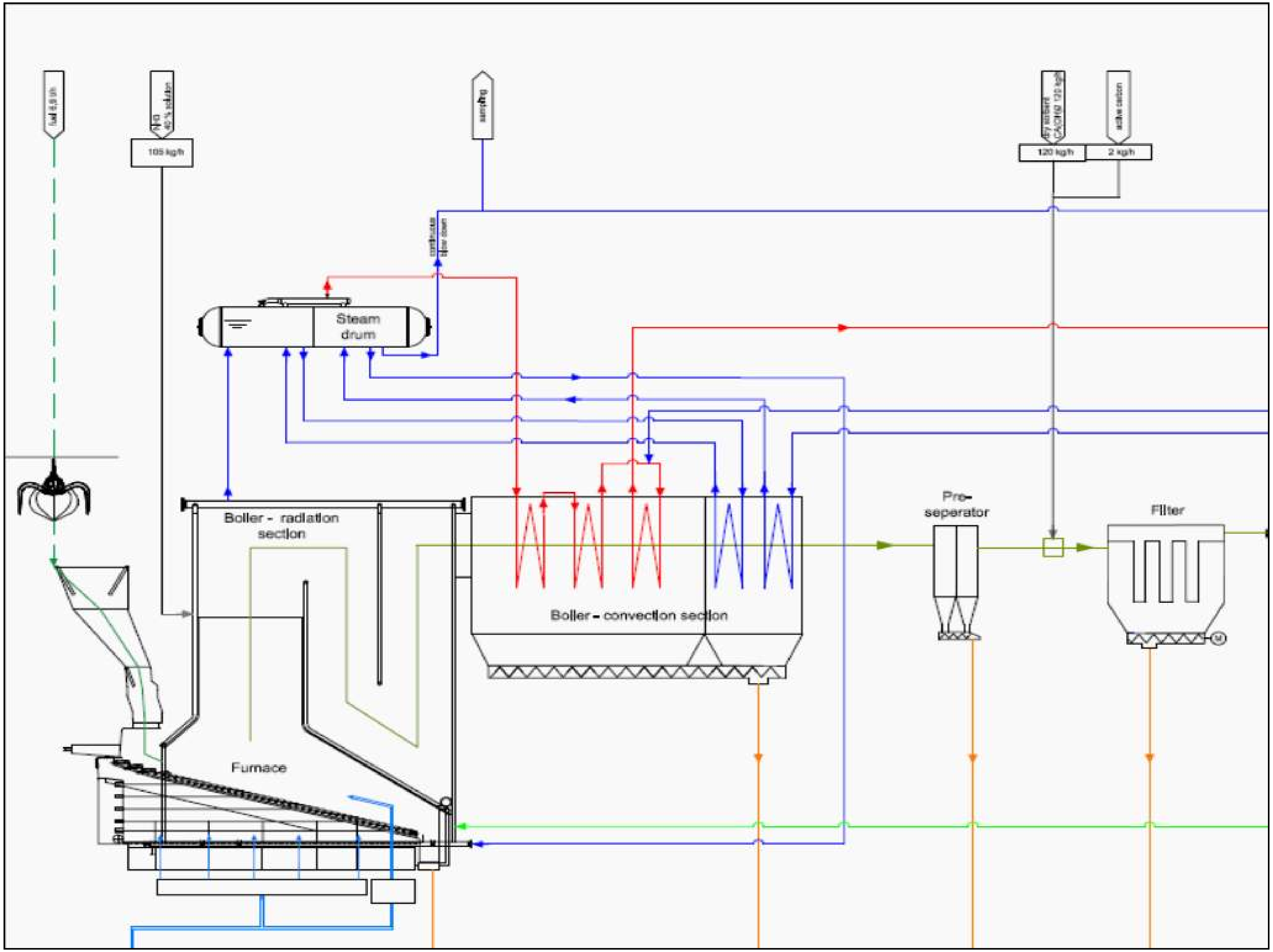
CALPUFF predictions for this application included particulate matter PM_{10} and $PM_{2.5}$, sulphur dioxide, nitrogen dioxide, carbon monoxide, mercury, and dioxins, and each of these has been assessed against a number of ambient standards with the predicted effects ranging from less than minor (trivial) to no more than minor. As the modelling is considered to be conservative, the effects are expected to be even less than those predicted.

Other effects such as odour and dust or fugitive particulate emissions will be controlled using a 4 tier approach that includes, pre-processing of a large portion of the material off-site, excluding putrescible and odourous material, the use of a double door air lock system and maintaining a slight negative pressure within the building. The first of these means that there will be no significant odour that requires control, but the remaining three controls ensure that both any slight residual odour and particulate discharges are well controlled.

APPENDIX A

BOILER DETAILS

Boiler Detail



APPENDIX B

EMISSION DATA

B1 Flue Gas Data

B2 Emission Calculations

B3 Fuel Consumption and Flue Gas Comparison

B4 Combustion Data

B1 Flue Gas Data

Fuel Consumption And Flue Gas Data Per Unit				
Exit Temperature	C	175	448.15	K
Stack Height	m	38		
Stack ID	m	1.15		
Total Steam to Turbines	TPH	80		
No of Units	No	3		
Steam Output per Unit	Tonne hr^{-1}	26.7		
Hfg From and at 100 °C	kJ kg^{-1}	2257		
Heat Required	MJ hr^{-1}	60186	60186	60186
Efficiency Overall (Worst case)	%	**72**	**73**	**75**
Heat Input Required	MJ hr^{-1}	83848	82799	80249
Heat Input Required	MW	23.3	23.0	22.3
LHV	MJ kg^{-1}	**10**	**12**	**15**
Fuel Required	kg hr^{-1}	**8385**	**6900**	**5350**
Residual O2 % (dry gas)	%	6	6	6
Flue Gas	Am^3 hr^{-1}	62580	59089	56174
Flue Gas	Nm^3 hr^{-1} (dry)	**31122**	30390	29114
Exit Velocity	m sec^{-1}	16.7	16	15
CO_2 Factor	kg kg^{-1}	1.043	1.24	1.35
CO_2 Emission	kg hr^{-1}	8749	8568	7217

Note that the boilers are rated at a Nominal 6900 kg h^{-1} for 12 MJ kg fuel, and a nominal stack exit temperature of 200 C. For the purposes of this assessment, 10 MJ kg-1 fuel is assumed with a lower stack temperature of 175 so that short term effects due to operation variability will not be under-estimated.

