REPORT

Technical Air Quality Assessment

Genera Limited

Submitted to:

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Distribution List

Abbreviations and Units

Acronym	Meaning
Genera	Genera Limited
BoPRC	Bay of Plenty Regional Council
MB	Methyl Bromide
EDN	Ethanedinitrile
VOC	Volatile Organic Compound
GC-FID	Gas Chromatography Flame Ionisation Detector
PID	Photoionization detector (measures total VOCs)
GPG Industry	Good Practice Guide for assessing discharges to air from industry
MfE	Ministry for the Environment
TELs	Tolerable Exposure Limits
OEHHA	Office of Environmental Health Hazard Assessment
WHO	World Health Organisation
TSLC	Texas screening limit criteria
$\mu g/m^3$	Milligram per cubic metre
°C	Degrees Celsius

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1.0 INTRODUCTION

Genera Limited (Genera) holds a resource consent from the Bay of Plenty Regional Council Consent (BoPRC) (No. 62719) that authorises discharges of contaminants to air from the fumigation processes at the Port of Tauranga. A copy of No. 62719, which expires on 30th April 2020, is provided in APPENDIX B.

Genera seeks to continue discharging contaminants into air from its fumigation operation at the Port of Tauranga. Golder Associates (NZ) Limited (Golder) has been engaged to prepare an assessment of the potential air quality effects resulting from air contaminants discharged to air associated with fumigation processes operated by Genera at the Port of Tauranga. This report[1] will form part of an assessment of environmental effects (AEE) and an associated application for renewal of the site's existing air discharge consent.

This assessment considers the potential effects from the discharges of methyl bromide (MB) from the fumigation processes using MB at the Port of Tauranga. A significant portion of this report is focussed on describing the MB emissions from the operation. These measured and calculated values are then used as the basis for a modelling-based assessment of short and long-term air contaminant exposure concentrations (arising from the fumigation discharge). Directly measured MB levels at key on-site and off-site locations, in combination with meteorological conditions and operational information is also used to provide further information on current MB concentrations. The assessment concludes with predictions of offsite MB concentrations as result of future Genera operation that are based on both the modelling and the monitoring data.

2.0 SITE AND OPERATIONAL INFORMATION

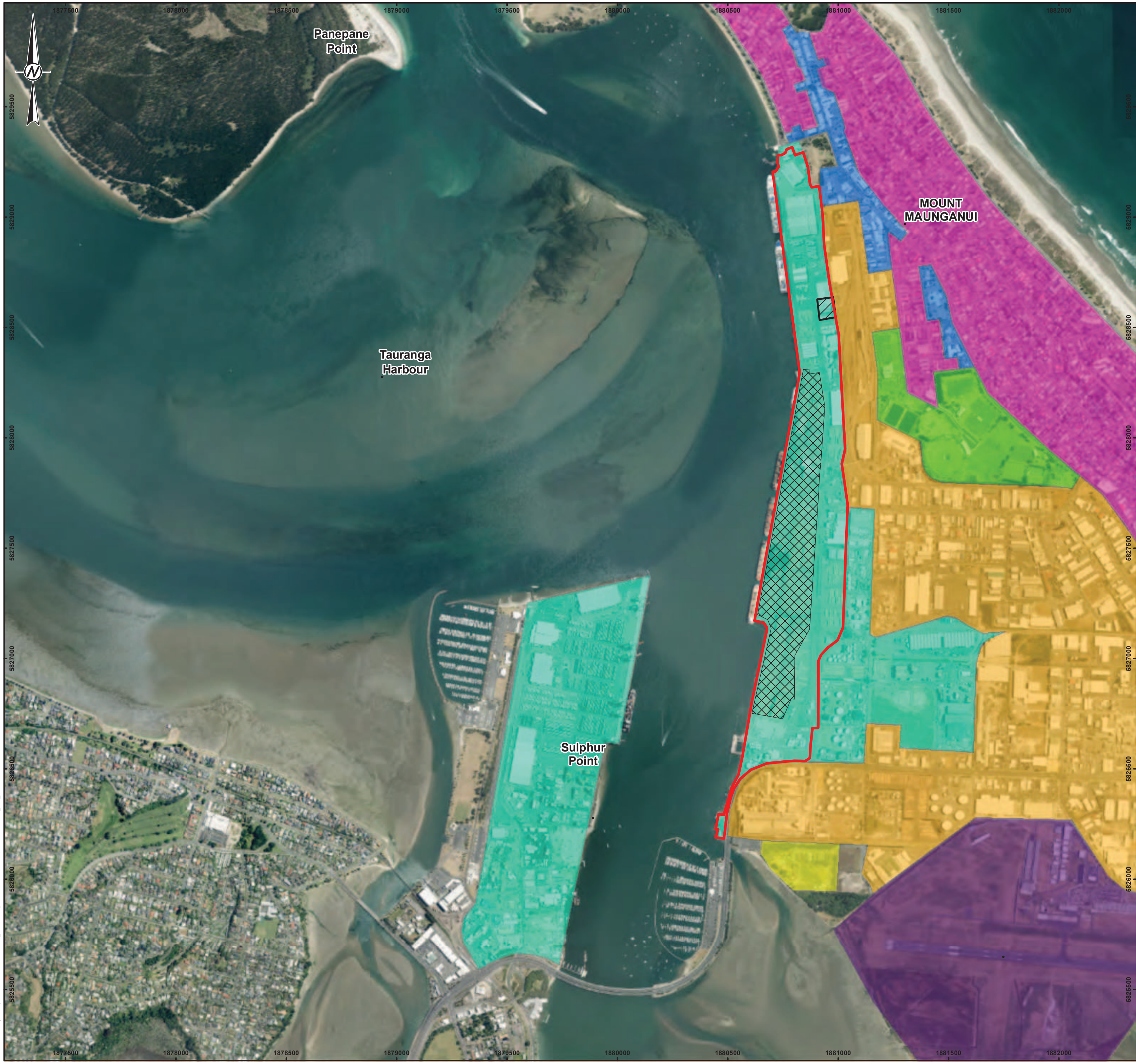
2.1 Introduction

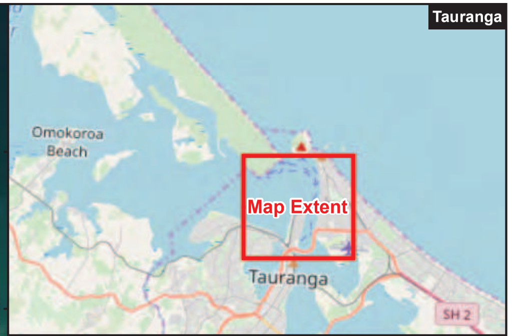
Genera is a biosecurity company which carries out fumigations at the Port of Tauranga. The Port of Tauranga is a large, highly active port which processes a significant portion of New Zealand's log exports. Genera's activities include the fumigation of log stacks, ship holds and containers with MB as required for biosecurity reasons. The main fumigation areas operated by Genera within the Port of Tauranga are shown in Figure 1 (referred to as "the site").

Genera has recently been granted consent to fumigate other bulk in-hold cargo on request from Ministry for Primary Industries. There is little information on potential MB usage or discharge rates during fumigation of bulk in hold cargos. However, Golder understands that future bulk in-hold fumigations will be completed using phosphine and therefore has not assessed MB emissions from these fumigations.

Further information on Golder's understanding of export log storage, MB usage and dose as well as the fumigation methods and procedures are provided below.

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





LEGEND

- Site boundary
- Container Fumigation Area
- Log stack Fumigation Area
- Port Industry
- Mt Maunganui Urban Area
- Mt Maunganui Industrial Area
- Commercial Business
- Tauranga Airport
- Whareroa Marae Residential Area
- Active Open Space and Community Area

NOTES

1. Aerial: LINZ 2019, CC-BY-3.0-NZ.
2. Map image: © OpenStreetMap (and) contributors, CC-BY-SA Sourced from the LINZ Data Service and licensed for re-use under the Creative Commons Attribution 4.0 New Zealand licence
3. Schematic only, not to be interpreted as an engineering design or construction drawing.

0 500 1,000 METRES

REFERENCE SCALE: 1:17,000 (at A3)

PROJECTION: NZGD 2000 New Zealand Transverse Mercator

CLIENT
GENERA

PROJECT
AIR QUALITY ASSESSMENT

TITLE
MAIN OPERATING AREA AND SENSITIVE RECEPTORS

CONSULTANT
GOLDER

YYYY-MM-DD	2019-10-14
PREPARED	AE
REVIEW	IX
APPROVED	CN

PROJECT NO.	REPORT	REV.	FIGURE
1898728	008	2	01

2.2 Export Log Processing

Logs are harvested and transported to the port by truck for export. When the trucks arrive at the port the logs are unloaded from the trucks and stacked in rows. The location of the logs is dependent on port operational requirements and also depends on the owner's lease arrangements with the port.

The rows, which have large metal posts at the end called book ends, which allows log stacks to be up to 6 m high and up to 80 m long. These logs stay stacked at the port until they are ready to be loaded onto a ship for export. When logs are being exported, they can be either stowed in the hold or on the deck of the ship. Logs are loaded into the hold first using cranes on the ship which lift the logs using large chains and lower them into the hold through gaps made by large top opening hold doors. Depending on the destination country's biosecurity requirements, various methods and/or fumigants are required. Only logs that still have bark are required to be fumigated.

If the logs are stowed in the holds, they are fumigated in hold by one of two ways. This can be either with MB at the port as described below in Section 2.4 or in the hold in transit using phosphine. Phosphine is then released when the ship is at sea and the assessment of the effects of this is beyond the scope of this assessment. Logs which are to be top stowed are fumigated under tarpaulins on the dock using MB before being loaded onto the ship. This is described in Section 2.3.

2.3 Log Stack Fumigation

Log stack fumigation is the most common fumigation completed by Genera. First, gas piping is laid alongside the log stacks. The piping has nozzles at regular locations along the length of the log pile. The stacks are then covered with a thick tarpaulin. A plastic tube is placed around the stack and filled with water to provide an airtight seal between the tarpaulin and the concrete dock. The log stack length is then estimated by pacing out the length of the stack of logs. MB gas is then pumped from a mobile tank through the piping under the tarpaulin at the required dose rate. Depending on the destination of the logs there are different concentration requirements which need to be maintained in the wood pile throughout fumigation (discussed further in Section 3.2.2).

The dose is calculated using the volume of the log piles to determine the mass of MB gas required. Leak checks (using handheld meters) are performed around the base of the pile. The logs are required to be left under the tarpaulin for between 16 – 24 hours (depending on the destination of the logs). The concentration of MB under the tarpaulin is measured at the start of fumigation and at the end either by using a Riken MB detecting instrument or sampling with a syringe and then analysing the sample using a calibrated Gas Chromatography Flame Ionisation Detector (GC-FID). The measured concentrations are compared to start and end concentration requirements to ensure the required concentration has been meet. Multiple log stacks maybe under individual tarpaulins at any one time and may be treated as a single fumigation event.

Once it has been confirmed that the requirements for fumigation have been met, (time and concentration) and any recapture (see Section 3.4) has been completed, the tarpaulins are prepared for removal. The water tubing is popped, to empty it of water, and the tarpaulin is pulled off the log pile and rolled up using a forklift, this takes about 10 minutes per log stack. Tarpaulins are typically removed one at a time. The time that the water tubing is popped is noted as the start of the ventilation.

The tarpaulin is visually inspected by Genera for any tears or damage during removal so it can be repaired prior to being rolled up. Ministry for Primary Industries (MPI) require the logs to be loaded onto the ship within 36 hours of the removal of the tarpaulin in summer and within 504 hours in winter. Golder understands the maximum time logs can remain on the docks is related to the mobility of insects and the chance to re-infesting fumigated logs.

For all fumigations, an exclusion zone and ambient monitoring is set up. These are described in the Fumigation Management Plan (FMP) (Beca, 2019).

2.4 Ship Hold Fumigation

For the Port of Tauranga, India is the main destination country that requires the use of MB for in hold for log stowed below deck. Once a hold is fully loaded with logs air ventilation and required doors have been sealed, and the crew has vacated the vessel, Genera can fumigate the ship hold. Prior to fumigation, leak checks are conducted throughout the vessel to ensure it is suitable for fumigation in a safe manner. The hold is filled with the required amount of MB with the hold doors closed. Measurements are taken from sampling tubes within the hold using a syringe at the beginning and end of fumigation then analysed using a GC-FID to confirm the required concentration of MB has been achieved. When the required time has been reached, preparation for ventilation begins. Hold fumigations use a significantly larger mass of fumigant per fumigation event compared to log stacks and container fumigations because a ship hold has a much larger volume. Operations relating to ship hold fumigation have been reviewed based on this air assessment and based on initial modelling results. Future ship hold fumigations are likely to require further mitigation than is currently undertaken.

Preparation for ventilation includes setting up exclusion zones and ambient monitors. The holds are currently opened sequentially with approximately 5 minutes between the beginning of one hold opening and the beginning of the next hold opening. A 2-hour gap between hold openings is being considered for future operation. Under the current FMP procedures (Beca, 2019), ambient concentrations are constantly recorded using PID during ventilation and the these are used to determine the rate and timing for holds to be opened. The total duration of venting for ship hold fumigations is often between 10 and 12 hours. The fumigation of a ships holds occur approximately once per month with most ships having 5 ship holds.

2.5 Container and Break Bulk Cargo Fumigation

Container fumigations are carried out at various locations around the port and occasionally at the Sulphur Point area of the Port of Tauranga. Container fumigation can be completed via one of two methods, depending on the contents and void volume of the container. Either the container doors are opened, and a cover is placed over one or multiple containers and the process is completed as per log stacks, or piping is placed in the container, the container doors shut and MB pumped in via the piping. Fans may be used under the cover to circulate MB. Once the fumigation period has been completed final measurement are collected to ensure the fumigation has met the criteria concentrations. From April 2018 onward, all container fumigations have required recapture before ventilation. When recapture is complete the doors of the containers are opened, and tarpaulins lifted to ventilate the enclosed area.

Occasionally (6 times in 2018) break bulk cargo is fumigated under tarpaulins. The mass of MB used per fumigation event for break bulk cargo is similar to the mass used for container fumigation.

Container fumigations use a significantly smaller mass of fumigant per fumigation event compared to log stacks and hold fumigations because the containers have a much smaller volume. The risk zone control processes are similar to that employed during fumigation of the log stacks, but the setback distances are generally smaller because less MB is used. Container fumigations make up approximately 10 % of all fumigation jobs but a significantly lower percentage of the annual MB mass.

3.0 NATURE OF AIR DISCHARGES

3.1 Introduction

Genera conduct fumigations primarily in the area shown in Figure 1. The log fumigations can be conducted in any of these areas and the locations are dictated by the port and customer storage arrangements. Typically ship holds are fumigated at the southern berths (as shown in Figure 2) and container fumigations are carried out at various locations around the port, including locations towards the northern end of the port (as shown in Figure 3) and Sulfur Point.

The largest use of MB on the port are during log stack and ship hold fumigations. Container and bulk cargo fumigations use less MB and recapture is currently undertaken for all container fumigations and from the end of October 2019, for all break bulk cargo. The calculation of MB emissions is based on log and ship hold fumigations, as container and break bulk cargo fumigation emissions are expected to be lower than these. This is discussed further in Section 3.7.

The release of MB into the atmosphere occurs when the fumigation enclosure is removed or ventilated. This allows the release of the residual MB that remains in the headspace. The residual MB is the dose amount less than the mass that has been sorbed into logs (or other material) and that recaptured from the headspace at the end of fumigation (prior to venting).

Following the headspace release, the MB that was sorbed into the logs is also slowly released due to desorption during the period that the logs remain on the wharf or in the case of the ships hold, while the hatches remain open.

This section describes MB usage and sets out how the residual headspace concentration was determined. It includes discussion on sorption, recapture, the method of ventilation and the assumed desorption rates. It then summarises the expected MB emission rates.

Figure 2: Locations of fumigation and non-fumigation areas at the southern end of the Port of Tauranga (Beca 2019).

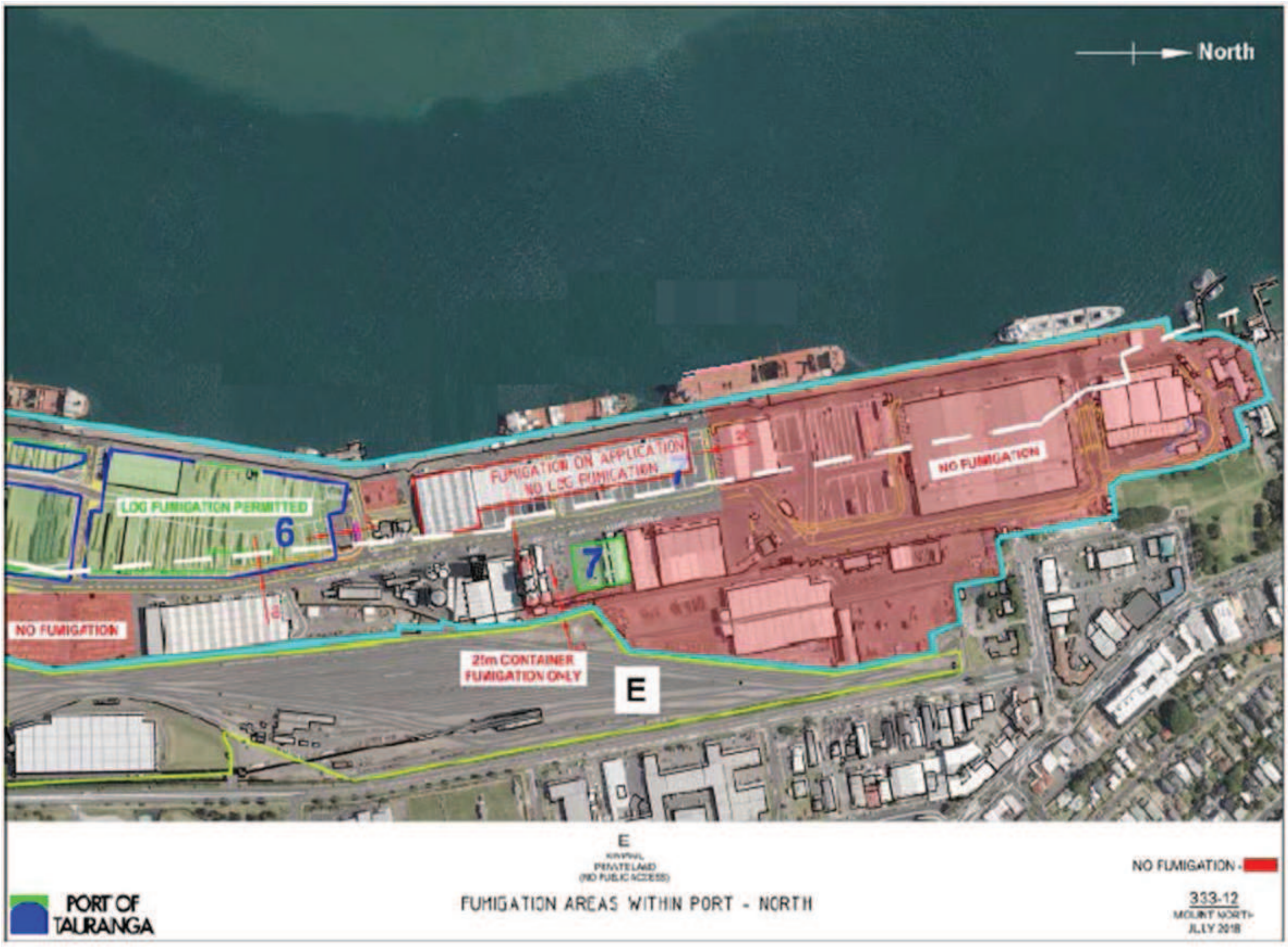


Figure 3: Locations of fumigation and non-fumigation areas at the northern end of the Port of Tauranga (Beca 2019).