B2 Emission Calculations

Emission Calculation

LHV	10	**MJ kg^{-1}**
Using Fuel Consumption of	8385	**kg hr^{-1}**
Gross Heat Output	83848	**MJ hr^{-1}**
Flue gas	31122	**Nm^3 hr^{-1} (dry)**
% NOx as NO_2	5	**%**

	Concentration mg Nm^{-3} Dry Gas 11% O_2	**Concentration mg Nm^{-3} Dry Gas 6% O_2**	**Emission Rate kg hr^{-1}**
Emissions Germany Limits for "Waste" as Fuel			
Particulate TSP	**10**	15	**0.47**
Particulate PM10	10	15	**0.47**
Particulate PM2.5	10	15	**0.47**
SO2	**50**	75	**2.33**
NOx as NO2	**150**	225	**7.00**
NO2	**7.5**	11	**0.35**
HCl	**10**	15	**0.47**
HF	**1**	1.5	**0.047**
Hg	**0.03**	0.045	**0.00140**
CO	**50**	75	**2.33**

PCDD/PCDF Emissions

Heat Gross Output	83848	MJ hr^{-1}
Flue Gas Nm-3 Dry Gas 6% O2	31122	Nm^{-3} hr^{-1}
Fuel Consumption	8385	kg hr^{-1}

USEPA C02s01.pdf	**kg Mg^{-1} or kg Tonne^{-1}**	**Concentration mg Nm^{-3} Dry Gas 6% O_2**	**Emission Rate kg hr^{-1}**
USEPA PCDD/PCDF SI Units	1.22E-08	3.29E-12	**1.02E-07**
PCDD/PCDF TEQ units (note 1)	2.44E-10	6.57E-14	**2.05E-09**
PCDD/PCDF WHO-TEQ units (note 2)	2.68E-10	7.23E-14	**2.25E-09**

Note 1. USEPA factor 1:50 for g to I-TEQ

EPA-454/R-97-003 LOCATING AND ESTIMATING AIR EMISSIONS FROM SOURCES OF DIOXINS AND FURANS May 1997

Note 2. 10% increase convert to WHO-TEQ

WHO Consultation May 25-29 1998, EXECUTIVE SUMMARY

Assessment of the health risk of dioxins: re-evaluation of the Tolerable Daily Intake (TDI)

B3 Fuel Consumption and Flue Gas Comparison

Fuel Consumption And Flue Gas Comparison Per Unit

Fuel CV (LHV)	MJ kg^{-1}	10	12	15
LHV	MJ kg^{-1}	10	12	15
Fuel Required	kg hr^{-1}	8385	6900	5350
Residual O2 % (dry gas)	%	6	6	6
Flue Gas	$\text{Am}^3\ \text{hr}^{-1}$	62580	59089	56174
Flue Gas	$\text{Nm}^3\ \text{hr}^{-1}$ (dry)	31122	30390	29114
Exit Velocity	m sec^{-1}	16.7	16	15

	Concentration mg Nm^{-3} Dry Gas 6% O_2	Emission Rate kg hr^{-1}	Emission Rate kg hr^{-1}	Emission Rate kg hr^{-1}	Diesel Emission Rate kg hr^{-1}
Particulate TSP	15	0.47	0.46	0.44	0.13
Particulate PM10	15	0.47	0.46	0.44	0.13
Particulate PM2.5	15	0.47	0.46	0.44	0.03
SO2	75	2.33	2.28	2.18	0.019
HCl	15	0.47	0.46	0.44	-
HF	2	0.05	0.05	0.04	-
Hg	0.03	0.00140	0.00137	0.00131	-
CO	75	2.33	2.28	2.18	0.64

Note. Emissions for diesel are total for 2 x 6.25 MW burners operating at 100 % MCR