3.2 Methyl Bromide

3.2.1 Properties

MB is a fumigant gas which is used to control quarantine pests when exporting and importing various goods. In New Zealand this is predominantly pine logs. The intake mechanism of MB for quarantine pests is by inhalation. MB also known as Bromomethane is an Organobromine compound which has the formula CH_3Br with a molecular weight of 94.94 g/mol and a half life in air of approximately 7 months. It is an odourless, colourless and nonflammable gas. It is an ozone depleting compound and as part of the Montreal Accord 1987 (an international agreement to phase out ozone depleting substance) the use of MB for applications, other than quarantine and pre-shipment purposes, were phased out by 2005. MB is also produced by natural sources (predominantly by marine organisms) and manufactured. MB is classified as a hazardous substance under the Hazardous Substances and New Organisms Act (HSNO).

3.2.2 Dosage rates

When using MB for treating export materials, dosage rates are set by the importing country. The primary markets that require MB fumigation are China and India. The required dosage is set based on ambient temperature and a higher dosage is required in winter months due to the reduced respiration rate of insects in colder weather. The dose rates shown in Table 1 are used to determine the mass of MB that Genera apply into the fumigation enclosure for each fumigation.

The MB dosage criteria are based on the air concentration in the fumigation enclosure, in other words the criteria are based on the headspace concentration. The headspace of an enclosure is the volume of free air – in other words the difference between the total volume and the volume of material in the enclosure.

Table 1: Current methyl bromide quarantine and pre-shipment treatments used for New Zealand pine logs[2].

Country/ fumigation time	Temperature Range (°C)	Dose (g/m$^3_{air}$)
China >16hr	5-15	120
	>15	80
India 24hr	10-11	72
	11-15	64
	16-20	56
	>21	48

At the beginning of fumigation, the volume of the fumigation enclosure is calculated using measurements of the log pile/ship hold or container dimensions. Then the mass of MB based on the dosage requirements in Table 1 is applied to the enclosure. This is rounded up to the nearest kilogram.

The minimum headspace MB concentration which needs to be met at the end of fumigation is variable depending on the length of fumigation, for a 16-hour fumigation for example, it is approximately 50 % of the dose rate.

Genera measure the fumigant concentration in the enclosure at the beginning and end of each fumigation to ensure the concentration is above the requirements.

3.2.3 Usage rates

Genera has provided daily records of the amount of MB used for each fumigation job from January 2018 to May 2019. In 2018 the total amount of MB used at Port of Tauranga was 205,000 kg, while the MB usage for the first five months in 2019 was 77,600kg. Approximately 180,000 kg MB was used for log stack/container fumigations, while 25,000 kg was used for ship hold fumigation in 2018.

The weekly and monthly MB used during January 2018 to May 2019, is provided in Figure 4 and Figure 5 respectively. It is noted that a significant amount of MB (13,600 kg) was used in week 33. This is due to a total of 10,500 kg of MB that was used for a ship hold fumigation on 31 July and 1 August 2018 and was a result of the end point concentration not being achieved and the ship needing to be re fumigated. Figure 5 shows that the monthly MB usages for January to April 2019, are higher than the those recorded for January to April 2018. For the modelling purposes, the higher MB usage was used to develop the hourly varying MB

[2] Data source: Ministry for Primary Industries (China), (2016) and Ministry of Primary Industries (India), (2016).

emission rate[3], i.e., those recorded from May 2018 to April 2019, was used. An annual MB usage of 215,000 kg was calculated for the period.

Genera have advised that annual MB usage will decrease in the future as a new log debarking facility has been built nearby and logs which have their bark removed do not require fumigation, and, therefore, maximum future use of MB is expected to be 150,000 kg per year.

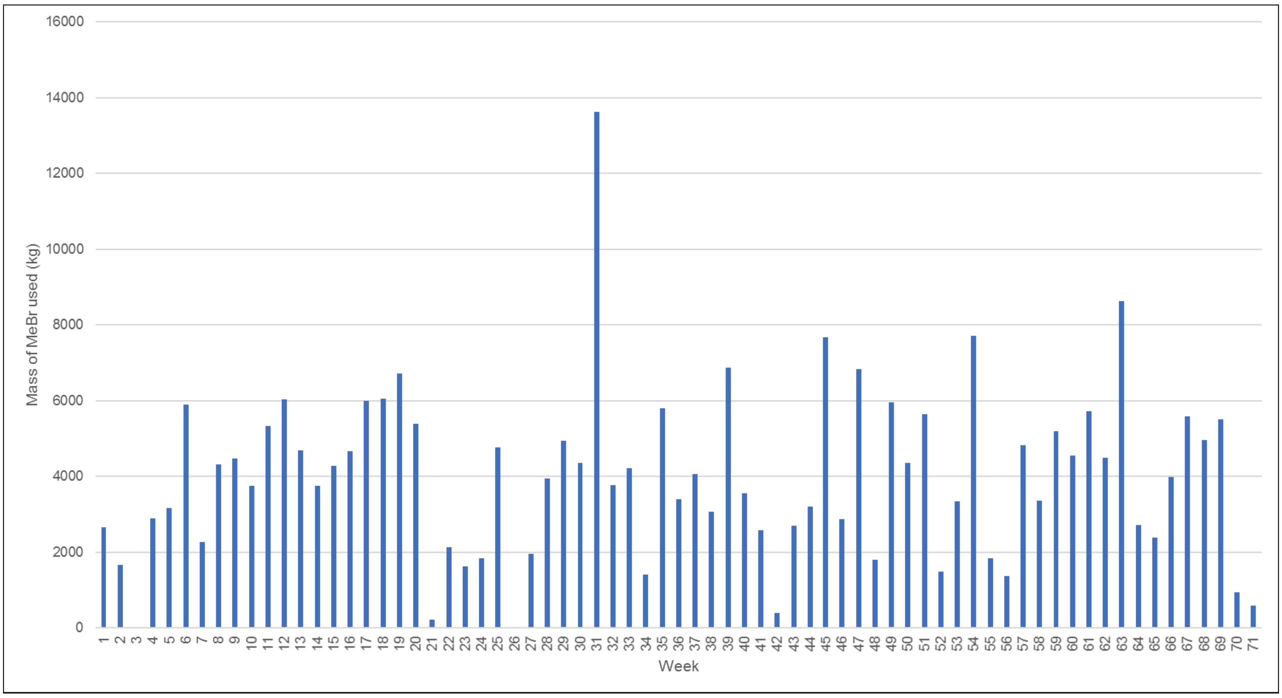


Figure 4: Weekly mass of MB used at the Port of Tauranga (January 2018 to May 2019).

[3] Records for January to April 2019 have been used to replace those recorded for the same months in 2018.

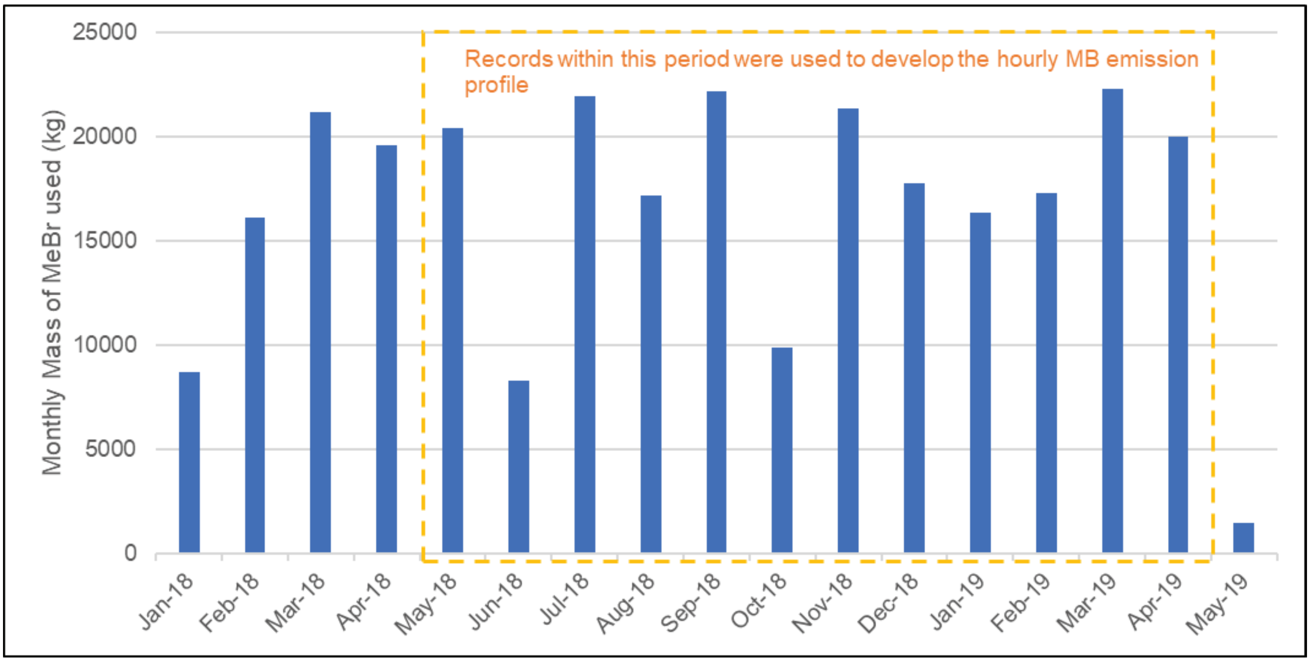


Figure 5: Monthly MB usage at the Port of Tauranga (January 2018 to May 2019).

3.3 Sorption

When logs are fumigated there is a certain amount of sorption that occurs which reduces the concentration of MB in the headspace of the enclosure. Sorption is a term used, which describes the loss of fumigant by the process of adsorption and absorption by the materials being fumigated.

M Hall et al (2016) has investigated and identified that the sorption of MB is directly proportional to the dose of fumigant applied and the duration of the fumigation. The study has found the surface area of the logs is the most important factor influencing MB sorption and desorption rates. The equation developed by M Hall et al (2016) could be used to calculation the theoretical sorption rates (see APPENDIX C).

Genera field records of log and ship hold fumigation can be also used to determine a site-specific sorption rate. A sample of the log fumigation records in period October 2018 to April 2019, have been used to calculate the change in headspace concentration in the enclosed log stack/container fumigation volume. The Genera paper records include the mass of MB used, total enclosed volume, log volumes via the Japanese Agricultural Standard (JAS) method, and initial and final headspace concentrations.

Initially a sample of 63 log fumigation events were evaluated and it was found that on average 47 % of the initial MB mass used remained in the headspace of the enclosure and was available to be reduced further using recapture technology. Subsequent data analysis confirmed that this is a conservative estimate of the mass remaining in the headspace and is approximately the 70-percentile value (rather than the mean) of the additional data (in other words, 70 % of the samples had a lower calculated percentage of MB left in the headspace). Further details on calculation method is provided in APPENDIX C. It is noted that the sorption percentage, calculated based on actual initial and final concentration measurement, is consistent with the average theoretical sorption rate calculated by using the sorption equations developed by M Hall et al (2016).

The ship hold fumigation record on 16 May 2019, was used to derive the sorption rate for ship holds fumigation. The details of the field measurements are also shown in APPENDIX C.

3.4 Recapture

Prior to venting, to reduce the emissions of MB to atmosphere, MB is extracted from under the tarpaulin and destroyed in a process called recapture.

Genera has developed recapture and MB treatment technology. Golder has relied on Genera information regarding the operation and effectiveness of this technology. A scrubber-based system is used for most recapture, but a carbon filter system is also used. Both systems work by connecting a flexible pipe to port(s) installed between the cover and the ground. The port allows an air connection under the cover and has a flattened central section to allow the water pipe sealing (see Section 2.3). The exterior part of the port has a flexible quick connect hose and this is closed when fumigation is taking place.

To undertake recapture, the scrubber is moved into place on the back of a truck or on a trailer. It is then connected to two openings in the log stack tarpaulin. The headspace air is extracted, scrubbed and then returned under the tarpaulin as a closed loop system.

If the filter type recapture/removal is being used, the headspace air is extracted through an activated charcoal filter and then vented to atmosphere. This method uses a photoionization detector (PID) on the outlet to determine when the filter media is saturated and needs to be replaced. The saturated activated charcoal is not reusable and must be discarded.

For both systems, Genera have advised that recapture technology reduces the final headspace concentration by 80 % and this is also in line with values documented in research (Armstrong, 2018).

Currently MB recapture is used on 80 % of log stack fumigation events and for container fumigations 100 % of fumigations are recaptured. Recapture technology is not currently used on ship hold fumigations. Due to improvements in recapture technology and the possibility that some desorption may occur during recapture it is possible that the total amount of MB recaptured could exceed the 80 % as outlined in Armstrong 2018. There are also data that indicates that 80% recapture is not achieved in all recaptures. However, as there is currently insufficient evidence to quantify any recapture of desorption it has been assumed no desorption happens during recapture. Genera have advised that there is no technology available yet that will allow the storage and reuse of recaptured MB at a scale that is economic.

3.5 Ventilation

In each of the different fumigation scenarios (log stacks, ships hold and containers) there is an enclosure. This enclosure can be a tarpaulin, ships hold or the inside of a containers. When fumigation is completed the enclosure is naturally ventilated. A 'ventilation' event refers to the stage in the process when the enclosure is opened to the air. The ventilation methods for ship holds, log stacks and containers are discussed further below.

Ship hold ventilation

Before a ship's cargo hold ventilation is started, a monitored safety zone is set up as described in the FMP (Beca, 2019) and PID monitors are set up along this monitored safety zone. The ventilation is started by partially opening the hold doors. The rate of opening hold doors is linked to the monitoring at the safety zone. If the monitors along the monitored safety zone exceed the trigger level (currently set at an instantaneous reading of 25 ppm or above) the hold doors are closed or partially closed until the reading drops back below the trigger. This process of partially opening and closing the hold doors continues until the PID readings are reading at background levels for at least 15 minutes indicating the hold has been fully vented. While the venting ship holds takes approximately 12 hours, the majority of MB is released in the first 2 hours after a hold door is opened. Further details of the current ship hold fumigations procedure can be found in the FMP (Beca 2019).

Log stacks

For log stacks, a monitored safety zone is set up around the stack area and ambient monitors are set up at the downwind end of the monitored safety zone and at the port boundary. Typically, the time the ventilation starts until the cover is completely removed from a log row is approximately 10 minutes.

The time of ventilation is when there is the highest rate of release of MB gas and is the main focus of assessing short term exposures. If there is no recapture or destruction of MB from the headspace of the enclosure, all the remaining gas which has not been absorbed, adsorbed or leaked is released to atmosphere. For the purpose of this assessment, it has been assumed during the fumigation process there is negligible loss of MB due to leakage. Therefore, all the dosed fumigant is assumed to be either in the headspace of the enclosure or in the logs.

After ventilation has been completed the logs are loaded onto the ship. The logs must be loaded within 36 hours of ventilation in summer and within 504 hours in winter.

Containers and bulk break cargo

For containers and bulk break cargo, a monitored safety zone is set up around the fumigation area and ambient monitors are set up at the downwind end of the monitored safety zone. All container fumigations have recapture of MB before ventilation is completed. If a tarpaulin has been used, ventilation is completed in a similar fashion as a log stack. If no tarpaulin was used the container doors are opened and the container allowed to vent.

3.6 Desorption

When fumigation and recapture (if conducted) is completed, the enclosure is opened to allow ventilation, at this point, the materials which have collected fumigant by sorption start to release the fumigant by desorption. Desorption is the process of the materials releasing MB that has been collected through sorption.

The process of desorption means the discharge continues (albeit at a much lower rate) and needs to be taken into account when considering the release mechanisms of fumigants. The rate of desorption quickly decreases after ventilation occurs. It is very difficult to measure and quantify actual desorption rates in the field and as such there are no measured records to use to determine desorption. The desorption equation developed by M Hall et al (2016) has been used to determine desorption rates of MB for Genera. This equation is presented in APPENDIX C, along with how the equation was used to develop the desorption rate.

The MB desorption rate on every ventilation hour was calculated based on M Hall *et al*'s study (2016). It was found that a total of 13 % and 15 % of the initial mass of MB used is released into the atmosphere after 13 hours (ship holds fumigation length) and 132 hours (log stacks) of ventilation, respectively.

3.7 Emission Rates and Characteristics used for Modelling

In summary, MB emission can be made up of the initial headspace MB release (the remaining MB left in headspace after sorption) and the desorption of MB from the logs. These can be determined by the initial mass MB usage, and the assumed sorption, recapture and desorption rates as discussed in above sections.

Golder has used Genera's recorded information on fumigation types, locations, initial mass MB used, and ventilation start and end time for each job during May 2018 to April 2019[4]. These field measurements on a job by job basis have been used to develop an hourly varying emission file for each of the fumigation locations.

3.7.1 Log stack and container fumigation

The log stack/ container fumigations have been recorded at locations shown in Figure 2 and Figure 3. The distribution of MB usage by locations is presented in APPENDIX E. As the vast majority of the log/container fumigation occurred at locations 1, 2, 3 and 6, it has been assumed all fumigations happen in these locations for the purpose of modelling. Other assumptions can be also found in APPENDIX E.

Genera have recorded the MB usage, and ventilation start and end time for each specific fumigation job at each location. An average hourly MB usage for each job at each location was developed based on the recorded initial mass MB used and ventilation start and end time. This assumes the recorded MB is proportionally released over the ventilation hours[5]. Based on proposed limits on future operation, a maximum hourly MB usage of 450 kg/hr has been used to develop the hourly varying MB emission rate. Any excess MB that is above 450 kg/hour was added to the next hour. This approach limited the amount of MB that can be released in an hour but maintains the total amount of MB that can be released for longer periods (i.e., over a day and a year).

The hourly MB usage was used to determine the sorption and recapture mass and to calculate the MB remaining in headspace before ventilation starts. This headspace mass was modelled to be released at first venting hour.

Based on the mass of MB that calculated to be sorbed by the logs the assumed desorption rate was used to establish the MB emission rate due to desorption. An example of the emission profile for a maximum hourly MB usage (450 kg/hr) is discussed below.

Figure 6 shows the fumigation profile for using a maximum hourly MB usage (450 kg/hr). It shows the change of mass MB in the headspace and logs over the fumigation and recapture period. Based on Genera's measurements, 47 % of the MB usage (212 kg) has been assumed to remain in headspace due to the sorption and 53 % (239 kg) MB is sorbed by the logs over the period the logs are under the tarpaulin prior to recapture. Based on an hourly average of 80 % of headspace recapture on 80 % of the fumigations[6], 30 % of the applied MB (135 kg) is assumed to be able to be recaptured over a period of four hours. This results in 17 % (76.5 kg) MB left in the headspace before ventilation starts.

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[4] Over the period from January 2018 to May 2019, the months with higher mass of MB used (May 2018 to April 2019, inclusive) were used to calculate the hourly varying MB emission rate, i.e. Records for January to April 2019 have been used to replace those recorded for the same months in 2018.

[5] For example, 150 kg MB was used for a job vented from 10:00 am to 12 am, then the hourly MB usage at 10 am is 75 kg/hr, while at 11 am is 75 kg/hr.

[6] For container fumigation, recapture is completed on 100% of the fumigations. This makes a lower MB discharge rate compared to the log stack fumigation. For modelling purposes, all the container fumigations were conservatively assumed to be. log stack fumigation (80% recapture on 80% of fumigations).

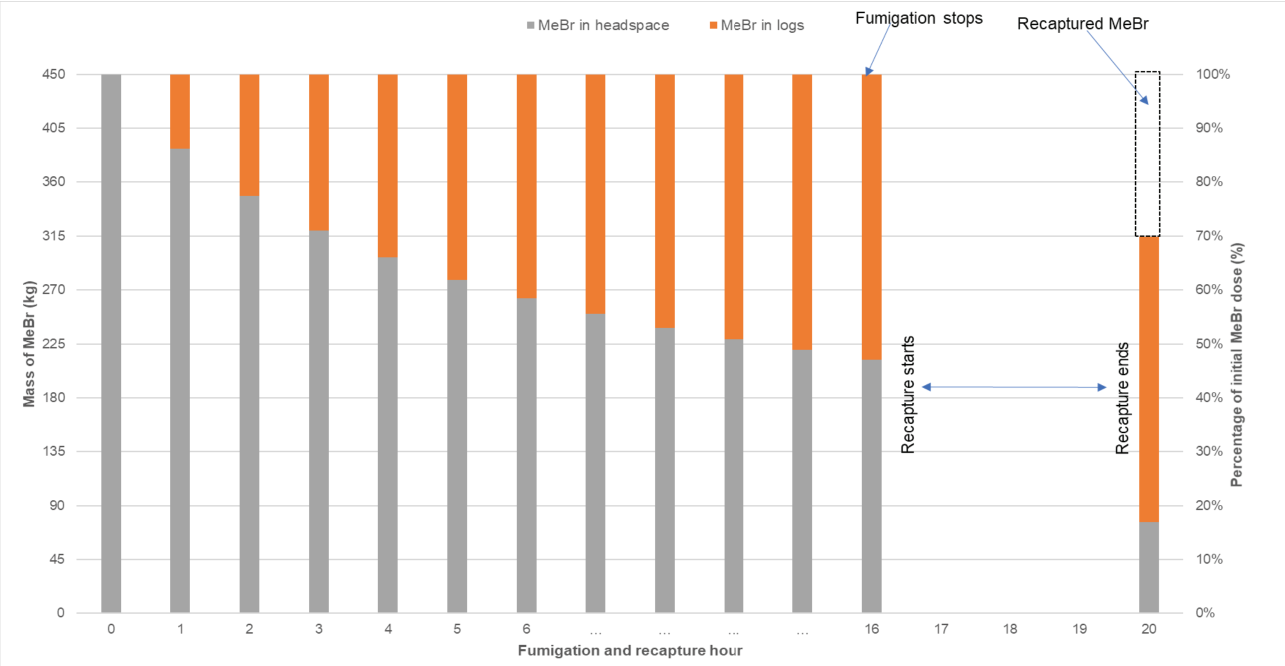


Figure 6: Log stack fumigation profile (for an hourly MB usage of 450 kg).

Figure 7 illustrates the assumed MB emission profile for the maximum hourly MB usage. At the first venting hour, the remaining 17 % (77 kg) MB in the headspace is completely released into the atmosphere. In addition to that, it is assumed MB in the logs started to release (due to desorption) from the first venting hour. A small amount of MB absorbed in the logs would gradually release (as described in Section 3.6). It is estimated that approximately 3 % (14 kg) MB is released at the first venting hour and a total of 15 % (68 kg) is desorbed over the 132 venting hours. Therefore, accounting for the remaining MB in headspace and log MB desorption, there would be 32 % (144 kg) MB released into the air, while 38 % (170 kg) MB remains in the logs.

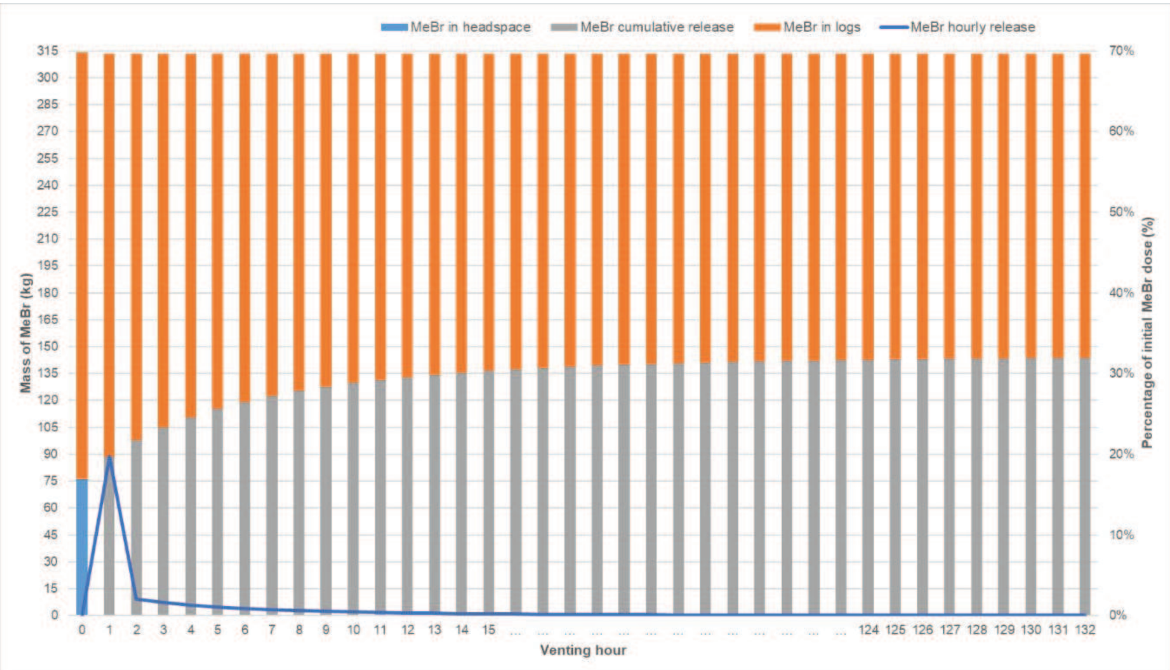


Figure 7: Log stack fumigation venting profile (for an hourly MB usage of 450 kg).

Based on the above, the hourly MB release rate for 450 kg/hr MB usage is presented in Figure 8. It shows the maximum release rate that occurs at the first venting hour is approximately 89 kg/hr (25 g/s), which primarily consists of the MB remained in headspace after fumigation, but also some MB desorption from the logs. After that, the release rate decreases significantly to under 10 kg/hr (3 g/s), which is due to the MB desorption from the logs.

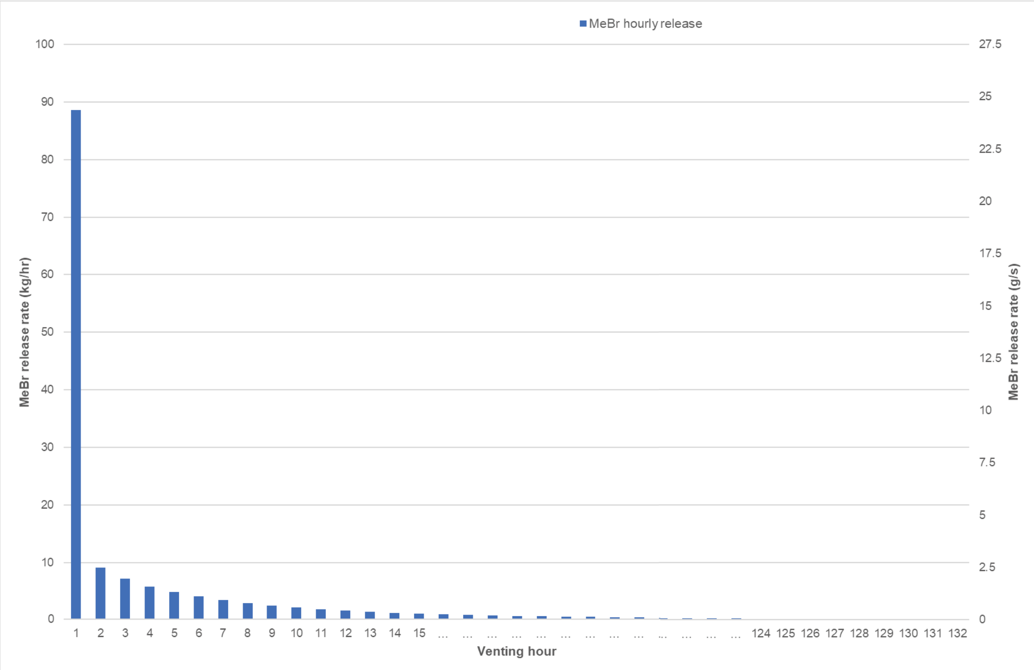


Figure 8: Hourly MB release rate (for an hourly MB usage of 450 kg).

The above hourly MB emission profile has been established for every hour using the calculated hourly MB usage and assumptions of sorption, desorption rates and recapture. Then for each hour of the year, the hourly MB emission rates were summed for each location. As such, each hourly emission can be made up of headspace releases (if a ventilation started on that hour) and the desorption emissions from logs on that hour and/or from previous ventilation events. This hourly varying MB emission dataset at each location is referred to as the base dataset, which is presented in Figure 9, along with the total emissions from all locations. It has been used to develop model emissions for assessing 1-hour and 24-hour effects (see Section 3.7.3).

As discussed in Section 3.2.3, Genera advised that the annual MB usage is expecting to reduce from 215 tonnes[7] to 150 tonnes per year due to the increased level of debarking prior to export. Therefore, when assessing future annual effects, the hourly emission of the base dataset has been scaled to reflect an anticipated annual MB usage of 150 tonnes compared to the recent records of 215 tonnes.

[7] Recorded mass of MB used from the start of May 2018 to the end of April 2019.

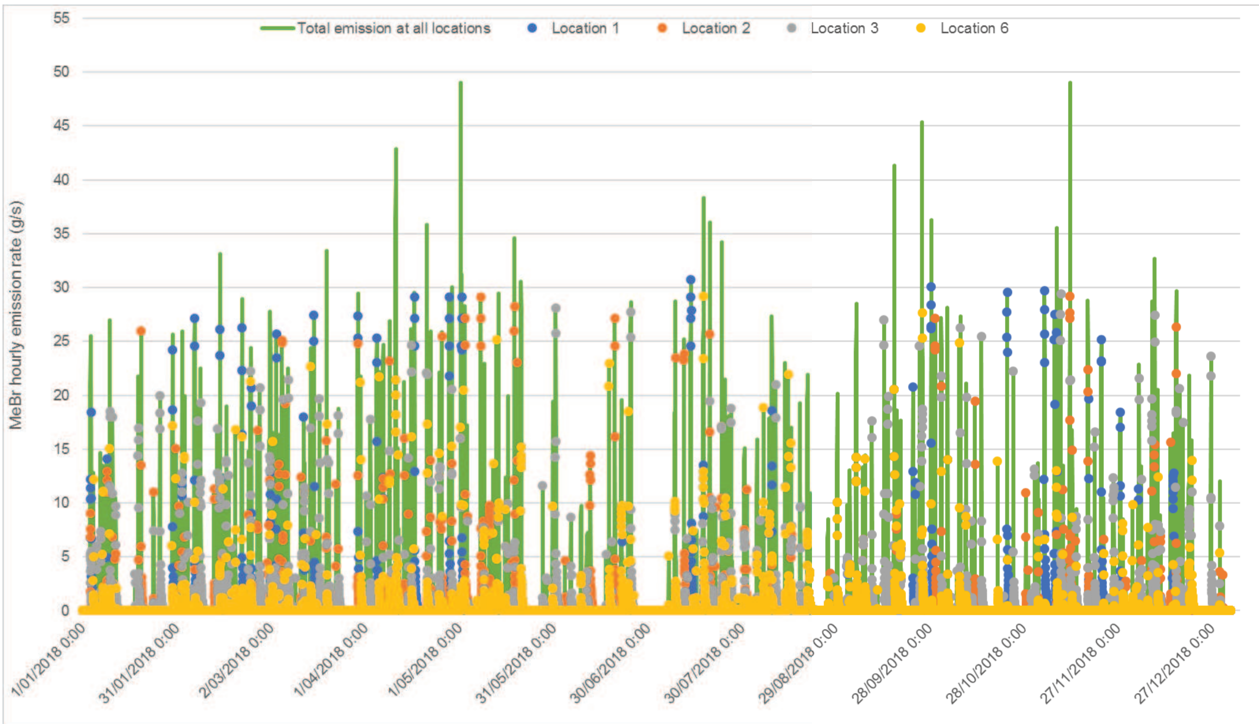


Figure 9: Base datasets for log stack/container fumigation (fumigation records for January to April 2019 were applied for January to April 2018).

3.7.2 Ship hold fumigation

Genera's field records show that one ship can contain two or five holds. This assessment assumes that each hold is vented two hours apart during 10 pm to 7 am, i.e., ventilation of each hold starts at 10 pm, 12 am, 2 am, 4 am, and 6 am (for the two-hold event, it starts at 10 pm and 12 am). The ventilation of each hold lasts for 13 hours. It is also assumed the remaining 35 % MB in the headspaces to be released evenly over the first two ventilation hours (18 % MB released in each hour). This is based on the ship hold fumigation records on 16 May 2019 discussed in APPENDIX E. Review of further records would confirm, or otherwise, the robustness of this assumption.

The recorded MB usage for each ship event was divided by number of holds to calculate the average MB usage per hold. The calculated average MB usage per hold, the initial headspace release and desorption rate described in Sections 3.3 and 3.6 were used to develop the hourly MB emission rate per hold and, then when these occurred on the same hour the hourly emissions were summed. An example of hourly emission profile for a five-hold event is discussed below.

A maximum of 5236 kg MB usage was recorded for a five-hold event and that gives an average MB usage of 1047 kg per hold. For each hold, 20 % of MB usage (215 kg) that is released into the air at the first venting hour. This primarily consists of 17 % MB that remains in headspace and 3 % desorbed from the logs. The MB release (19 % of MB usage) on the second venting hour is slightly lower due to a lower desorption rate (2 % MB usage). After that MB release rate drops significantly to a few percent as it only accounts for MB desorption from the log. This approach was repeated for the remaining four holds to calculate MB emission per hold, and those MB emission rates on the same hour were summed to develop the overall MB emission profile, as shown in Figure 10.

The overall hourly MB release rate (per ship) is between 205 kg/hr (60 g/s) to 256 kg/hr (71 g/s) within the first 10 venting hours and it drops to under 50 kg/hr (14 g/s) after that. At the end of venting, there is approximately 48 % MB released into the air, while 52 % is assumed to remain in the logs.

Based on the above, the hourly MB emission rates for each recorded ship fumigation event were developed. They are referred to as the base dataset and are shown in Figure 11. This base dataset has been used to develop the model emission rates for assessing 1-hour and 24-hour effects (see section 3.7.3).

To assess the annual effect, an annual base dataset was been established based on each hold vented one hour apart (i.e., the initial ventilation of the first hold starts on the recorded hour, then the second starts on the next hour, and so on). The annual base dataset is expected to result in similar annual effects compared to the above base dataset that assumes each hold is vented two hours apart. The annual base dataset is shown in Figure 12.

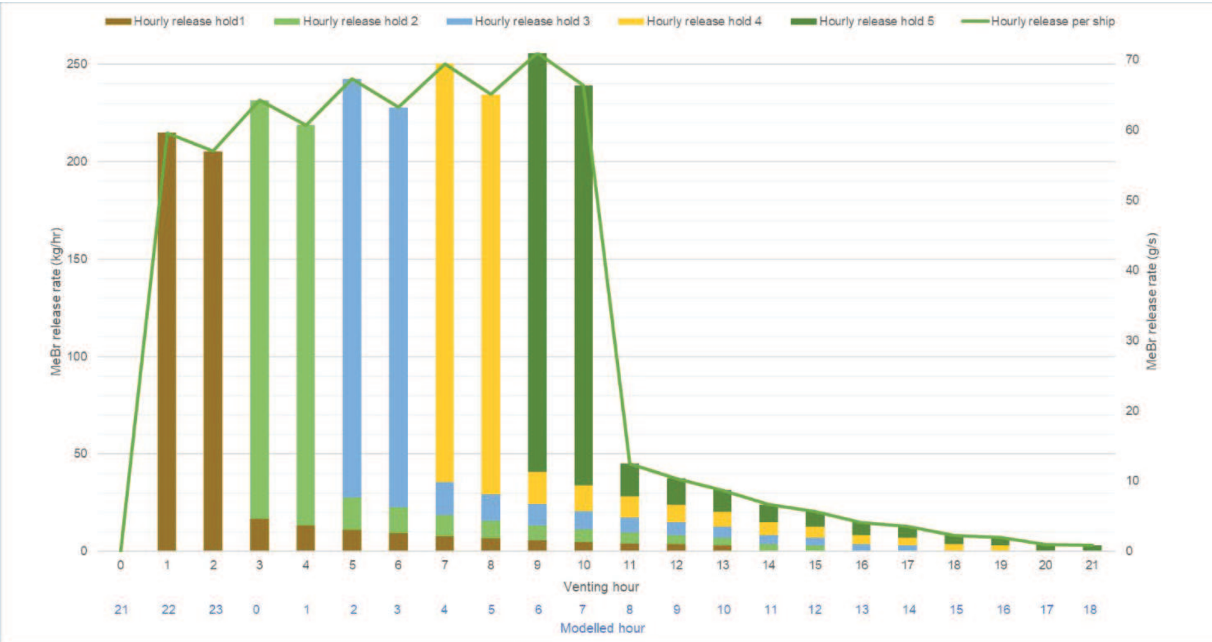


Figure 10: Hourly MB release rate for a five-hold event using 5236 kg MB.