B4 Combustion Data

RDF ulitmate analysis provided by boiler supplier Lambion Energy Solutions GmbH

```
             WINFLUE2 v1.3 TJBrady 2000 - 2004
           COMBUSTION FLUE GAS CALCULATOR for WINDOWS
           Terry Brady Consulting Ltd (c). All rights reserved

           COMBUSTION CALCULATIONS FOR     RDF10 MJ.inp

           RDF Boiler

           Output File    D:\Jobs\3263\5000\TJB Calcs\RDF10 MJ.txt
           DATED          11:22:55   08-20-2021



          COMPUTED VALUES ARE BASED ON THE ULTIMATE ANALYSIS
          OF THE FUEL AS FOLLOWS

          C =  28.4 %
          H =  4.2 %
          O =  29.4 %
          N =  0.4 %
          S =  0.1 %
        H2O =  24.5 %
        ASH =  13 %
      TOTAL =  100 %

======================================================================
OTHER USER INPUT DATA
======================================================================

Fuel Combustion Rate         8385  kg per hour
Air H2O Internal calc from   70% RH and
Inlet Air Temperature        20  °C
Inlet Air Moisture           0.01026  kg/kg dry air
Stack Temperature            175  °C
Ambient CO2                  370ppm or 0.037%
Sulphur Retention            0  %
Final Flue Gas Dry O2        6 %

======================================================================
INTERMEDIATE MODEL CALCULATIONS
======================================================================

STOICHIOMETRIC VALUES FOR EXCESS AIR FACTOR E=1 ARE
VOLUMES CORRECTED TO 0°C
Required oxygen              6707.408  kg hr-1           4698.05 m3 hr-1
Required DRY air             29074.729  kg hr-1          22428.27 m3 hr-1
CO2 Emission                 8742.587  kg hr-1           4452.474 m3 hr-1
H2O Emission                 5524.891  kg hr-1           6873.503 m3 hr-1
Total wet flue gas           36670.561  kg hr-1          29096.361 m3 hr-1



REQUIREMENTS FOR EXCESS AIR FACTOR E= 1.5 ARE

Reqd DRY air                 43612.093  kg hr-1          33642.405 m3 hr-1 @ 0°C
Reqd MOIST air At ambient    44059.422  kg hr-1          36702.965 m3 hr-1 @ 20 C


ACTUAL FLUE GAS OUTPUTS WITH VOLUMES CORRECTED TO  448.15 K   or  175  °C
```

```
O2   Discharge               3353.704  kg hr-1           3853.981 m3 hr-1
CO2  Discharge               8750.734  kg hr-1           7324.311 m3 hr-1
H2O  Discharge               5674  kg hr-1               11581.531 m3 hr-1
SO2  Discharge               16.754  kg hr-1             9.617 m3 hr-1
Total wet flue gas           51355.273  kg hr-1          66414.714 m3 hr-1
Total dry flue gas           45681.273  kg hr-1          54833.182 m3 hr-1
CO2 CONC by VOL % Dry        13.33
CO2 CONC by VOL % Wet        11.01
O2  CONC by VOL % Dry        7.03
O2  CONC by VOL % Wet        5.8
DRY SO2                      501.309 mg m-3 (corrected to 0°C Dry Gas)
ACTUAL (wet) SO2             252.268 mg m-3 (at stack temperature)

Total dry Flue gas at 0°C   33421.139 m3 hr-1 @  7.03 % O2 or    13.33 % CO2



======================================================================
FINAL OUTPUT CONDITIONS FOR SPECIFIED PARAMETERS
======================================================================


REQUIREMENTS FOR EXCESS AIR FACTOR E= 1.4 ARE

Reqd DRY air                 40631.961  kg hr-1          31343.528 m3 hr-1 @ 0°C
Reqd MOIST air At ambient    41048.723  kg hr-1          34194.952 m3 hr-1 @ 20 C

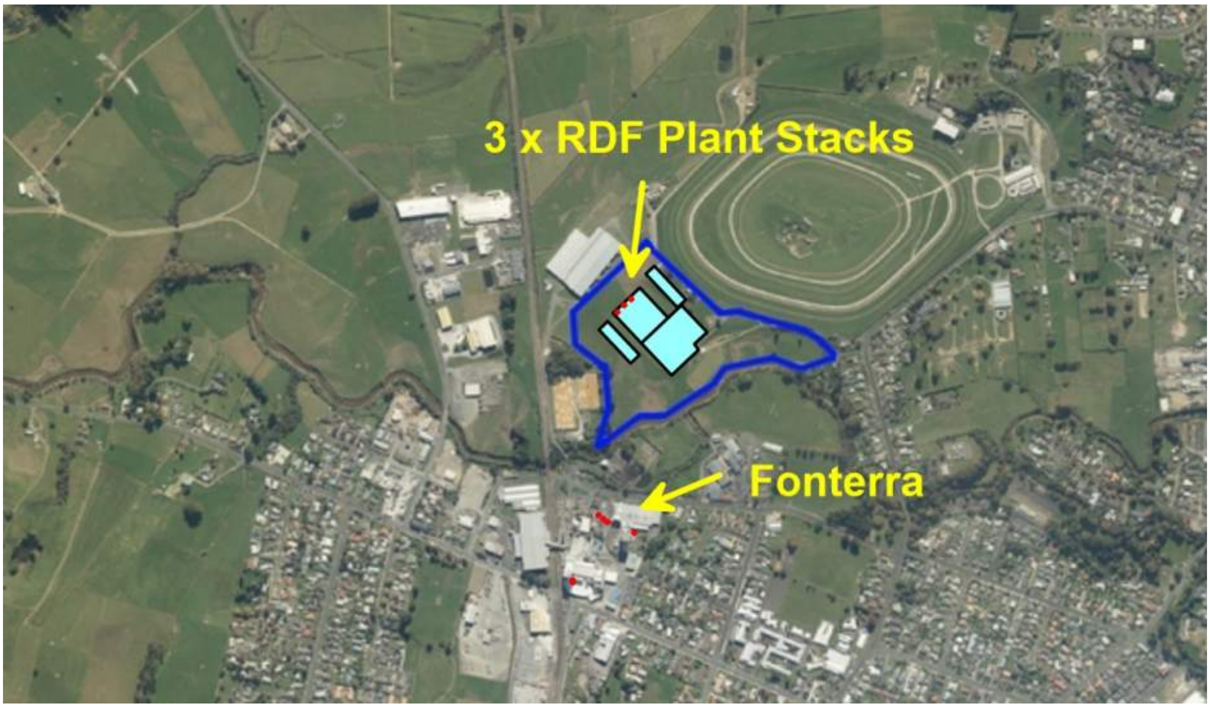

ACTUAL FLUE GAS OUTPUTS WITH VOLUMES CORRECTED TO  448.15 K   or  175  °C

O2   Discharge               2666.201  kg hr-1           3063.923 m3 hr-1
CO2  Discharge               8749.063  kg hr-1           7322.064 m3 hr-1
H2O  Discharge               5643.433  kg hr-1           11519.138 m3 hr-1
SO2  Discharge               16.754  kg hr-1             9.617 m3 hr-1
Total wet flue gas           48344.574  kg hr-1          62580.616 m3 hr-1
Total dry flue gas           42701.141  kg hr-1          51061.477 m3 hr-1
CO2 CONC by VOL % Dry        14.32
CO2 CONC by VOL % Wet        11.68
O2  CONC by VOL % Dry        6
O2  CONC by VOL % Wet        4.9
DRY SO2                      538.338 mg m-3 (corrected to 0°C Dry Gas)
ACTUAL (wet) SO2             267.724 mg m-3 (at stack temperature)

Total dry Flue gas at 0°C   31122.263 m3 hr-1 @  6 % O2 or    14.32 % CO2
```

APPENDIX C

STACK LOCATIONS


3 x RDF Plant Stacks
Fonterra

APPENDIX D

METEOROLOGICAL DATA

CALMET Meteorological Model for Te Awamutu

Memo 2107_01 (version 01) for Terry Brady Consulting
Neil Gimson, NRG Science NZ, 1 May 2021
Wellington, New Zealand

1.0 Introduction

This memorandum provides information on the meteorological modelling carried out in support of an Assessment of Effects on the Environment (AEE) prepared by Terry Brady Consulting (TBC). The modelling uses a combination of climate-monitoring data, The Air Pollution Model (TAPM) and the CALMET model to simulate the meteorology of an area centred on Te Awamutu. The area extends to Hamilton, Tokanui and Waikeria to include local climate monitoring stations. The modelling was done for a three-year period (complete years 2014, 2015 and 2016).

The text and figures in this memo may be used in the full AEE; figures are high resolution and will remain sharp when enlarged.

2.0 Meteorological Modelling

2.1 Introduction

Meteorological inputs for TBC's dispersion modelling have been developed using the CALMET model (see Scire *et al.*, 1999). In the absence of routine atmospheric soundings in the area, upper-air information was provided to CALMET using the meteorological component of TAPM (see Hurley *et al.*, 2005).

The following general comments are made regarding the modelling methodology:

- Surface-based data from monitoring sites at Hamilton Airport, Tokanui and Waikeria have been assimilated into the modelling.
- These sites are some distance from Te Awamutu and are outside the CALMET computational domain. Therefore, they are not used in the CALMET modelling.
- However, the TAPM computational domain does include these site locations, and the data are assimilated into the TAPM runs. They are thus able to influence the meteorology of Te Awamutu, and this influence propagates from TAPM through to CALMET.