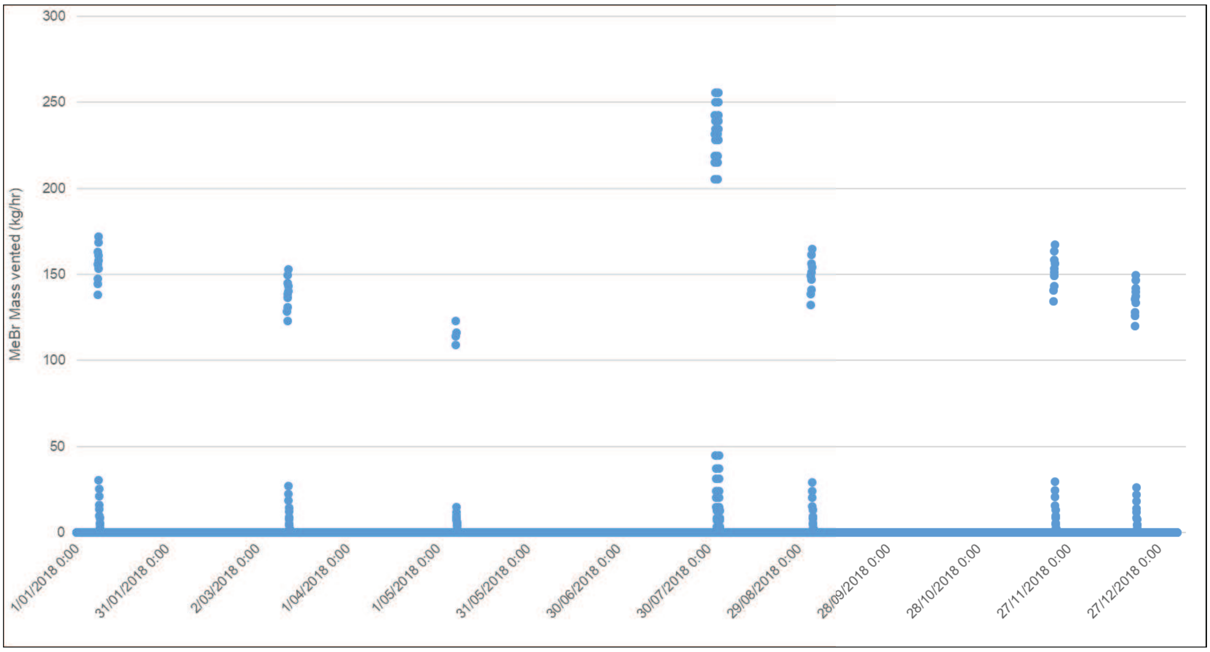


Figure 11: Base emission dataset for ship hold fumigation (fumigation records for January to April 2019 were applied for January to April 2018).

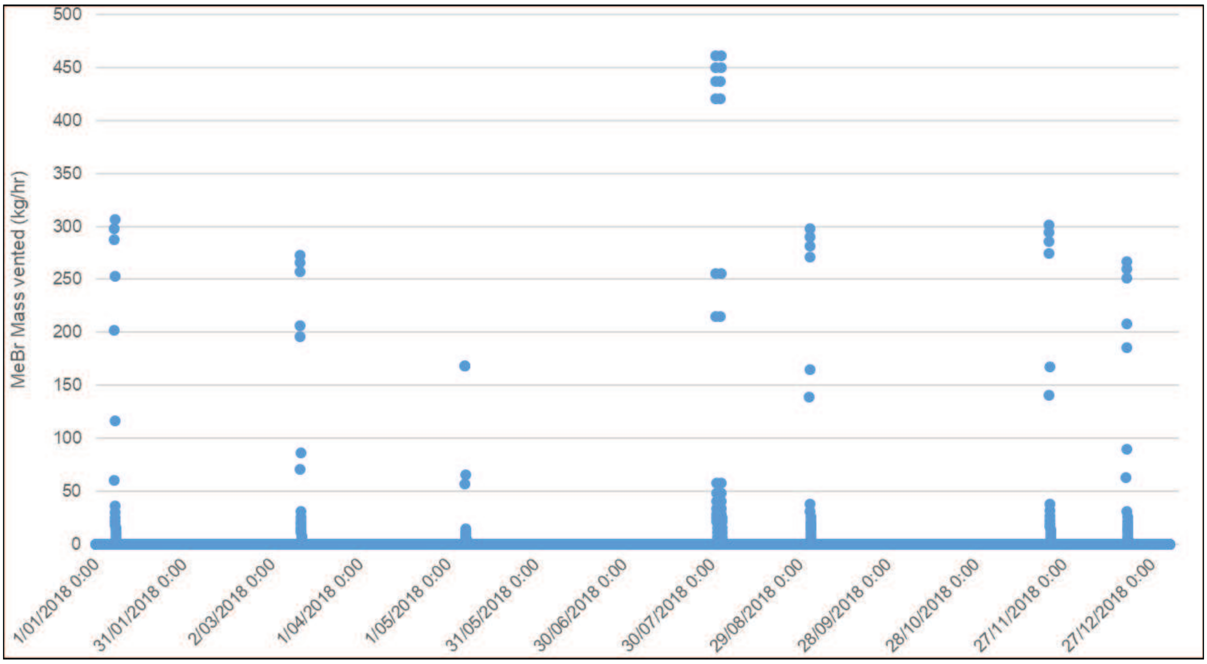


Figure 12: Annual base emission dataset for ship hold fumigation (fumigation records for January to April 2019 were applied for January to April 2018).

3.7.3 Model emission rates

Given that peak emissions can align or not with meteorological conditions that are worst case for dispersion of MB release, to assess potential future effects, offsetting the above base hourly emission datasets by a various period or using the maximum daily emission was considered necessary to cover a range of different combinations of MB emission profiles with different meteorology. This approach is essential when there is high variability in the hour varying emission data to ensure a robust assessment that allows for different combinations of meteorological conditions. The key with this approach is to not overstate long-term effects, while still allowing for the short-term variability. Therefore, three emissions profiles were created for each of the three time based effects criteria (1 hour, 24 hour and annual). Hourly emission rate files were calculated for three modelling scenarios as follows:

- **Annual effect scenario**: the annual base dataset was offset by one month and by eleven months. There were three emission datasets. The base data set was the first hour emission starting at 0:00 on 1 January. This base dataset was manipulated so that the 1 January emissions were offset to the 1 February, 2 January to 2 February and so on with December emissions looped around to be used in January. The second offset was for the 1 January emissions to be used for 1 December and so on. The three data sets were modelled for each modelling year (2014, 2015 and 2016). This provided nine different meteorological conditions (three emission scenarios for three different modelling years) for each emission and therefore, sufficient variation for determining annual average effects for future meteorological conditions. Examples of the annual emissions offset by eleven months are shown in Figure 13 (for log fumigations) and Figure 14 (for ship holds). This emission scenario was only used for prediction of annual concentrations. This is not considered to be an overly conservative approach.
- **24-hour effect scenario**: The day with maximum daily emission rate[8] for each location was determined and the hourly emission rates on that day were used for every day of the year. These emissions were also repeated for each of the modelling years (2014, 2015 and 2016). The maximum daily emissions for each fumigation location are listed in Table 2, along with the day they occurred and the initial mass of MB used on that day. The total MB usage for all log/container fumigation is approximately 7,400 kg, while the MB usage for ship holds is approximately 5,200 kg on these maximum emission days. Examples of the daily emissions are shown in Figure 17 (for log fumigations) and Figure 18 (for ship holds). This is considered the most conservative for log and ship holds and modelling results using this emissions profile are considered to be conservative, especially with the proposed reduced MB usage in the future.
- **1-hour effect scenario**: It was considered in the order of 12 emissions scenarios would be required to robustly allow for various combinations of hourly meteorological conditions with MB emissions. To prevent having to run 36 individual modelling years (12 scenarios each for 3 years), a composite emission file was developed. This emission file was made up by comparing the original hourly emission rate of each month was compared to every other matching hour in the other 11 months. The maximum MB emission rate per location on the same hour of the same day were used and repeated for every month. The method is equivalent to offsetting the original hourly emissions by one to eleven months[9], and creating twelve emission datasets (including the base emission dataset) and using maximum results from the modelling completed using these 12 emission datasets. The composite hourly emission file was modelled for each modelling year (2014, 2015 and 2016). Examples of the one-month emissions are shown in Figure 15 (for log fumigations) and Figure 16 (for ship holds). Due to the variation in hourly emissions and meteorology this is not considered to be an overly conservative approach.

[8] The daily MB emission rate was calculated on any day and the maximum daily emission rate over one year was used.

[9] This makes first hour emission starting at 0:00 on 1 January, 1 February, 1 March, 1 April, 1 May, 1 June, 1 July, 1 August, 1 September, 1 October, 1 November and 1 December respectively

Table 2: The maximum daily emissions and associated initial MB used.

	Log fumigation location 1*	Log fumigation location 2*	Log fumigation location 3*	Log fumigation location 6*	Ship hold fumigation
Maximum daily emission (g/s)	168	144	151	126	702
Maximum daily emission occurred on	13/07/2018	11/11/2018	25/09/2018	17/07/2018	1/8/2018
Total initial MB used on peak emission day (kg)	2175	1837	1754	1650	5236

Note: *emissions accounting for 80 % recapture, 80 % of the time for log fumigation.

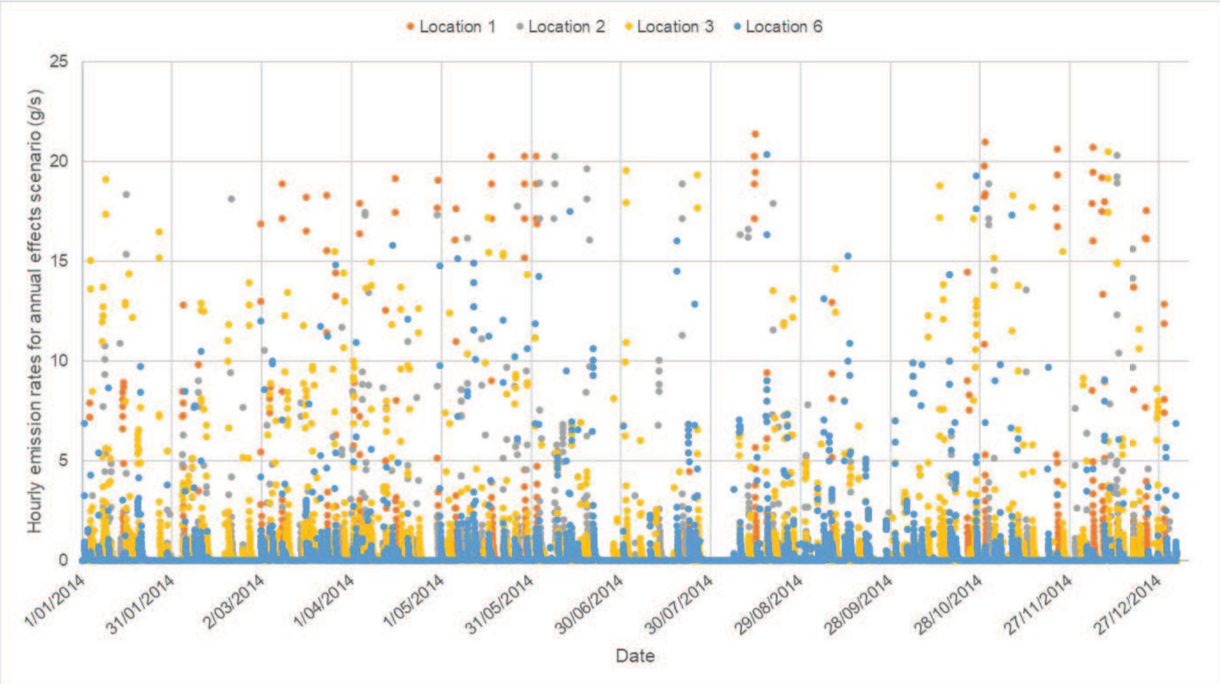


Figure 13: Example of emission for annual effect scenario (the base annual dataset offset by eleven months). Log fumigation only.

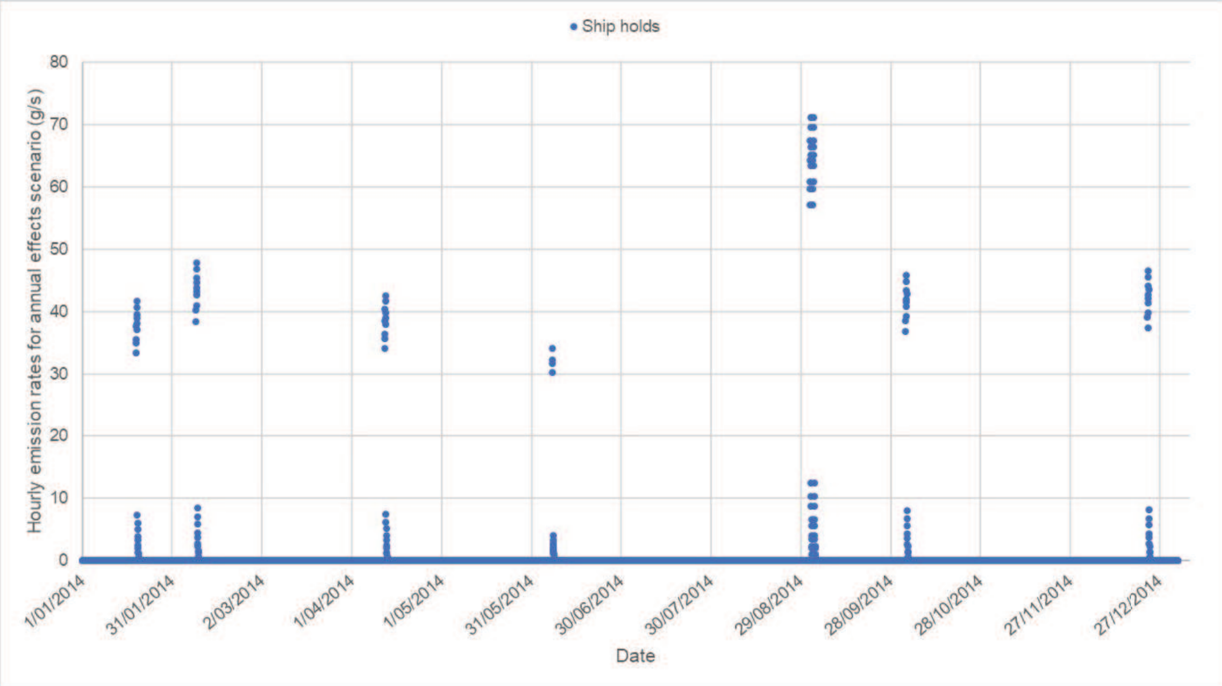


Figure 14: Example of emission for annual effect scenario (the base annual dataset offset by eleven months). Ship hold fumigation only.

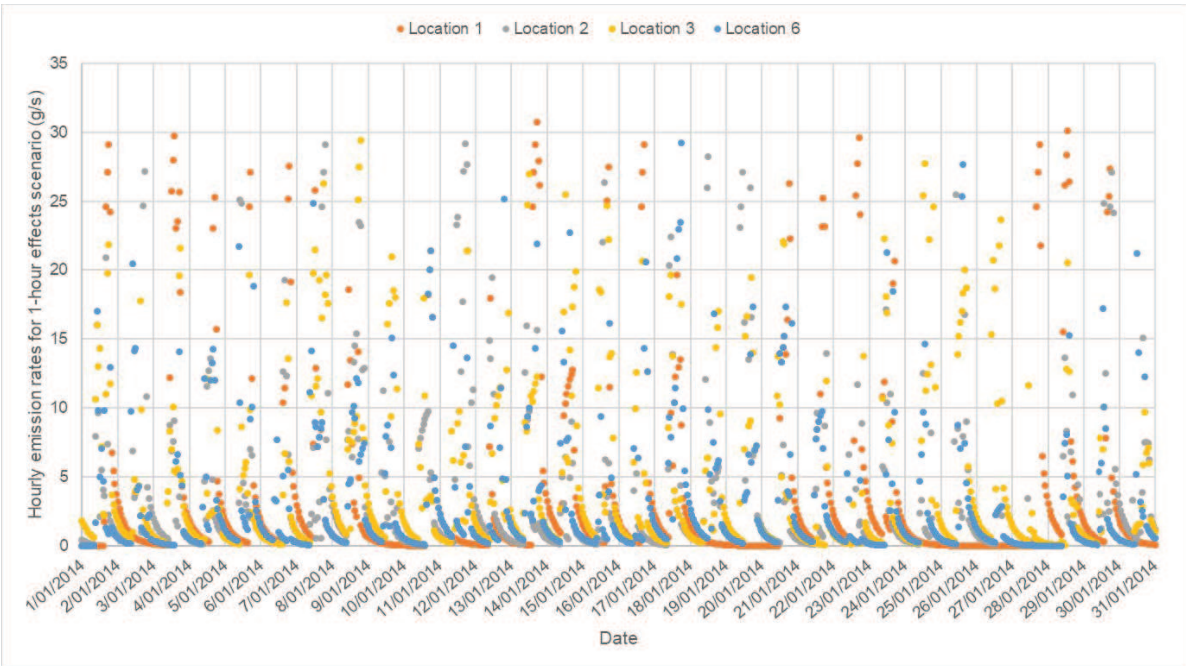


Figure 15: Example of the one-month emissions for 1-hour effect scenario. Log fumigation only.

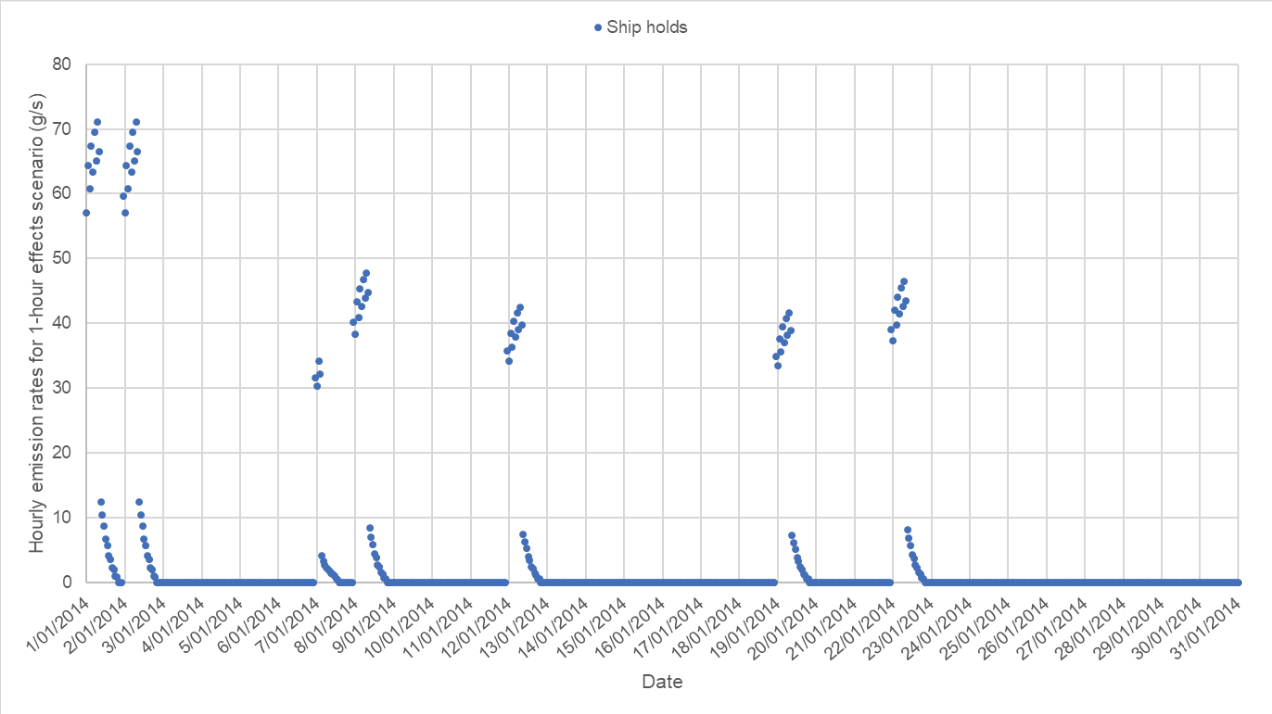


Figure 16: Example of the one-month emissions for 1-hour effect scenario. Ship hold fumigation only.

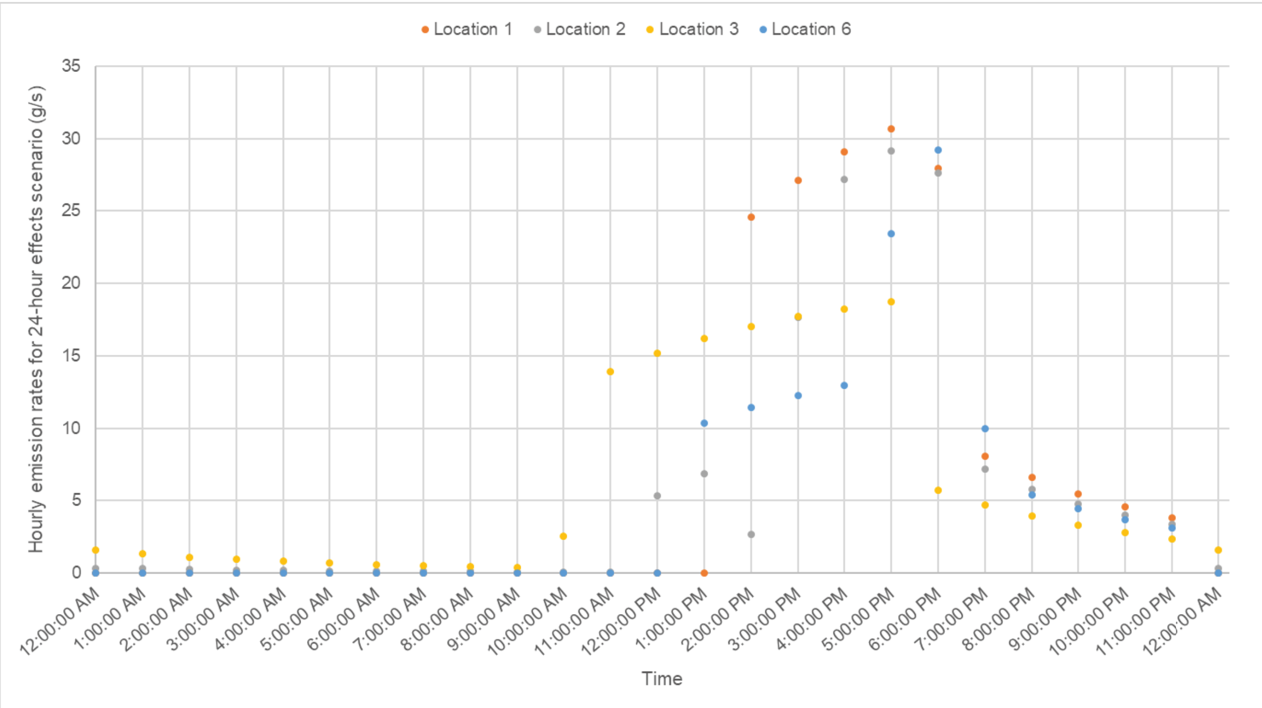


Figure 17: Example of the daily emission for 24 hour effect scenario. Log fumigation only.[10]

[10] Note that hours shown in this figure are one hour behind the release. This is because the model requires the end of hour emissions.

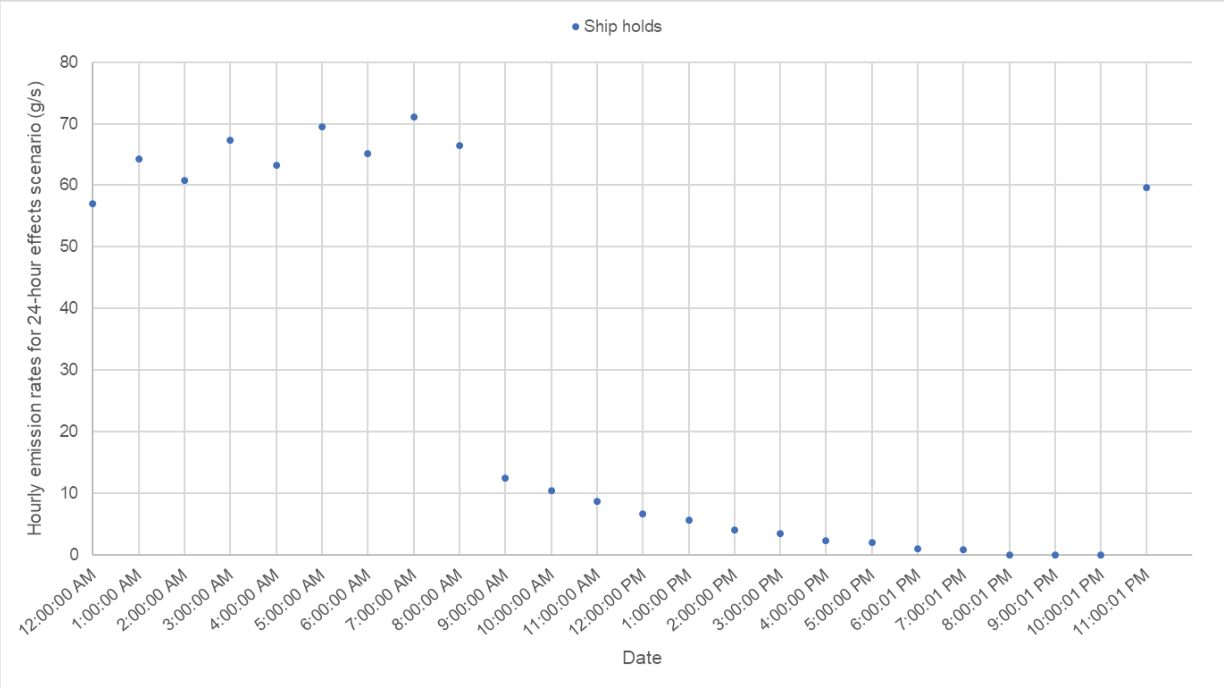


Figure 18: Example of the daily emission for 24 hour effect scenario. Ship hold fumigation only.

4.0 RECEIVING ENVIRONMENT

4.1 Introduction

In order to assess the potential effects on the environment from Genera's fumigation activities at the Port of Tauranga, it is necessary to identify the nature of the potentially effected environment. The following sections discuss the location of the site and neighboring industrial sites, the meteorology, the existing air quality and the location of sensitive receptors to the site.

4.2 Site Location and Sensitive Receptors

The Port of Tauranga is located in the industrial zone area of Mount Maunganui, the southern end of the port is approximately 1 km to the north west of Tauranga airport and is 2 km from central Tauranga. The Port of Tauranga has a large footprint and the main area where Genera operates is only a small portion of the port area (see Figure 1). For a complete map of fumigation areas (see APPENDIX E, Section 4).

The port is surrounded by predominantly industrial sites such as Ballance Agri-Nutrients fertiliser plant, Dominion salt plant, Lawter chemical manufacturing plant, Ixom chemical manufacturing plant, Inghams animal feed mill manufacturer and various other industrial activities such as fuel storage, vehicle maintenance, engineering workshops and freight companies.

The surrounding residential dwellings are indicated in Figure 1. Most of the residential dwellings are located along the coast of Mount Maunganui. The nearest residential receptors are located approximately 300 m to eastern port boundary on Tawa Street it should be noted that Genera operate mainly to the southern end of the port which is further from these receptors. Other residential dwellings associated with the Ngai Te Rangi

Settlement trust and Marae are located approximately 600 m south of the port. There is a large sports area between the port and the residential properties to the north east of the port. The sports area contains the Mount Maunganui playcenter which is an early childhood center. The Tauranga Bridge Marina located approximately 600 m to the south of the port offers short to medium term stays for people living in a boat.

Most of the residential dwellings are located along the coast of Mount Maunganui. The nearest residential area to the port is located approximately 300 m from eastern port boundary on Tawa Street. The nearest residential dwellings to the Genera operational areas are approximately 400 m. Other residential dwellings associated with the Ngai Te Rangi Settlement Trust and Whareroa Marae are located approximately 600 m south of the port. There is a large sports area between the port and the residential properties to the north east of the port. The sports area contains the Mount Maunganui playcenter which is an early childhood center. The Tauranga Bridge Marina located approximately 600 m to the south of the port offers short to medium term stays for people on boats.

In summary all locations beyond the port boundary are expected to be sensitive to discharges from the fumigation operation. Industrial and non-residential areas are expected to be less sensitive to long term (annual) exposure as people are less likely to be exposed at these locations for the averaging period.

4.3 Topography and Meteorology

Tauranga is located in the Bay of Plenty region in the North Island of New Zealand and has a generally sunny climate which is relatively sheltered by the elevated terrain to the east, west and south of the region. The site area is largely flat, with the nearest significant terrain (Mount Maunganui) being approximately 4 km to the north of the site.

The prevailing winds in Tauranga are typically from southwest as shown by the wind rose in item (a) of Figure 19. This wind rose is generated by the meteorological data measured at Tauranga Airport Weather Station from January 2014 to December 2018 (inclusive). It also shows that winds from south-south-west are relatively frequent and typically lighter. Drainage flows (i.e., cold, light winds that generally follow the terrain, flowing downhill) are also likely to be from the southern quadrant.

Wind roses for specific times of the day are provided in items (b), (c) and (d) of Figure 19. These show the following:

- Morning - from 00:00 to 08:00 hours, winds are most frequent from the south-southwest and typically light to moderate. The south-south-westerly winds occur for approximately 13 % of the time during these hours.
- Daytime - from 8:00 to 18:00 hours, prevailing winds are typically moderate to strong west-south-westerly winds, followed by moderate to strong westerly and south-westerly winds.
- Evening - from 18:00 to 23:59 hours, prevailing winds are also typically moderate to strong westerly and west-south-westerly winds.

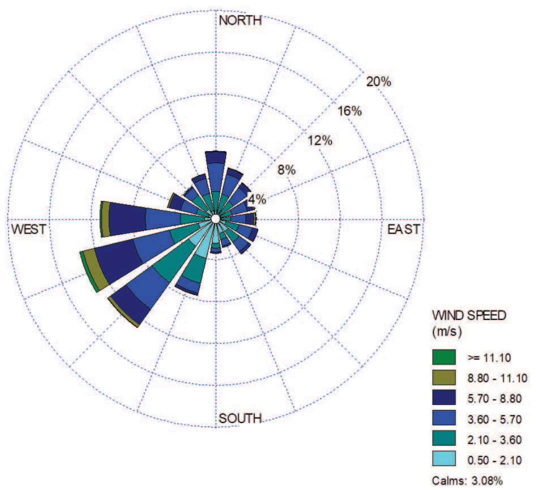
Items (a), (b), (c) and (d) of Figure 20 present wind roses for each season of the year, which indicate the following:

- Summer: winds are typically either moderate to strong westerly to south-westerly winds, or moderate northerly winds.

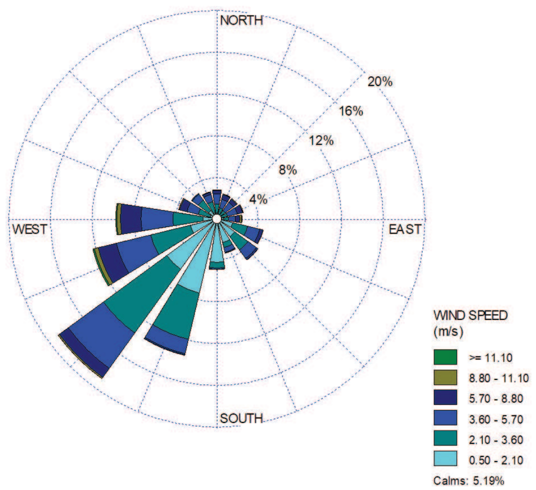
- Autumn: winds are typically either light to moderate south-westerly and south-south-westerly winds, or moderate to strong west-south-westerly and westerly winds.
- Winter: winds are typically either light to moderate south-westerlies and south-south-westerly winds, or moderate to strong west-south-westerly and westerly winds.
- Spring: winds are typically moderate to strong west-south-westerly and westerly winds.

Light winds that are driven by atmospheric drainage conditions are also likely to be generally from the south (towards the north). Given the above, early morning or night conditions are likely to provide for the poorest dispersion of MB generated by the site, whereas conditions during the middle of the day are more likely to provide for better dispersion. With regard to the seasons, spring and summer typically have a higher proportion of strong winds where MB from the site would be more readily dispersed and diluted, whereas winter and autumn are more characteristic of lighter winds.

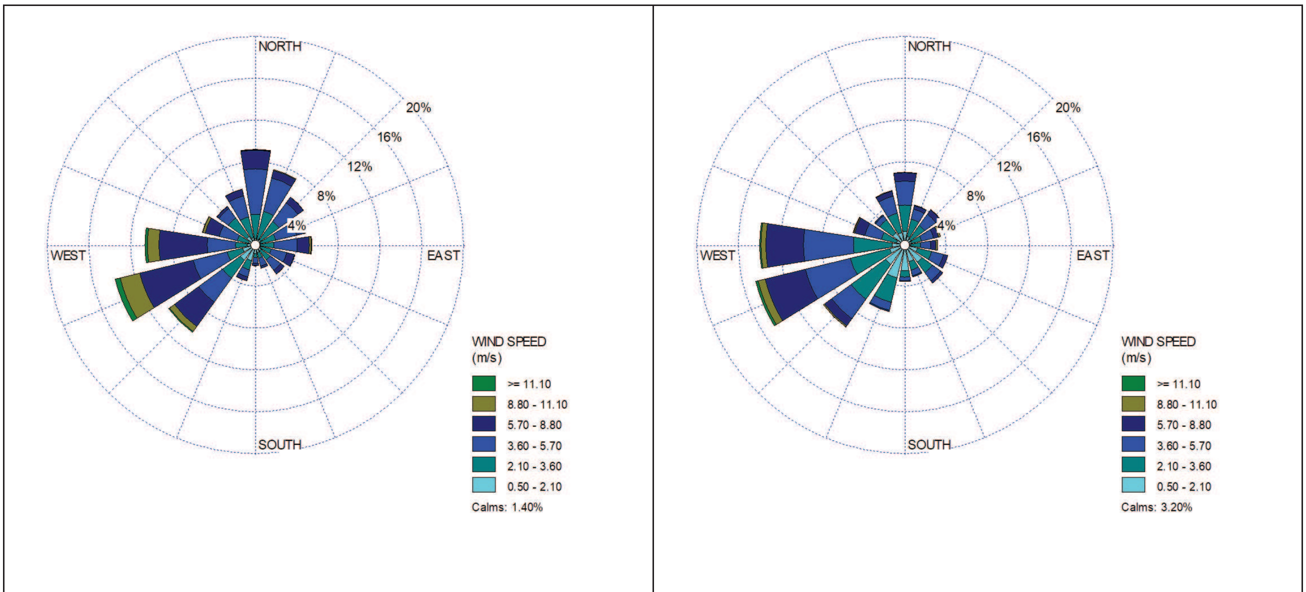
Tauranga has a mean temperature of 15.4 °C, and a range from highest to lowest of 30 °C to 0 °C. The mean wind speed for the years 2014 to 2018 was 13 km/h (or 3.7 m/s). The rainfall for Tauranga is 1189 mm per year on average with rain occurring on 151 days per year (ASG, 2018a).



a) All hours



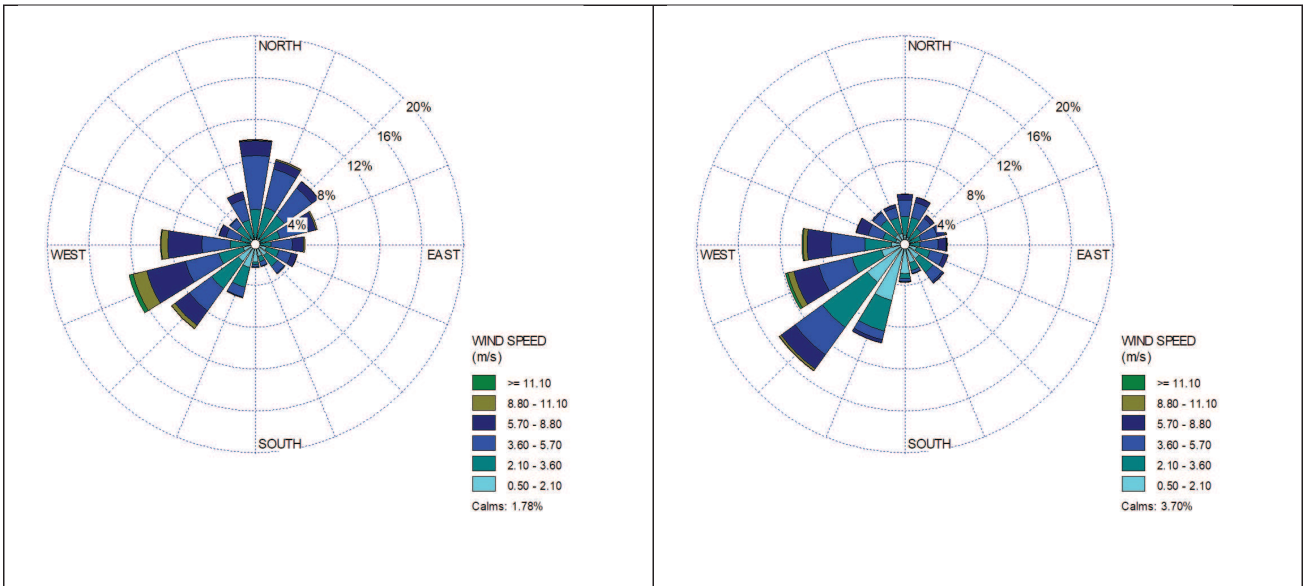
b) 00:00 to 08:00



c) 08:00 to 18:00

d) 18:00 to 23:59

Figure 19: Wind rose measured at Tauranga Airport Weather Station for different periods of the day (2014 – 2018).