2.2 TAPM configuration

TAPM contains a prognostic meteorological model that calculates hourly, three-dimensional fields of meteorological variables such as wind, temperature, and atmospheric turbulence. It was configured as a set of nested grids of points, with successively smaller areas at higher resolution. Each of four grids contained 33 x 33 cells in the horizontal directions, with grid-cell resolution 27 km, 9 km, 3 km, and 1 km, and 25 levels in the vertical. The first (coarsest and largest) grid covered the North Island of New Zealand and the top of the South Island; the fourth, finest grid covered an area 33 km x 33 km around Gisborne and southern parts of Hamilton.

TAPM models the large-scale wind fields in three dimensions in hourly steps. In addition to being driven by global meteorological analyses supplied by its developers (CSIRO), wind data from local climate sites were assimilated into TAPM, to improve its surface-level wind patterns. Sites used were MetService's Hamilton Airport AWS, the AgResearch site at Tokanui, and the NIWA-run EWS at Waikeria[60].

The configuration parameters used in the TAPM model runs are tabulated in Appendix A. The electronic files used to set up TAPM are available on request. **Figure 8-1** shows the locations of the finest TAPM grid, the CALMET grid (see section 0), and the three climate sites. Wind roses for the climate sites are shown in **Figure 8-2**, along with a TAPM-generated wind rose for a point in central Te Awamutu. The distribution of wind speed

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[60] Data from Waikeria EWS were available from March 2016 only.

and direction has different characteristics at each climate site, with prevailing westerlies at Hamilton Airport, and lower wind speeds at Tokanui. TAPM assimilates these data, weighted according to distance from the site, to produce the wind rose at Te Awamutu shown in **Figure 8-2** (lower right panel). This has a moderate westerly component, but generally lighter winds, like those at Tokanui. Tokanui is closer than Hamilton to Te Awamutu. The wind field in TAPM varies in three-dimensions; outputs were extracted from TAPM and converted using the CALTAPM utility to provide hourly initialization data for CALMET.

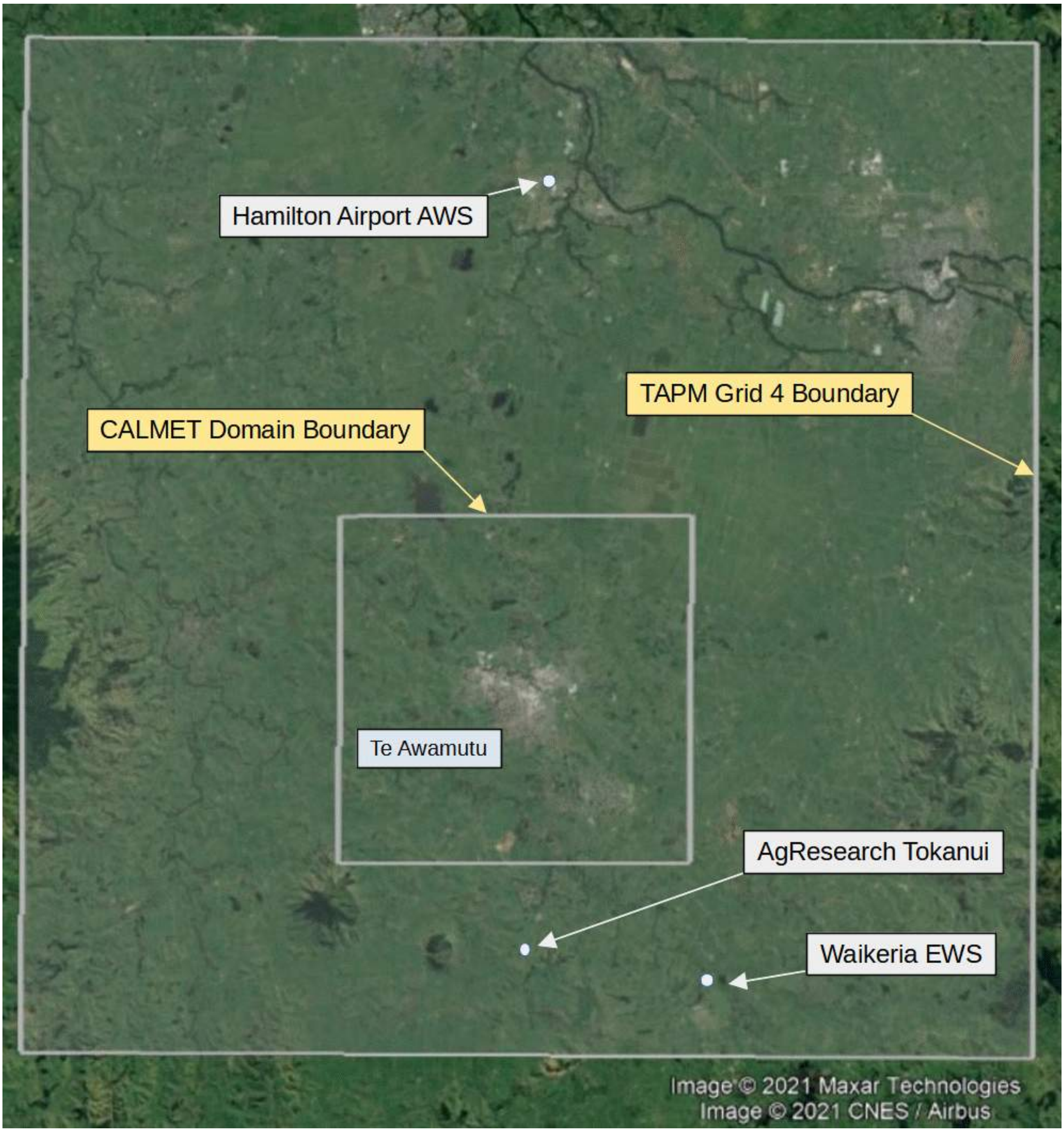
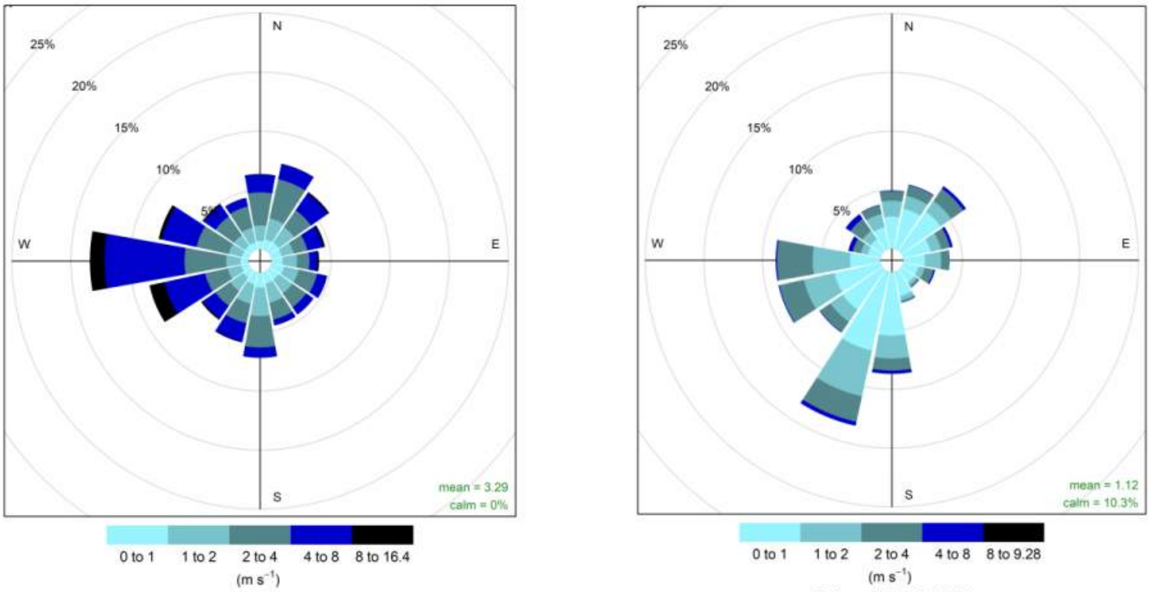
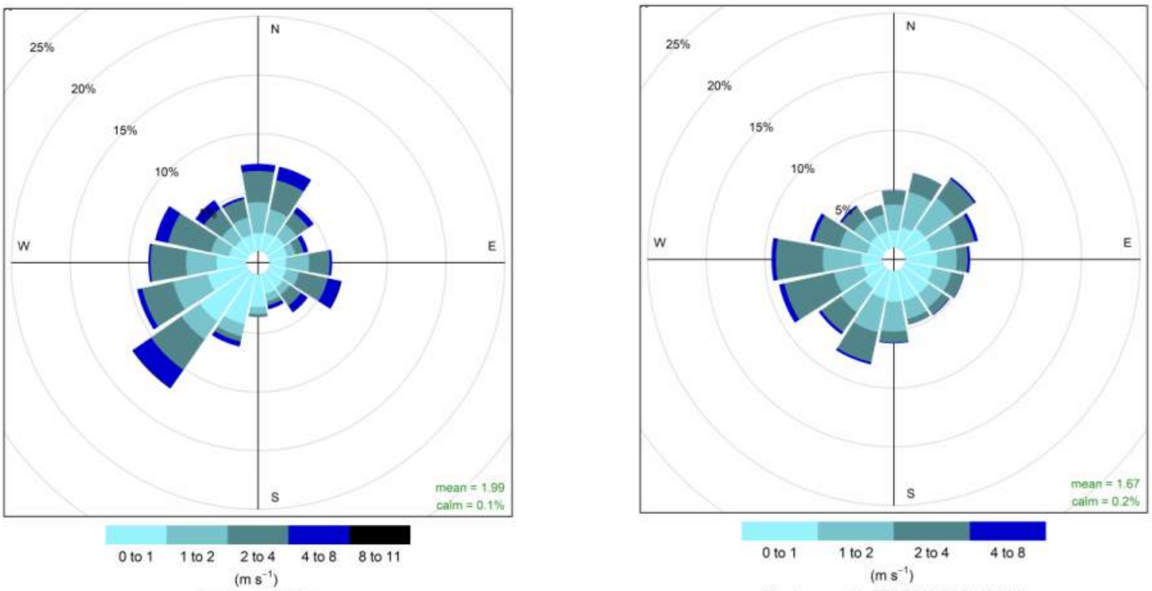


Figure 8-1: Inner TAPM domain (grid4, 1 km horizontal resolution), CALMET model domain and meteorological monitoring sites. Aerial photograph from Google Earth.



Hamilton Airport 2014-2016

Tokanui 2014-2016



Waikeria 2016

Te Awamutu (TAPM) 2014-2016

Figure 8-2 Wind roses for the three climate sites (top left, top right, lower left). Wind rose from TAPM for Te Awamutu (lower right).

2.3 CALMET configuration

CALMET was run over an area 11 km by 11 km at a horizontal grid resolution of 200 m, to provide a fine-resolution grid of meteorological data for the CALPUFF dispersion model. CALMET is initialized each hour by TAPM outputs. It interpolates the three-dimensional outputs at 1 km resolution, onto the 200 m grid. It then superposes terrain-driven flows at the new resolution. As mentioned above, the climate sites are outside the CALMET model domain, and are therefore not used in the CALMET run.

CALMET requires terrain and land use data on the model's regular 200 m grid. Landcover data were obtained from the LRIS portal[61], under the Creative Commons Attribution 4.0 International License. Terrain data were obtained from the LRIS portal, under the Landcare Data Use License[62]. Terrain and land use derived for the 200 m grid are shown in **Figure 8-3**. CALMET's land use classes are urban (10), agriculture (20), rangeland (30), forest (40), water (54), wetlands (62) and barren land (70).

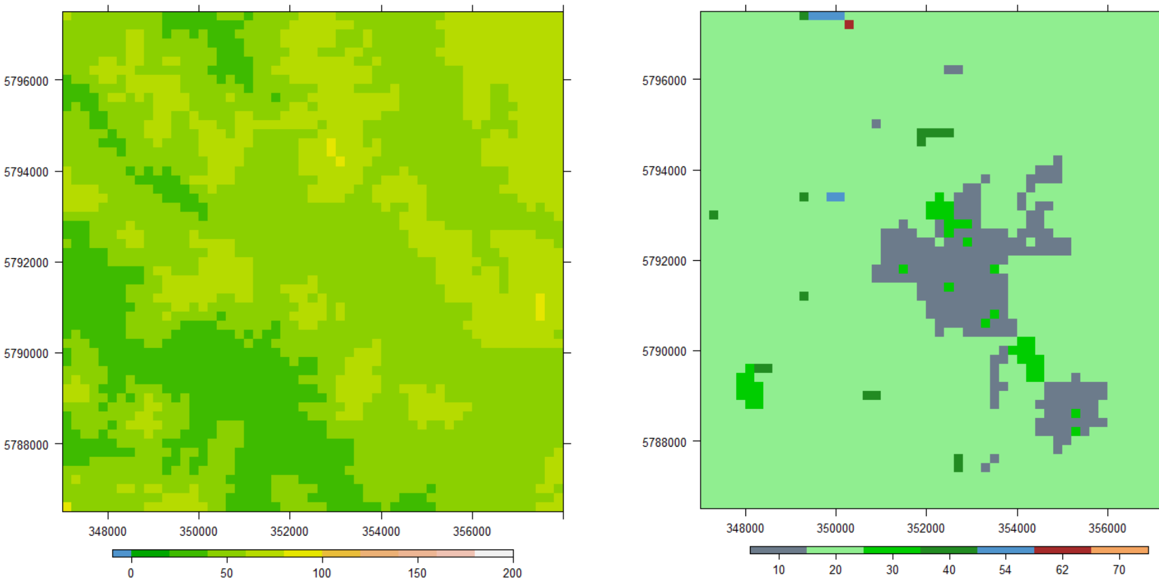


Figure 8-3 Terrain and land use classes, used by CALMET. . Axes are in metres (UTM zone 60S); terrain heights are in metres

Over the domain shown in **Figure 8-3**, the terrain is gently undulating, with elevations less than around 60 m above sea level. Strong terrain effects are not expected, so that the CALMET wind fields – and therefore the wind rose - are not expected to differ greatly from those from TAPM. Configuration parameters for the CALMET modelling are summarized in Appendix B. The electronic files used to set up CALMET are available on request.