(a) Summer

(b) Autumn

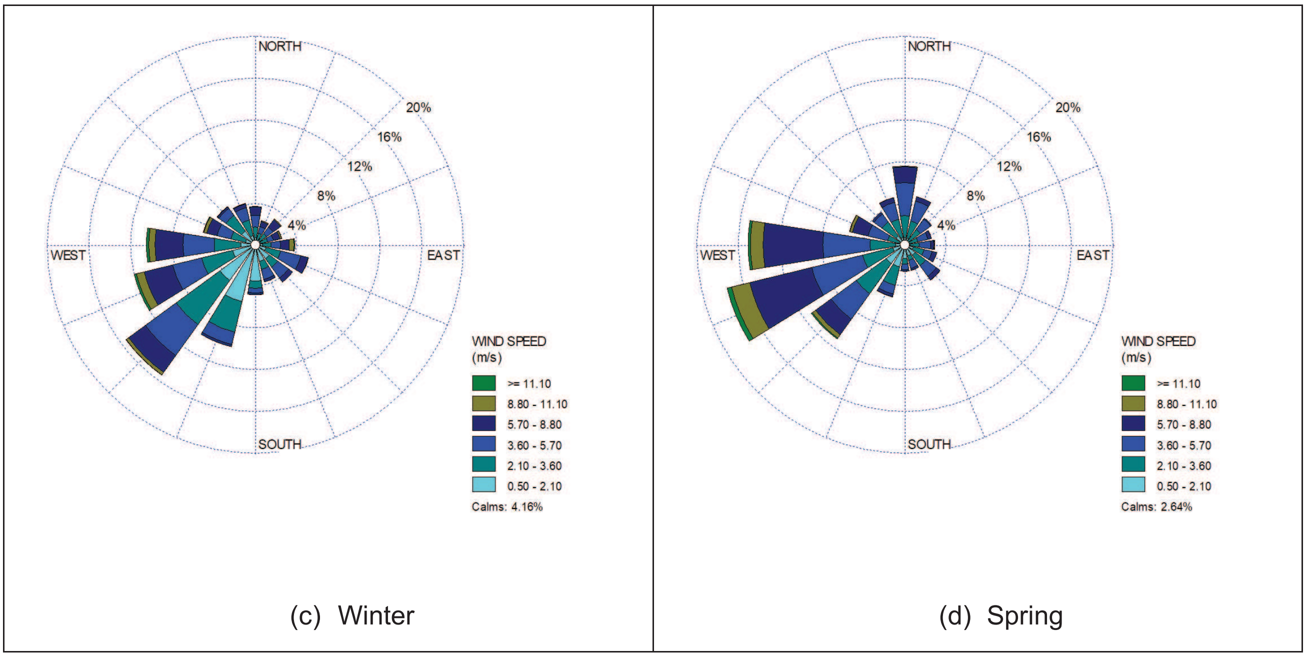


Figure 20: Wind rose measured at Tauranga Airport Weather Station for different seasons (2014 – 2018).

4.4 Background Air Quality

MB in the air can originate from natural sources such as the ocean and anthropogenic sources such as biomass burning and motor vehicles running on leaded gasoline (Golder note, leaded petrol is no longer used in New Zealand) (Yvon-Lewis & Bulter, 2015).

To confirm that there are low levels of background MB, a background sampling of MB has been undertaken as part of the ambient MB monitoring programme. The monitoring programme is described in detail in APPENDIX F. A background sample was collected in a rural area approximately 2 km to the south of Katikati. A 24-hour sample was collected using a whole air sampling canister on 8 August 2019. It was found that MB was below the detection limit of 0.01 ppm in this sample. Additionally, there was one occasion for a sample at the port where a 1-hour sample was taken when the fumigation was not upwind of the cannister. This sample was also below the detection limit of 0.01 ppm.

The BoPRC has been running five ambient monitoring sites continuously along the boundary of the Tauranga Port. MB is monitored using a photoionization detector (PID) to monitor total volatile organic compounds (TVOC), of which MB can be a component. While this provides useful information on TVOC concentrations, the relationship between TVOC and MB will vary depending on the sources upwind at the time of sampling. Therefore, this data cannot effectively be used to determine background MB concentrations at the Port of Tauranga.

Given the above, it is assumed that the background concentration of MB is likely to be negligible at Mt Maunganui.

5.0 ASSESSMENT METHODOLOGY

5.1 Overview

This section describes the assessment criteria and methods that are used for assessing onsite and offsite air quality effects of MB resulting from the fumigation processes. The onsite zone is considered to be outside the working area of Genera, but still within the port land.

The off-site assessment was carried out using an air dispersion model to predict the MB concentrations at ground levels beyond the Port of Tauranga. The model results used in combination with the monitored MB at and beyond the site boundary. The aim of the modelling is to assess compliance with the guidelines for ambient MB as set out in Section 5.2. The ambient guidelines are based on 1 hour, 24-hour and annual timescales. The assessment method is designed to assess potential future exposures and does not include an evaluation of previous offsite effects.

The assessment of onsite air quality effects is limited to comment on onsite monitoring data as modelling of air quality effects in the immediate near field is not considered an effective method for assessing onsite effects, considering there are multiple MB sources that have relatively variable release mechanisms and local complex wind and potential building wake (downwash) effects.

5.2 Assessment Criteria

The following sets out the ambient assessment criteria based on the priority set out in the Good Practice Guide for Assessing Discharges to Air from Industry (Ministry for the Eironment, 2016).

The highest priority are national environmental standards for air quality (Ministry for the Environment, 2011) followed by national ambient air quality guidelines (Ministry for the Environment, 2002). There are no MB criteria in either of these documents.

The New Zealand EPA produced a document in 2011 (NZEPA, April 2011), outlining ambient guidelines for MB, which while not explicitly cited in (Ministry for the Eironment, 2016), is considered to be next in order of priority for consideration. The NZ EPA Ambient Tolerable Exposure Limits (TELs) for MB are the same as the Office of Environmental Health Hazard Assessment (OEHHA) for both acute (1 hour) and long term (annual) values.

The BoPRC air plan was reviewed and did not contain guidelines for MB. Air quality material was reviewed from both the World Health Organisation (WHO) and United States EPA and there is a significant body of information about MB, but ambient guideline concentrations are not specified.

In summary, based on ESR (2019) Golder understands the TELs (NZEPA, 2011) for MB are likely to be the most appropriate guidance for both Port area (excluding the Genera exclusion zone) and offsite effects.

For MB, the workplace exposure standard (WorkSafe, 2018), is 5 ppm or 19 mg/m^3 as an 8-hour time weighted average and has a skin notation which means that there is potential for significant skin absorption. Based on ESR (2019), Golder understands Workplace exposure standards are relevant for Genera staff. The effects on Genera staff are considered under workplace health and safety requirements and these have not been assessed in this report.

Table 3: Tolerable Exposure Limits (TELs) for methyl bromide.

Averaging period	Parts per million (ppm)	Milligrams per metre cubed (mg/m³)
TEL air (annual):	0.0013	0.005
TEL air (24 hour):	0.333	1.3
TEL air (1 hour):	1.0	3.9
Workplace Exposure Standard (8 hour)	5.0	19

5.3 Onsite Assessment Approach

5.3.1 Analysis of Monitoring Results

Data collected using whole air cannisters in the current ambient monitoring programme has been used to evaluate MB concentrations. There is also significant ambient PID monitoring data near the fumigation events and at the boundary. The data collected by the PIDs has not been able to be used to quantify the MB concentrations as a relationship between whole air cannister and PID records has been unable to be developed.

5.4 Offsite Assessment Approach - Atmospheric Dispersion Modelling

5.4.1 Meteorological modelling – CALMET

This assessment makes the use of the CALMET meteorological datasets provided by BoPRC. These were developed by ASG (2018a) for the SO_2 dispersion modelling study over the Tauranga and Mount Maunganui Area. CALMET (version 6.5.0, February 2015) was run for the years 2014, 2015 and 2016, based on outputs from the prognostic Weather Research and Forecasting model (WRF, version 3.7, April 2015)[11], and on data from nine surface-based meteorological monitoring stations. Upper-air information was provided by WRF, and recent local terrain and land cover data were used[12].

5.4.2 Dispersion modelling - CALPUFF

CALPUFF has been used to model dispersion of MB around the Port of Tauranga. As MB is denser than air, Golder has also considered the use of specialised dense-gas dispersion models. However, most of the specialised dense-gas models assume flat, uniform terrain and therefore would not be suited to the complex meteorology of the coastal environment of the Port of Tauranga. CALPUFF is not a dense-gas model, but is well-established as a model for regulatory assessments, has been widely tested and verified in many cases; its formulation as a 'puff' model based on spatially-varying meteorology is like that of some dense-gas model.

[11] See https://www.mmm.ucar.edu/weather-research-and-forecasting-model for more information on WRF.

[12] Land cover database (LCDB) version 4.1, July 2015.

As a check, the model results were reviewed in with consideration of monitored MB at and beyond the site boundary.

CALPUFF, version 7.2.1, was run to simulate the dispersion of MB released after fumigation has been carried out at the Port, to represent off-site ground-level concentrations (GLCs). This model runs include the fumigation of log piles at the waterside, as well as ship holds fumigation.

MfE (2016) recommends that the predicted 99.9th percentile 1-hour GLC is recommended to be reported as the maximum GLC. This practice usually produces robust and more realistic model results (compared to monitoring data), and minimises the effects of unrealistic modelled meteorological conditions – which do not occur in reality.

However, in this assessment, a test model run using a constant emission rate shows that the difference between maximum and the second highest value is not substantial (1 % reduction, and approximately 10 % reduction to the 9th highest). This indicates the CALMET meteorological dataset does not appear to show extreme weather conditions. A SO_2 dispersion modelling assessment was carried out by ASG for the Tauranga and Mount Maunganui area (ASG 2018b) using the same CALMET dataset. It shows that the maximum 1-hour SO_2 modelling results predicted by ASG (when using actual emissions) are generally consistent with the SO_2 monitoring results. Finally, as hourly varying emissions have been used and the likelihood of the peak emissions combining with the worst model generated meteorological condition is low, even when considering the composite emissions data.

Finally, and most importantly, the modelled maximum value and 99.9th percentile value has been reviewed and evaluated with the monitoring results as presented in APPENDIX F. This analysis shows that potentially, the maximum predictions are underpredicting the effects for these nearfield locations, it is noted that these may be due to the emissions assumptions.

Therefore, in this case it is considered appropriate to use the modelled maximum (100th percentile) 1-hour average GLCs as the maximum GLCs and these are presented in Section 6.0. For 24 hour and annual modelling results, maximum predictions are also reported.

To assist in health risk assessment, the predicted 99.9th percentile 1-hour and 24-hour GLCs are also shown in Section 6.0 (ESR, 2019).

APPENDIX D provides a summary of the CALPUFF input settings. Most standard options were used, including the ‘pdf’ option for dispersion under convective conditions.

5.4.3 Hourly varying emissions and discharge parameters

Hourly varying input files for CALPUFF were developed for log stack/container and ship hold fumigations. These included MB emission rates for each fumigation location, elevation of ground at each source, effective height above ground and initial sigma-y and sigma-z.

The calculation of hourly emission rate is described in Section 3.7 and APPENDIX E. The time and location varying emissions were calculated based on mass of MB used for the period from May 2018 to April 2019, inclusive.

The log stack/container and ship hold fumigations were modelled as volume sources. This was considered the best source type to simulate their dispersion based on the source information available. The assumed discharge parameters are summarised in Table 4. Parameters such as log stack heights were estimated based on Genera’s operation and sigma Y is set so the volume source did not exceed the area where fumigation was carried out.

Table 4: Emission source parameters.

Parameters	Log stack fumigation_ Location 1	Log stack fumigation_ Location 2	Log stack fumigation_ Location 3	Log stack fumigation_ Location 6	Ship hold fumigation
Coordinates (UTM, km)	427.885, 5832.063	427.891, 5831.48	427.949, 5831.764	427.993, 5832.535	427.776, 5831.904
Source height (m)	6	6	6	6	6
Base elevation (m)	3.77	2.31	3.38	3.51	0
Initial sigma Y (m)	23.26	37.21	34.88	32.56	12.79
Initial sigma Z (m)	1.4	1.4	1.4	1.4	1.4

6.0 AIR DISCHARGE MODELLING RESULTS

6.1 Introduction

The following sections provides a summary of the dispersion modelling predictions for MB discharges from log stack[13] and ship hold fumigation. While on port modelling results are shown, modeling should only be used for reviewing offsite effects. The onsite predictions are considered to be too close to the discharge of MB to be considered reliable. All CALPUFF contour maps showing MB GLCs can be found in Appendix G.

6.2 Methyl Bromide

6.2.1 Modelling Results at Specific Locations

The predicted 1-hour and 24-hour average MB GLCs at the maximum offsite location (at eastern site boundary) and the nearest residential dwelling are presented in Table 5 (due to logs only), Table 6 (due to ship hold only) and

Table 7 (due to both ship hold and log stacks).

The predicted maximum annual average MB GLCs at the above locations are shown in Table 8.

Table 5: Predicted GLCs at the maximum offsite location and nearest residential dwelling due to fumigation of log stacks only (1-hour and 24-hour).

Percentile	Maximum offsite location (Eastern site boundary)		Nearest Residential dwelling	
	1-hour GLCs (ppm)	24-hour GLCs (ppm)	1-hour GLCs (ppm)	24-hour GLCs (ppm)
100th (Maximum)	1.2	0.1	0.7	0.06

[13] Including containers.

Percentile	Maximum offsite location (Eastern site boundary)		Nearest Residential dwelling	
	1-hour GLCs (ppm)	24-hour GLCs (ppm)	1-hour GLCs (ppm)	24-hour GLCs (ppm)
99.9th	0.3	0.09	0.1	0.06
99.5th	0.1	0.06	0.05	0.04
99th	0.08	0.06	0.03	0.03
98th	0.05	0.04	0.02	0.02
95th	0.03	0.03	0.01	0.01
90th	0.02	0.02	0.00	0.01

Table 6: Predicted GLCs at the maximum offsite location and nearest residential dwelling due to fumigation of ship hold only (1-hour and 24-hour).

Percentile	Maximum offsite location (Eastern site boundary)		Nearest Residential dwelling	
	1-hour GLCs (ppm)	24-hour GLCs (ppm)	1-hour GLCs (ppm)	24-hour GLCs (ppm)
100th (Maximum)	3	0.5	1	0.2
99.9th	0.5	0.4	0.3	0.1
99.5th	0.1	0.3	0.06	0.09
99th	0.06	0.2	0.02	0.06
98th	0.02	0.11	0.01	0.04
95th	0.00	0.05	0.00	0.02
90th	0.00	0.03	0.00	0.01

Table 7: Predicted GLCs at the maximum offsite location and nearest residential dwelling due to fumigation of log stacks and ship holds (1-hour and 24-hour).

Percentile	Maximum offsite location (Eastern site boundary)		Nearest Residential dwelling	
	1-hour GLCs (ppm)	24-hour GLCs (ppm)	1-hour GLCs (ppm)	24-hour GLCs (ppm)
100th (Maximum)	3	0.6	1	0.15

Percentile	Maximum offsite location (Eastern site boundary)		Nearest Residential dwelling	
	1-hour GLCs (ppm)	24-hour GLCs (ppm)	1-hour GLCs (ppm)	24-hour GLCs (ppm)
99.9th	1	0.4	0.4	0.1
99.5th	0.2	0.2	0.1	0.1
99th	0.1	0.2	0.05	0.08
98th	0.07	0.2	0.03	0.07
95th	0.04	0.1	0.01	0.05
90th	0.02	0.06	0.01	0.03

Table 8: Predicted annual GLCs at the maximum offsite location and nearest residential dwelling due to fumigation of log stacks and ship holds.

Modelling year	Maximum offsite location (Eastern site boundary) (ppm)			Nearest Residential dwelling (ppm)		
	Original	Offset by 1 month	Offset by 11 months	Original	Offset by 1 month	Offset by 11 months
2014	0.0007	0.0009	0.0008	0.0002	0.0003	0.0003
2015	0.0011	0.0008	0.0009	0.0000	0.0003	0.0004
2016	0.0009	0.0009	0.0013	0.0000	0.0003	0.0005

6.2.2 Predicted maximum (100th percentile) results

The predicted maximum (100th percentile) contour map results for MB are presented in Appendix G Figure 1 to Figure 7. The combined maximum effect is very similar to the ship hold predictions as there is little additive effect as maximum predictions occur at different times of day.

The predicted contour for the 1-hour assessment criteria of 1 ppm (3,900 µg/m³) - outlined in blue dotted line in Appendix G Figure 1 extends less than 150 m beyond the eastern site boundary, whereas the contour of the assessment criteria in Appendix G Figure 3 extends further, approximately 500 m beyond the eastern port boundary, into the public playground (shaded as green) and approaching the edge of residential area (shaded as pink). The predicted maximum 1-hour MB GLCs (due to the both log stacks/container and ship hold fumigation) at Mt Maunganui Playcentre (marked as a green square) and the nearest sensitive receptor (marked as a red dot) are approximately 1 ppm. This is primarily due to the effects of the ship hold emissions.

Appendix G Figure 4 shows the predicted contour of the 24-hour assessment criteria (0.33 ppm or 1300 µg/m³) only extends onto the sea to the west of the site, where exposure over a 24-hour is not so relevant. Combined with the effects from ship hold fumigation, Appendix G figure 6 shows the predicted contour of assessment criteria extends approximately 250 m beyond the east of the site boundary, just into the neighbouring industrial zone. This is also driven by the ship hold emissions.

Appendix G Figure 7 presents the predicted contour of the annual assessment criteria (0.0013 ppm or 5 µg/m³) extends less than 100 m beyond the eastern boundary, approaching the industrial sites immediately adjacent to the site.

6.3 Predicted 99.9th percentile results (1-hour, 24-hour)

The predicted 99.9th percentile results were used for the health impact assessment (ESR, 2019). The predicted 99.9th percentile contour map results for MB are presented in Appendix G Figure 8 to Figure 11.

7.0 MONITORING RESULTS

7.1 Overview

The MB monitoring is important for the assessment of both onsite and offsite ambient effects. The MB monitoring completed by BoPRC and Genera using PIDs provides instantaneous total VOC monitoring. However, for the purposes of quantifying on-port and offsite MB concentrations, further validation of the existing monitoring data was required.