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[61] https://lris.scinfo.org.nz/layer/104400-lcdb-v50-land-cover-database-version-50-mainland-new-zealand/ *Note, this work is licensed under the Creative Commons Attribution 4.0 International License. To view a copy of this license, visit http://creativecommons.org/licenses/by/4.0/ or send a letter to Creative Commons, PO Box 1866, Mountain View, CA 94042, USA.*

[62] Refer to https://lris.scinfo.org.nz/license/landcare-data-use-licence-v1/ for more information.

REFERENCES

Hurley, P., Physick, W. and Luhar, A. (2005) ‘TAPM - A practical approach to prognostic meteorological and air pollution modelling’, *Environmental Modelling & Software*, pp. 20:737-752.

MfE (2004) *Good practice guide for atmospheric dispersion modelling*. Report ME522. Wellington, New Zealand: Ministry for the Environment.

Scire, J. *et al.* (1999) *A User’s Guide for the CALMET Meteorological Model (Version 5.0)*. Concord, Massachusetts: Earth Tech.

Appendix A – TAPM Configuration

The parameters used to set up TAPM are shown in the following table. Parameters not mentioned in the table are not required or take default values.

Parameter name	Parameter value(s)	Units
Centre latitude and ongitude	(37.9666672, 175.324997)	degrees south and east (WGS84)
Centre cartesian coordinate	(352868, 5796560)	metres (UTM zone 60S)
Number of grid points	33 x 33	
Number of grids	4	
Grid resolutions	(27, 9, 3, 1)	kilometres
Number of model levels	25	
Levels	(10, 25, 50, 100, 150, 200, 250, 300, 400, 500, 600, 750,1000, 1250, 1500, 1750, 2000, 2500, 3000, 3500, 4000, 5000, 6000, 7000, 8000)	metres above ground leve
Start date	1 January 2014	
End date	31 December 2016	
Wind observation sites	Hamilton AWS, AgResearch Tokanui, Waikeria EWS[63]	
Site coordinates	(353593, 5807857), (352524, 5783691), (358613, 5782452)	metres (UTM zone 60S)
Site mast heights	10, 3, 10	metres above ground leve
Site radius of influence	21, 12, 16	kilometres

---

[63] Waikeria data are available from March 2016 only.

Appendix B – CALMET Configuration

The parameters used to set up CALMET are shown in the following table. Parameters not mentioned in the table are not required or take default values.

Parameter name	Parameter value(s)	Units
Start date and time	1 January 2014 00:00	NZST, UTC + 12h
End date and time	1 January 2017 00:00	NZST, UTC + 12h
Model time step	3600	seconds
Geodetic datum	WGS-84	
Map projection	UTM, zone 60S	
Southwest corner coordinates	(347, 5786.5)	kilometres, UTM
Number of grid points	55 x 55	
Grid resolution	200	metres
Number of layers	11	
Layer face heights	0, 20, 50, 100 , 200 , 300 , 450, 650, 950, 1400, 2000, 3000.	metres above ground level
Observation mode	No observations, use TAPM outputs only	
Extrapolation of surface winds	No extrapolation	
Inputs from prognostic model	Data from TAPM as the initial-guess field	
Terrain radius of influenc	1	kilometre
Number of surface meteorological stations	None	
Number of upper-air profile sites	None	
Number of precipitation stations	None	

APPENDIX E

BPIP and CALPUFF MODEL INPUT DATA

Source	X Coordinate (km)	Y Coordinate (km)	Stack Height (m)	Base Elevation (m)	Stack Diameter (m)	Exit Vel. (m/s)	Exit Temp. (deg. K)	$PM_{10/}PM_{2.6}$ kg/hr	SO_2 kg/hr	NOx kg/hr	CO kg/hr	Hg kg/hr	HCl kg/hr	HF kg/hr	PCDD/PCDF kg/hr
----	-- ----------	----------	------	------	--------	-----	--------	--------	--------	--------	--------	--------	--------	--------	--------
WEP1	351.7549	5792.9098	38	45	1.15	16.7	448.15	0.47	2.33	7	2.33	0.0014	0.47	0.05	2.25E-09
WEP2	351.7695	5792.9230	38	45	1.15	16.7	448.15	0.47	2.33	7	2.33	0.0014	0.47	0.05	2.25E-09
WEP3	351.7840	5792.9373	38	45	1.15	16.7	448.15	0.47	2.33	7	2.33	0.0014	0.47	0.05	2.25E-09

RDF Plant BPIP input data

```
'BPIP  RDF.'
'P'
'METERS' 1.0
'UTMN' 0.00
4
'BOILER' 1 45
4 35
351744.9 5792906.9
351803.4 5792962.1
351865.0 5792896.6
351806.8 5792841.3
'RECYCLE' 1 45
6 23
351931.1 5792826.8
351872.6 5792771.6
351806.8 5792841.3
351894.2 5792924.1
351949.8 5792865.4
351922.1 5792839.7
'EDUCATION' 1 45
4 15
351885.4 5792919.1
351816.5 5792992.1
351835.0 5793009.5
351903.8 5792936.5
'GENERATOR' 1 45
4 20
351783.4 5792797.7
351714.4 5792870.9
351733.7 5792889.1
351802.7 5792816.0
3
'WEP1' 45 38 351754.9 5792909.8
'WEP2' 45 38 351769.5 5792923.5
'WEP3' 45 38 351784.0 5792937.3
0
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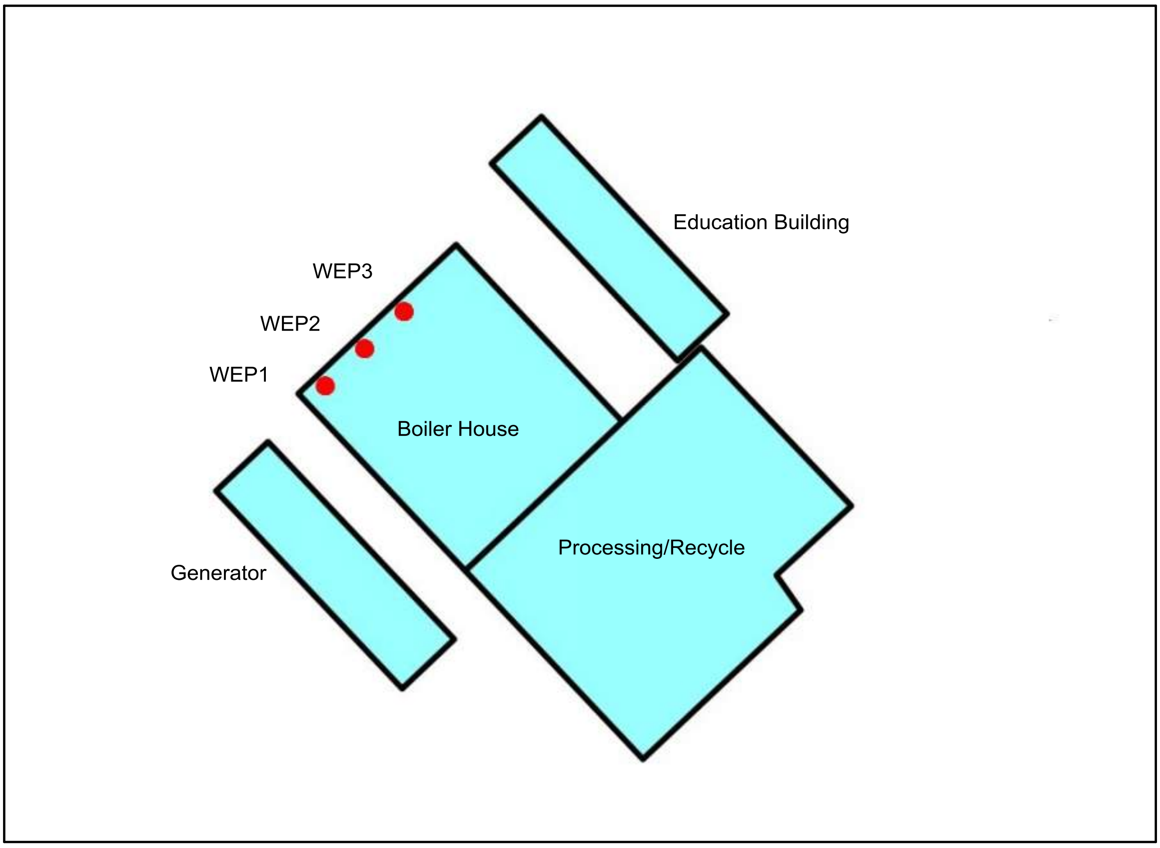

Education Building
WEP3
WEP2
WEP1
Boiler House
Processing/Recycle
Generator

APPENDIX F

FONTERRA MODEL INPUTS

Fonterra Discharge Parameters

	Model ID	X Coord UTM km	Y Coord UTM km	Stack Height (m) -----	Base Elevation (m) --------	Stack Diameter m -----	Exit Vel. m/s -----	Exit Temp. (K) -----	PM_{10} Emission Rates kg/hr --------	$PM_{2.5}$ Emission Rates kg/hr	NOx Emission Rates kg/hr
Whole Milk Plant	WMP	351.792	5792.428	46	44	14	0.45	346	1.8	1.58	-
Skim Milk Plant A	SMPA	351.657	5792.322	44	49	2.4	12.9	359	2.1	1.84	-
Skim Milk Plant B	SMPB	351.658	5792.326	44	50	1.8	12.4	359	1.1	0.97	-
Gas Fired Turbine	45GTG	351.733	5792.453	35	46	3.65	17	523	1.2	1.2	26.2
Solid Fuel Burner	SFB	351.713	5792.467	62	47	1.9	14	428	2.8	2.46	42.2
Gas Fired Boiler	GFB	351.725	5792.458	20	48	1.4	20	407	0.6	0.6	20.6

PM2.5 to PM10 Ratio for wood boiler and powder dryers taken from AP-42 Section 1.6 Wood Residue Combustion in Boilers c01s06 2003
that is typical of fabric filter discharges Table 1.6-1.
Gas fired discharges assume all PM10 is PM2.5

PM10	0.74 lb/MMbtu)
PM2.5	0.65 lb/MMbtu)
PM2.5:PM10	0.88

UTM Zome 60S

FONTERRA BPIP

```
'BPIP Fonterra.'
'P'
'METERS' 1.0
'UTMN' 0.00
8
'LOTUS' 1 42.00
15 12
351517 5792522
351594 5792530
351599 5792476
351591 5792475
351592 5792473
351565 5792470
351562 5792476
351536 5792473
351535 5792488
351519 5792487
351518 5792495
351506 5792493
351506 5792507
351508 5792512
351518 5792514
'Coolstore' 1 47.00
16 47
351549 5792464
351603 5792469
351605 5792445
351612 5792447
351614 5792428
351618 5792428
351621 5792390
351617 5792390
351619 5792371
351611 5792371
351613 5792348
351562 5792342
351559 5792370
351543 5792370
351539 5792421
351553 5792423
'Boiler House' 1 46.00
4 12
351695 5792459
351716 5792455
351712 5792426
351690 5792429
'WMP Drier' 1 44.00
4 43
351777 5792442
351804 5792439
351801 5792412
351775 5792414
'Powder Store' 1 43.00
6 12
351765 5792489
351763 5792450
351845 5792440
351846 5792446
351860 5792444
```