The MB monitoring programme began on 30 May 2019 and is currently ongoing as of 15 October 2019. Air samples were collected using whole air sampling canisters also known as Summa canisters.

There were two objectives of the MB monitoring programme. The first was to investigate the relationship between Genera's Cub PID's measured VOC concentrations and MB concentrations. The second objective was to gather robust measured data which could be compared with the dispersion model predictions. Having measurement data to compare to modelled predictions of ambient MB is especially useful when the emission source has a release mechanism which is at ground level and variable - which is the case in this situation.

For full details on the monitoring programme and analysis of monitoring results see APPENDIX F.

7.2 Summary of Monitoring Results

Whole air sampling canister measurements of MB were generally in the order of two to three times higher than total VOC measurements by the Cub PIDs. This indicates that the Cub PID monitors are under reporting MB concentrations. From the monitoring data currently available, there is insufficient evidence to generate a correction factor which could be applied to PIDs to give more realistic MB concentrations or to demonstrate if this approach is feasible.

Samples which were downwind of ventilations and considered useful for comparison to modelled results are displayed in Table 9. The other samples described in APPENDIX F were not considered useful for comparison with modelled concentrations as they were not downwind during substantial MB emissions.

Table 9: Monitoring results suitable for comparison with modelling.

Id No. (1-hour unless noted)	Approximate time Downwind of venting	Average Release rate during downwind period (g/s)	Average Release rate while downwind over total monitoring period (g/s)	Distance from Venting (m)	Concentration (ppm)
1A (onsite)	100 %	39	39	60	35.9
2A	71 %	30	21	330	2.2
1B (onsite)	33 %	1.6	0.5	60	0.19
2B	67 %	25	17	230	<0.01
4B (24 hour)	17 %	12	2	450	0.05
1C (onsite)	57 %	21	12	80	6.4
2C	57 %	21	12	130	2.3
3C	57 %	9	5	290 – 340	0.01
1D	14 %	97	14	420	0.07
2D (24 hour)	5 %	37	3	420 – 650	0.02

7.3 Comparison of Monitoring with Modelling

Ambient monitoring results show exceedances of the 1 hour TEL at the site boundary at distances between 230 and 330 m from the fumigations locations during log stack fumigations. No ambient monitoring was undertaken during ship hold fumigations. During log stack fumigations only, maximum model predictions at the boundary are 1.5 µg/m³. The monitoring measurements were undertaken when the hourly average MB emission when downwind was between 40 % and 75 % of the maximum emission assumed in the modelling based assessment. At face value, these results would suggest that the modelling assessment is underpredicting the offsite concentrations. It is unusual for a limited period of monitoring to result in measured concentrations that are higher than the model predicted maximum offsite concentrations.

The typical causes for model underprediction are considered to be emission rate assumptions the source characterisation within the model set up and/or meteorological inputs. In this case the emission rate assumptions are expected to be the most significant in the differences in model predictions and monitoring results. The model emission rate assumptions are based on future expected operation and among other assumptions, assume that for 80 % of the log stacks vented in an hour, 80 % of the residual headspace MB is recaptured.

Golder used all of the available Genera recorded fumigation data during the monitoring periods to calculate the emissions for the monitoring period. However, recapture (or not) is only indicated by a tick box and there is no data on recapture efficiencies for these events. Therefore, it is unclear whether the emissions calculated for the monitoring periods are representative of actual emissions during those periods. For example, if recapture rates were lower than the assumed 80 %, the headspace MB release would be higher and the emission during the monitoring period could potentially be higher than that assumed in the modelling assessment. In this situation, the model may not be underpredicting, rather the emissions during the monitoring period are higher than what was calculated or anticipated in the modelling based assessment.

The meteorological data set is considered to be robust and well developed, a previous study (ASG, 2018a) of SO_2 effects has demonstrated that the data set performs relatively well compared to monitoring data. Paired meteorology could allow further review into understanding of meteorological conditions that caused the high monitoring data, but without robust concurrent emission data, the benefits of this type of study are unclear.

8.0 CONCLUSIONS

In conclusion, this report provides a modelling-based assessment of offsite MB concentrations with monitoring data used to assist in evaluating the modelling results. Considerable effort has gone into determining appropriate emission rate assumptions and accounting for both the initial release of MB during the venting procedure, and the ongoing MB release due to desorption from the logs. With the exception of determination of the ship hold headspace MB release, all data is based on a large number of measurements. Based on Golder's understanding of Genera's future operation, the key assumptions in the modelling based assessment include:

- A maximum MB usage of 450 kg/hr and 150,000 kg per annum.
- Recapture achieves an 80 % reduction of the headspace MB available at the end of the fumigation period.
- Recapture is undertaken on 80 % of the log stacks ventilated in an hour.
- Ship holds are ventilated at a rate of one hold per 2 hours.

The assessment accounts for various combinations of emissions and potential future meteorological conditions by running multiple emission scenarios for multiple modelling years. This is considered to be robust and appropriately conservative for predicting potential future effects.

The modelling results indicate that there are maximum offsite concentrations that exceed the 1 and 24 hour average TEL criteria at locations near to the boundary. For the 1 hour concentrations, this predicted exceedance just extends into the residential area. These are primarily as a result of ship hold fumigation events. The 24 hour average predictions are expected to be relatively conservative as they assume a ship hold fumigation occurs every day.

Predicted annual concentrations also exceed the TEL at industrial zoned locations just beyond the port boundary.

The monitoring has also shown exceedances of the 1 hour TEL at the port boundary during log stack fumigations. Calculations of expected concurrent emissions, assuming 80 % recapture, suggest that these measurements were made when emission rates were lower than that assumed in the modelling assessment.

However, the actual MB recaptured prior to the ventings that occurred during these measurements is unclear. Therefore, as the recapture percentage assumption is the primary driver of maximum calculated emission rates, it is uncertain whether these monitoring results are clearly indicative of model underprediction.

While the whole air cannister monitoring data shows ambient concentrations that are higher than those predicted using the modelling-based assessment, it is possible that these occurred under higher emission rates than those calculated based on assumed recapture rates. Therefore, the ongoing whole air cannister monitoring programme should focus on collecting sufficient data to allow better quantification of emissions during the periods of ambient monitoring and therefore allow the refinement of the relationship between the modelling and monitoring data. The collection of ambient monitoring during a ship hold venting should also be targeted.

9.0 REFERENCES

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APPENDIX A

Report Limitations

Report Limitations

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APPENDIX B

Existing Air Discharge Permit

Resource Consent

Resource Consent 62719-AP

Following the processing of the Application received on the 11 June 2004, the Bay of Plenty Regional Council has granted the applicant(s):

Genera Limited

Consent(s) to:

62719.0.01-DC	Discharge To Air	Expiry	30 April 2020

The consent(s) are subject to the conditions specified on the attached schedule(s) for each activity. Advice notes are also provided as supplementary guidance, and to specify additional information to relevant conditions.

The Resource Consent hereby authorised is granted under the Resource Management Act 1991 does not constitute an authority under any other Act, Regulation or Bylaw.

DATED at Whakatane this 24th day of May 2005

For and on behalf of The Bay of Plenty Regional Council

Fiona McTavish
Chief Executive

The change of the whole of this resource consent was approved under delegated authority of the Bay of Plenty Regional Council dated 3 April 2019

Bay of Plenty Regional Council

Resource Consent

Pursuant to the Resource Management Act 1991, the **Bay of Plenty Regional Council**, by a decision dated 24 May 2005, **hereby grants**:

A resource consent:

- **Pursuant to section 15(1)(c) of the Resource Management Act 1991 to Discharge Fumigants (Methyl Bromide and Phosphine) to Air**

subject to the following conditions:

1 Purpose

Change: CH18-01174

1.0 For the purpose of fumigation for quarantine and export and import requirements for the Port of Tauranga Limited. Such fumigations are limited to the following;

- Logs under sheets
- Logs in ships' holds
- Timber under sheets
- Cargo in sheds and on-wharf under sheets
- Shipping containers and contents
- Cargo in ships holds when directed by the Ministry of Primary Industries in relation to a biosecurity risk.

2 Location

2.0 At the Port of Tauranga as shown on BOPRC Plan Numbers RC 62719 and RC 62719/1; in the area zoned Port Zone; and at 9 and 11 Maru Street as shown on BOPRC Plan Number RC 62719/2 submitted with the application for this permit.

3 Map Reference

3.0 At or about map reference NZMS 260 U14: 9232-8833.

4 Legal Description

4.0 Lot 1, DP 311509 and Crown Land (seabed), Block VI, Tauranga SD (Tauranga District).

4 4B Fumigation Restrictions

4.01 4B.1 The consent holder shall ensure that weather conditions at fumigation sites are actively monitored and that real time meteorological information is used to manage the fumigation activity.

4.2 4B.2 The consent holder shall ensure that no ventilation to atmosphere occurs when inversion conditions are present or likely to occur. No ventilation to atmosphere shall occur during hours of darkness defined as being from 30 minutes after sunset one day, until 30 minutes before sunrise on the next day without active monitoring of venting procedures, gas levels, and wind conditions.

Reporting shall occur of all instances where venting to atmosphere has occurred at night to Bay of

Plenty Regional Council and Genera management, including documentation of conditions and venting activities to allow subsequent audit. Genera shall suspend ventilation should inversion conditions exist, or measured bromide levels indicate that air movement is inadequate to achieve safe ventilation. It is noted that the applicant may implement technology (with written approval by Regional Council) such as chimney assisted venting.

4.3 4B.3 Covering of goods for fumigation shall not take place if the wind speed is in excess of 25 knots.

4.4 4B.4 The consent holder shall ensure that the tarpaulins used for fumigation are maintained in good working condition without any rips or tears, to the satisfaction of the Chief Executive of the Regional Council or delegate.

5 Emission Controls

5.1 Fumigants must be under the control of an approved handler pursuant to Hazardous Substances and New Organisms Act 1996 (or any subsequent updates of that Act) at all times. Only approved handlers or an approved trained person working under the direct supervision of an approved handler may handle and use fumigants.

5.2 All persons discharging fumigants shall ensure that:

a) The fumigant is discharged in a manner that does not contravene any requirement specified in the manufacturer's instructions.

b) The use of fumigants complies with The Control and Safe Use of Fumigants - parts one, two and three, referenced HSNOCOP31 prepared by the Pest Management Association of New Zealand or any subsequent updates of that code.

c) The fumigant use must not result in any harmful concentration of fumigant beyond the boundary of the subject property or into water.

Change: CH17-00641

5.3 The permit holder shall prepare, maintain and comply with an appropriate Emergency Management Plan for all operations within one month of the consent being granted. The plan shall be to the satisfaction of the Chief Executive of the Regional Council or delegate (see Advice Note 1). The Emergency Management Plan shall as a minimum include, but not necessarily be limited to, the following;

- A list of all staff employed by Genera including their training qualifications related to fumigation, with dates these were obtained/completed and their expiry.
- Emergency contact details
- Contingency plan details
- Material Safety Data Sheet
- Details on the location and volumes of methyl bromide stored
- All related approvals e.g. location certificates
- Standard operating procedures for all types of fumigation operations carried out
- All meter calibration certificates

5.3.1 Each year for the duration of this consent, during the month of May, the consent holder shall submit to the Regional Council an updated version of their Emergency Management Plan to the satisfaction of the Chief Executive of the Regional Council or delegate

5.3.2 The consent holder shall ensure that only appropriately authorised Genera employees with the necessary PPE are allowed into the Risk Area as defined in Appendix 2 of the Fumigation Procedures for the Port of Tauranga - Version One 03/05/2011, or any superseded version of this document

5.3.3 All persons shall be excluded from any fumigation area where the methyl bromide concentration may be above the workplace exposure standard (WES) value, unless they are wearing appropriate respiratory protective equipment

5.3.4 The consent holder shall ensure that the level of Methyl Bromide at and beyond the boundary of the Port of Tauranga does not exceed the tolerable exposure limits (TELs) of 1 part per million-calculated as an hourly average, in accordance with the Environmental Risk Management Authority publication 'Methyl bromide fumigations – post-reassessment guidance for fumigators' dated April 2011 (143/01). The consent holder shall monitor Methyl Bromide levels downwind of fumigation events at the nearest corresponding Port boundaries to ensure compliance with this condition. Levels shall be measured at the location determined to be the worst case. Monitoring shall continue every 3 minutes from the start of ventilation until the exposure level is below 1 ppm for at least 15 minutes.

5.3.5 Monitoring shall occur in a directly downwind direction at the edge of the buffer zone and the Port boundary. Where the edge of the buffer zone in the downwind direction is over water, the monitoring location should be the point on land at the edge of the buffer zone.

5.4 Container fumigation shall occur no closer than 25 metres to the Port boundaries

5.5 Log stack and timber fumigation shall occur no closer than 100 metres to the Port boundaries.

5.5.1 No fumigation may occur at any time within 200m of a passenger cruise ship

5.5.2 The consent holder shall submit to Bay of Plenty Regional Council for approval a plan depicting the areas where fumigation is to be limited to including buffer zone setbacks. The areas identified for fumigation including specific buffer zones shall override the requirements of conditions 5.4, 5.5 & 5.5.1 above. Where fumigation is to be undertaken outside the approved plan areas then the buffer zones in conditions 5.4, 5.5 & 5.5.1 shall apply. The applicant may upgrade their fumigation plan with the prior written approval of Regional Council.

5.6 Fumigation signage is required at three locations. These are:

a) Points of access to the Port of Tauranga
b) The boundary of the monitored safety zone
c) Next to or on the products being fumigated

5.6.1 The consent holder shall erect and maintain prominent signs at every point of access to the Port of Tauranga. These signs shall clearly display, as a minimum, the following information:

- State that fumigation may be taking place
- State the name of the fumigant
- The international sign for toxic substances (Skull and crossbones)
- The name of the fumigation operator
- Provide 24 hour contact details for the operator

5.6.2 The consent holder shall ensure the boundary of the monitored safety zone (previously defined) is clearly marked. This may include the use of flags, warning tape and cones.

The following shall apply:

(i) Signage should be displayed at a minimum height of 1m on a self-supporting stand and displayed in a prominent position
(ii) Signage should remain in place until levels of methyl bromide remain under 5ppm for at least 15 minutes.
(iii) While venting additional signage must be prominently displayed with the wording "Danger Poisonous Gas Release in progress" and be associated with a flashing light
(iv) Additional warning signs shall be prominently displayed next to or on the products being fumigated
(v) All information shall be displayed in an outwards direction so it can be seen by people approaching the fumigation area.

5.6.3 All signage must be displayed and maintained to the satisfaction of the Chief Executive of the Regional Council or delegate.

5.7 Notwithstanding conditions 5.1 to 5.6 the consent holder shall ensure that all provisions of the HSNO Act (as amended by the 2010 Environmental Risk Management Authority (ERMA) Decision referenced HRC08002, (now superseded by Environmental Protection Agency (EPA)) shall be complied with.

5.8 For the avoidance of doubt, where inconsistencies exist between the conditions of this consent, “The Control and Safe Use of Fumigants” - parts one, two and three, prepared by the Pest Management Association of New Zealand, or any subsequent updates of that code, or the Hazardous Substances and New Organisms Act 1996 as amended by the 2010 Environmental Risk Management Authority (ERMA) Decision referenced HRC08002, then the most stringent provision shall apply.

5 5A Monitoring

5.1 5A.1 The consent holder shall, within one month of the review of this consent, engage a suitably qualified person to provide ongoing independent audit of all aspects of the monitoring, recording and reporting of Methyl Bromide and Phosphine use under this consent. This person shall report directly to senior management and also be available for regular meetings with Bay of Plenty Regional Council. As a minimum this audit shall consider and make recommendations as to the following;

- Use of GPS and text to identify sampling locations, link to map
- The use of fit for purposed monitoring devices
- Recording of persons onsite responsible for recording events.
- Any specific recommendations in respect of the identified fumigation areas as identified within the POT’s ‘Fumigation Procedures for the Port of Tauranga Version One 03/05/2011’
- Calibration of all meters and their accuracy
- Monitoring of methyl bromide and phosphine levels to ensure compliance with this consent and the ERMA decision.
- Levels of methyl bromide exposure to the public, Port workers and Genera staff including consideration of monitoring within office blocks on the Port.
- Reporting of fumigation levels and activities
- Bump testing, zeroing and calibration procedures
- Investigate options that are available for adding a stenching agent to the fumigation process, and assess the feasibility of doing so.
- Investigate technology such as chimney assisted venting during calm or inversion weather conditions.

5.2 5A.2 The consent holder shall, within 3 months of engagement of an environmental auditor submit the audit required by condition 5A.1 to the Chief Executive of the Regional Council or delegate for approval (Advice Note 1).

5.3 5A.3 The consent holder shall, within 6 months of the issue of this review, implement the recommendations of the Regional Council approved audit required by condition 5A.1 and 5A.2. The implementation of the recommendations shall be to the satisfaction Chief Executive of the Regional Council or delegate (Advice Note 1).

5.4 5A.4 Notwithstanding conditions 5A.1 to 5A.3 above, the consent holder shall as a minimum implement the following measures to ensure that accuracy of the monitoring of methyl bromide and phosphine use under this consent:

- Only use equipment which is recommended for the application intended
- Calibrate all equipment, at least as frequently as recommended by the manufacturer
- Return all meters used for reading methyl bromide levels to the supplier every 6 months for calibration or demonstrate to the satisfaction of BOPRC that calibration performed is to the same standard as performed be the manufacturer.
- Submit to Regional Council all calibration certification on request.
- Keep a detailed equipment calibration log and make this available on request
- Ensure all staff who use monitoring equipment are trained in its use, with records of training made available to Bay of Plenty Regional Council staff upon request.
- Keep a clear record of all locations used for fumigation and corresponding monitoring.
- Once a year in March (or as directed by Bay of Plenty Regional Council) Genera shall carry out ambient air sampling followed by laboratory analysis in combination with PIDs to determine the extent to which background VOCs may be influencing methyl bromide monitoring results

5 5B Reporting

5.1 5B.1 The consent holder shall keep accurate records for every fumigation event. The data to be recorded is to include:

a) Date and time of each application and ventilation to atmosphere
b) Type of fumigation event e.g. logs under tarpaulin
c) Amount of Methyl Bromide and Phosphine applied
d) Accurate location of where Methyl Bromide was applied and ventilated, including using GPS coordinates, reference to map locations.
e) Capacity (or dimensions) of the enclosed space fumigated
f) Name of person/s using Methyl Bromide.
g) Exposure levels for each monitoring location
h) The type and identifying features e.g. serial number, for equipment used for monitoring exposure levels.
i) The volumes of methyl bromide and phosphine used monthly

5.2 5B.2 The consent holder shall keep accurate records of all complaints made by the general public to Genera related to fumigation. This shall be made available on request of the Chief Executive of the Regional Council or delegate.