```
351865 5792479
'SMP Exist' 1 48.00
6 23
351678 5792364
351747 5792353
351739 5792302
351706 5792309
351700 5792292
351666 5792300
'Butter' 1 48.00
4 17
351657 5792425
351650 5792378
351710 5792368
351717 5792413
'SMP New' 1 48.00
4 42
351679 5792364
351666 5792300
351643 5792304
351651 5792368
6
'WMP' 44.00 46.0 351792 5792428
'SMPA' 49.00 44.0 351657 5792322
'SMPB' 50.00 44.0 351658 5792326
'45GTG' 46.00 35.0 351733 5792453
'SFB' 47.00 62.5 351713 5792467
'GFB' 48.00 20.0 351725 5792458
0
```

APPENDIX G

WRC PM BACKGROUND MONITORING SITE

Location of Waikato Regional Council Te Awamutu ambient air quality monitoring site 2013 to mid 2016. The monitoring station was located at the southern end of Albert Park and adjacent to Park Rd.

APPENDIX H

OZONE LIMITING METHOD

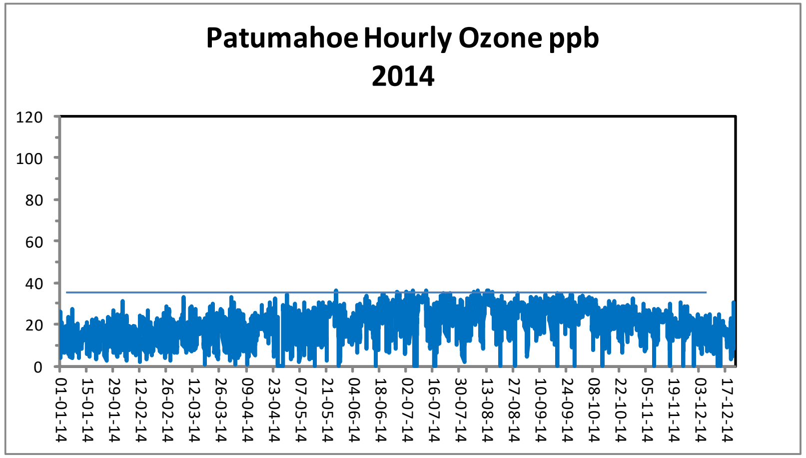
Background Ozone Levels.

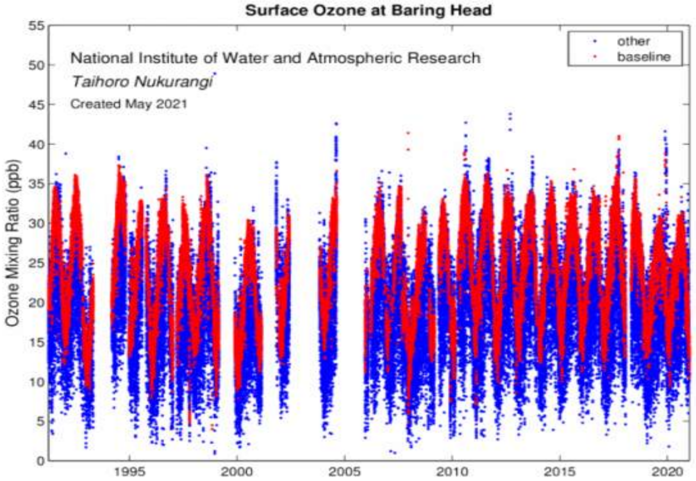
Showing similarity between Patumahoe and Baring Head

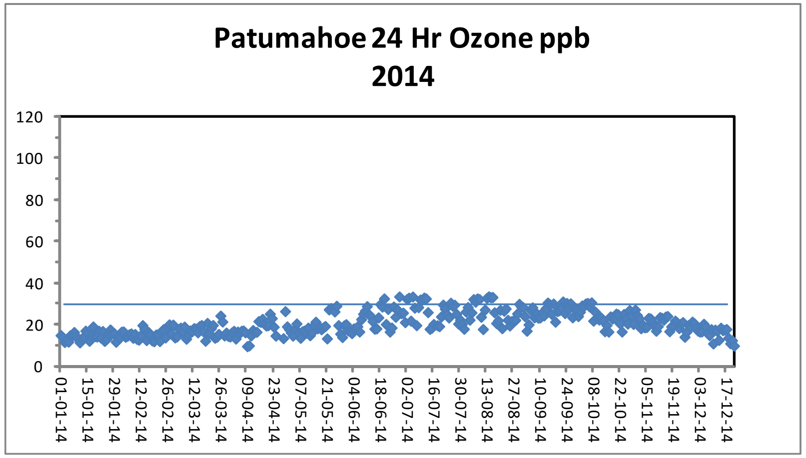
	O_3	+	NO	→	NO_2	+	O_2
MW	48		30		46		32

35ppb O_3 yeilds 35 ppb NO_2 = 35*46/22.4 = 72 µg m^{-3} NO_2

30ppb O_3 yeilds 30 ppb NO_2 = 30*46/22.4 = 62 µg m^{-3} NO_2







Derivation of Ozone Limiting Method Calculation

$[NO_2]$ = a+ $[NOx]_{tot}$ x10%				$[NO_2]$ = a+ $[NOx]_{tot}$ x 5%			
Percent NOx as NO_2		10 %		Percent NOx as NO_2		5 %	
Averaging Time	**O_3 ppb**	**a $\mu g\ m^{-3}$**	**Limit $\mu g\ m^{-3}$**	**Averaging Time**	**O_3 ppb**	**a $\mu g\ m^{-3}$**	**Limit $\mu g\ m^{-3}$**
1 Hr	35	72	80	1 Hr	35	72	76
24 Hr	33	68	76	24 Hr	33	68	72
Annual	20.49996	42	47	Annual	20.49996	42	44

The hourly O_3 is taken as 35 ppb the same as Baring Head

24 Hour O_3 average is the 99th %ile 24 hr average

Annual O_3 is the average for 2014

The limit value is the concentration below which all the NOx is assumed to be as NO_2

The percent NOx as NO_2 refers to the level of NO_2 in the discharge

1 Hr Equation $[NO_2]$ = 72 + $[NOx]_{tot}$ x 5% **For NOx less than 76 assume all as NO_2**

24 Hr Equation $[NO_2]$ = 68 + $[NOx]_{tot}$ x 5% **For NOx less than 65 assume all as NO_2**

Annual Equation $[NO_2]$ = 42 + $[NOx]_{tot}$ x 5% **For NOx less than 44 assume all as NO_2**

1 Hr				**24 Hr**				**Annual**			
Predicted NOx $\mu g\ m^{-3}$	NO_2 $\mu g\ m^{-3}$	Background** $\mu g\ m^{-3}$	Total $\mu g\ m^{-3}$	**Predicted NOx $\mu g\ m^{-3}$**	NO_2 $\mu g\ m^{-3}$	Background** $\mu g\ m^{-3}$	Total $\mu g\ m^{-3}$	**Predicted NOx $\mu g\ m^{-3}$**	NO_2 $\mu g\ m^{-3}$	Background** $\mu g\ m^{-3}$	Total $\mu g\ m^{-3}$
75	76	41	117	50	50	16	66	5	5	4	9
100	77	41	118	75	72	16	88	10	10	4	14
200	82	41	123	100	73	16	89	15	15	4	19
300	87	41	128	150	76	16	92				

▨ Less than the limit value

** Ref Use of Background Air Quality Data in Resource Consent Applications
July 2014 Guideline Document 2014/01
Auckland Council
Guideline Document 2014/01
ISBN 978-1-927302-46-0 (PDF)