5.3 5B.3 The consent holder shall, every month after of the issue of the review, submit to the Regional Council reporting of Methyl Bromide use under this consent (see Advice Notes 1 and 4).

5.4 5B.4 All records, reports and data collected as required by the HSNO requirements for Methyl Bromide reporting to the EPA as amended by the 2010 Environmental Risk Management Authority (ERMA) Decision E shall be made available to the Regional Council on request.

5.5 5B.5 No later than 30 June for each year for the duration of this consent (following the review) the consent holder shall submit to the Regional Council annual reporting of MB use as per the HSNO requirements for Methyl Bromide reporting to the EPA as amended by the 2010 Environmental Risk Management Authority (ERMA) Decision under s67A of the HSNO Act on June 2011.

5.6 5B.6 If there is a significant change in the consent holder’s process or its inputs that will result in a change in the adverse effects of the activity on the environment (the environment defined under the RMA (1991)) then the consent holder shall immediately and in writing inform the Chief Executive of the Regional Council or delegate (Advice Note 1).

5.7 5B.7 The consent holder shall advise the Bay of Plenty Regional Council (Advice Note 1 and 2);

- Immediately, via the Regional Council’s Pollution Hotline of any exceedances of Methyl bromide or phosphine concentration required by the conditions of this consent and/or the HSNO Act as amended by the 2010 Environmental Risk Management Authority (ERMA) Decision under s67A of the HSNO Act on June 2011.
- Within 24 hours of any complaints about the fumigation activity with the details of complaint
- Immediately, of any uncontrolled release of Methyl Bromide or phosphine.

5.8 5B.8 The consent holder shall notify Bay of Plenty Regional Council at least 12 hours in advance of ship holds being fumigated for the purposes of undertaking compliance inspections.

5 5C Recapture

Change: CH18-01174

5.1 5C.1 The consent holder shall implement the effective recapture of Methyl Bromide associated with all fumigation under this consent in accordance with the following schedule, to the satisfaction of the Chief Executive of the Regional Council or delegate (see Advice Note 3);

- 15% of all container fumigations by 30 April 2015
- 40% of all container fumigations by 30 April 2016
- 100% of all container fumigations by 30 April 2018
- 15% of all log and timber fumigations by 30 April 2016

- 60% of all log and timber fumigations by 30 April 2018
- 100% of all log and timber fumigations by 30 April 2019
- 60% of all cargo under sheets (other than logs and timber) fumigations by 30 April 2019
- 80% of all cargo under sheets (other than logs and timber) fumigations by 30 July 2019
- 100% of all cargo under sheets (other than logs and timber) fumigations by 30 October 2019.

(refer advice note below for latest schedule)

The consent holder may, subject to prior written approval by Bay of Plenty Regional Council, implement recapture on alternative dates to those specified in this schedule, as dictated by availability of appropriate technology. This shall be to allow for continuous development of recapture technology, and operationalising such technology as practicable to facilitate continuous improvement, to ultimately comply with recapture requirements imposed by the EPA. In the absence of an agreed alternative (for all or some of these dates) recapture implementation must comply as detailed in the above schedule.

In a response to a request by Genera Limited under the provisions of condition 5C.1 the Bay of Plenty Regional Council has provided written approval to the implementation of an alternative recapture schedule, as outlined below:

- 5% of all log and timber fumigations by 30 April 2016.
- 20% of all log and timber fumigations by 30 April 2017.
- 60% of all log and timber fumigations by 30 April 2018.
- 100% of all log and timber fumigations by 30 April 2019.

The Bay of Plenty Regional Council approved the alternative recapture schedule on 7 October 2016.

Advice Note 6:

In a response to a request by Genera Limited under the provisions of condition 5C.1 the Bay of Plenty Regional Council has provided written approval to the implementation of an alternative recapture schedule, as outlined below:

- 15% of all container fumigations by 30 April 2015.
- 40% of all container fumigations by 30 April 2016.
- 100% of all container fumigations by 30 July 2018.
- 5% of all log and timber fumigations by 30 April 2016.
- 20% of all log and timber fumigations by 30 April 2017.
- 60% of all log and timber fumigations by 31 October 2018.
- 100% of all log and timber fumigations by 30 April 2019.

The Bay of Plenty Regional Council approved the alternative recapture schedule on 30 April 2018.

5.2 5C.2 The consent holder ensure that all recapture material that is unable to be re-used is disposed of at an appropriately authorised facility, to the satisfaction Chief Executive of the Regional Council or delegate

5.3 5C.3 The consent holder shall report to the Bay of Plenty Regional Council annually on progress in introducing recapture technology as required by this consent. This report is to be provided no later than 31 October each year and be to the satisfaction of the Chief Executive of the Regional Council or delegate.

6 Review of Permit Conditions

6.0 The Regional Council may, within six months of any impact, compliance or environmental investigation report carried out by the Regional Council which shows an adverse environmental effect, serve notice on the permit holder under s.128(1)(a) of the Resource Management Act 1991 of its intention to review the conditions of this permit. The purpose of such a review is to assess the need for further monitoring of discharges from the sites, and to impose monitoring and discharge control conditions if appropriate.

7 Term of Permit

7.0 This permit shall expire on 30 April 2020.

8 Resource Management Charges

8.0 The permit holder shall pay the Bay of Plenty Regional Council such administrative charges as are fixed from time to time by the Regional Council in accordance with section 36 of the Resource Management Act 1991.

9 The Permit

9.0 The Permit hereby authorised is granted under the Resource Management Act 1991 and does not constitute an authority under any other Act, Regulation or Bylaw.

Advice Notes

1

1. *Reporting, notification and submission of plans required by the conditions of this consent shall be directed (in writing) to the Pollution Prevention Manager, Bay of Plenty Regional Council, PO Box 364, Whakatane or fax 0800 884 882 or email notify@boprc.govt.nz, this notification shall include the consent number 62719.*
2. *The applicant is advised where Council needs to be notified immediately in relation to any of the requirements of this consent they should call Bay of Plenty Regional Council's Pollution Hotline 0800 884 883.*
3. *The 2010 ERMA decision considers that recapture technology should be introduced as soon as practical and affordable and definitely within a 10-year timeframe. In order to monitor the progress of the introduction of recapture technology; the Committee will require all fumigators using methyl bromide to submit an annual report to the Agency outlining the progress that they are making in introducing recapture technology.*
4. *The Regional Council can supply a template for the reporting required by condition 5B.3.*
5. *BOPRC supports the restriction of public access to the monitored safety zone from the seaward side by utilising the harbourmaster to enforce boat mooring/fishing restrictions near Port.*

APPENDIX C

Sorption and Desorption Rate Calculations

1.0 INTRODUCTION

To run the CALPUFF model and predict the Methyl Bromide (MB) ground level concentrations due to the operation of fumigation at the port area, it is necessary to account for sorption and desorption of MB.

M Hall et al (2016) have investigated and identified the sorption and desorption characteristics of MB in the process of fumigation of pine logs, and established equations that relate the sorption and desorption rate for logs with different surface area. These equations can be used to calculate the theoretical sorption and desorption rates for Genera's operation.

Additionally, Genera has records of initial mass of MB applied and end concentrations for log stack and shiphold fumigations, which can be also used to determine the actual MB sorption rates. Golder considers that the field measurements that contain actual scale data is desirable to determine the actual sorption or desorption rate. However, when the field measurement is not available, using theoretical sorption or desorption rates based on laboratory tests is considered appropriate.

This appendix discusses the sorption and desorption equations developed by M Hall et al (2016) and how these equations in combination with Genera's site measurements were used to develop the MB sorption and desorption rates for log stacks and ship hold fumigation events. An actual sorption rate was determined by the field measurements, while the theoretical desorption rates calculated from the equation developed by M Hall et al (2016) was used.

2.0 SORPTION

2.1 Lab scale Sorption Calculations

The equation developed by M Hall et al (2016) to describe the change in concentration/ initial concentration (C/C_0) of MB due to sorption is shown in below:

$$\frac{C}{C_0} = (R_0 - R_\infty)\exp(-kt^p) + R_\infty \quad \text{Equation 1 (M Hall et al, 2016)}$$

Where t is the time from the start of fumigation, R_0 is the ratio of concentration to dose at time t =0, R_∞ is a horizontal asymptote, and parameter k and p describe the shape of sorption curve. In this study those parameters were derived for logs with and without end-grain sealing in M Hall et al (2016)'s experiment (see Table 1). The sample logs were approximately 270 mm long with a diameter of 250 mm. Golder have estimated that the logs fumigated by Genera are generally 6.5 m long with an average diameter of 250 mm, therefore they are equivalent to 23 sealed logs and 1 unsealed log in the M Hall et al (2016)'s study. Weight factors of 0.96 (for sealed log) and 0.04 (unsealed log) are applied to calculate the parameters for Genera, as shown in Table 1. Golder notes that the study was carried out based on an average log load factor[1] of 46.4 ± 1.5 %, which is typically close to the commercial load factor. This load factor is also used to develop the theoretical sorption parameters for Genera.

[1] Log load factor = log volume / total volume.

Table 1: Theoretical parameters for the equation used to describe sorption of MB.

Parameters	**Sealed log in** (M Hall et al, 2016)	**Unsealed log in** (M Hall et al, 2016)	**Genera's log**
R_0	1.9429	1.9429	1.9429
R_∞	0.5474	0.2078	0.5333
k	0.2587	0.5665	0.2715
p	0.6965	0.4321	0.6855

2.2 Field data collected by Genera – Log Stacks

Given that Genera has measured the mass of MB used, initial and final MB concentrations (using a Riken MB detector) in the headspace and total volume for log stack/container and ship holds fumigations, the actual mass, volume and concentration measurements can be used to determine the actual MB sorption rate.

A range of log stack fumigation records were obtained for periods from October 2018 to April 2019. These records include MB used, total enclosure volume, initial and final headspace concentrations for 173 log stack fumigation events. Among them, Japanese Agricultural Standard (JAS) volumes were recorded for 63 events. JAS volumes are slightly less, but similar to log volumes. These recorded JAS volumes were used to determine the average load factor. This average load factor was used to calculate the mass MB left in the headspace based on the recorded final headspace concentrations. Given these, actual MB reductions for these 173 events were determined. The distribution of MB reduction is shown in Figure 1.

The assumed sorption used in the modelling was based on the initial 63 measurements using log row specific calculated load factors giving an overall average of 53 % reduction in headspace MB concentration. This left 47 % of the initial MB in the headspace, which is available to be reduced further using recapture technology. When considering all 173 events a 53 % reduction in headspace concentration was approximately the 28th percentile value indicating the assumed sorption used for modelling was conservative and the majority of fumigations had a higher sorption.

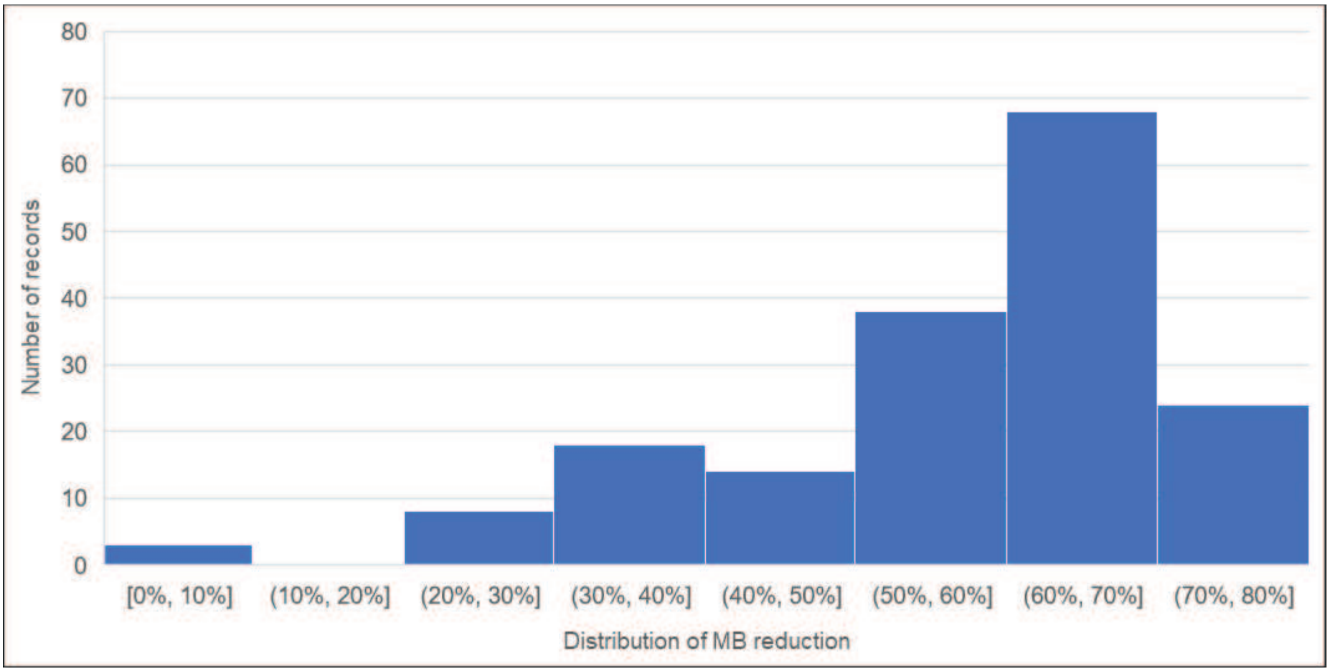

Figure 1: Distribution of MB reduction based on load factor.

There are several factors and assumptions related to determining the reduction in MB through sorption from the measurement data provided by Genera. These include:

- It is assumed that no sorption occurs while the MB is being applied to the enclosure
- As initial concentrations are measured within 1 hour of the dose of MB being applied there is some uncertainty how much sorption happens before measurement.
- It has been assumed that there is no sorption or desorption during recapture.
- The Riken MB detector has a maximum measurable concentration of 200 g/m³ of MB and it is not unusual to reach this reading at the beginning of fumigations. When the initial reading exceeds 200 g/m³ the decrease in MB due to sorption will be understated.
- The MB lost through leaking or permeation through the tarpaulins has been assumed to be negligible.
- There are different fumigation durations ranging from 16 - 44 hours - the longer of these coming from fumigations where ventilation of all stacks happens over two days. However, different durations are not expected to alter the reduction in headspace concentration from sorption significantly.
- The range of different load factors and surface areas for different log stacks which will have an impact on sorption as it is dependent on surface area.
- The JAS method for quantifying volume of logs gives an estimate of the usable volume of wood from the perspective of milling so will slightly underestimate the total volume of wood being fumigated.

- The method for estimating total covered volume as briefly described in Section 3.2.2 of the main report assumes the log stacks are rectangular when, in reality, they generally have sloping ends causing the measurement to conservatively overestimate total volume.

On balance these are considered to be appropriate assumptions and unlikely to significantly impact the assumed sorption mass.

As an alternative, a method that solely relies on the difference between start and end measured concentrations to determine the sorption rate for the log stack fumigation was calculated. The same recorded 173 log stack fumigation events for periods from October 2018 to April 2019 were used. Prior to using this method, the measurement value of the initial concentration needed to be corrected to be at time zero.

The time it takes to apply the correct amount of MB and then to take the initial measurement adds uncertainty to the sorption calculation as the rate of sorption is highest at the beginning of fumigation. It is assumed that the measured initial concentrations were taken half an hour after the beginning of fumigation[2]. A factor of 1.13 between the concentrations at t=0 and t=0.5 was calculated based on Equation 1. The theoretical initial concentrations (at t=0) were calculated by applying this factor to the initial measured concentration. The final measured concentration was divided by the scaled initial concentration to determine the fraction of MB remaining in the enclosure. The average calculated MB reduction using this method is approximately 52 % which is consistent with the assumed MB reduction modelled. The distribution of the values is shown in Figure 2,

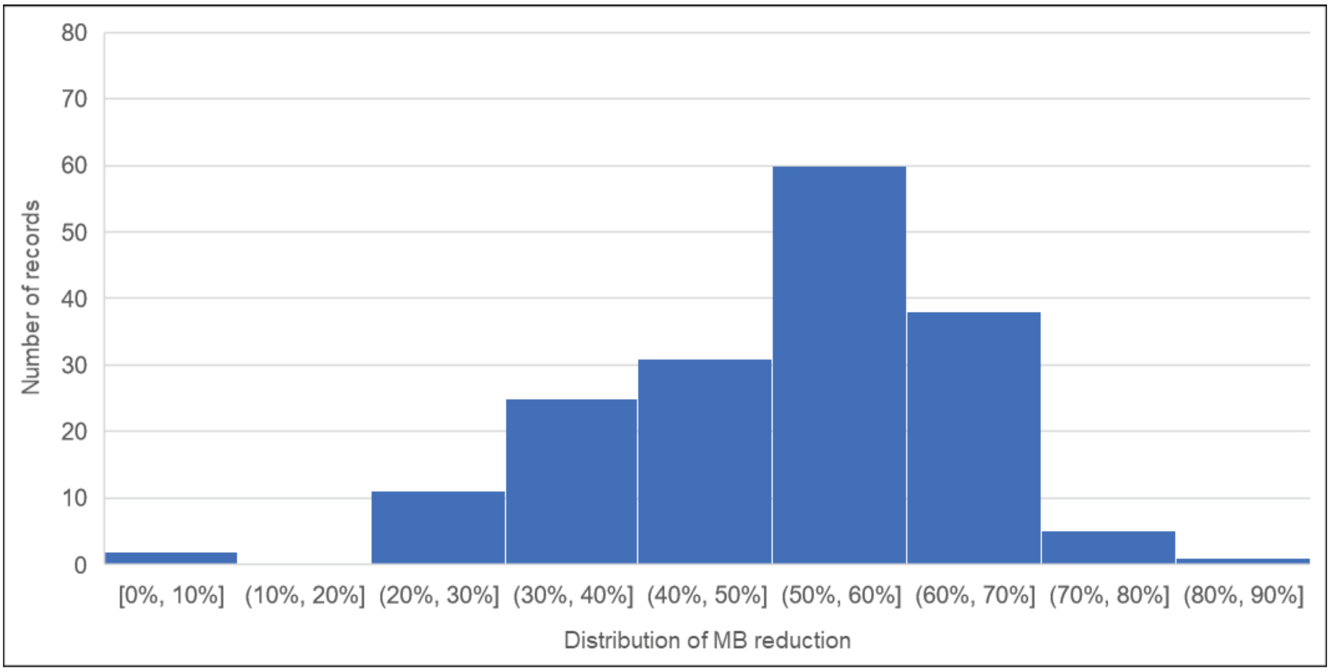

Figure 2: Distribution of MB reduction based on the difference between measured concentrations.

[2] Pers Comms M Wilson (Golder) B Edwards (Genera) the measurement of initial headspace recorded on the test sheets can occur any time up to an hour after the fumigant has finished being added.

2.3 Field data collected by Genera – Ship Holds

Five ship hold fumigation records collected on 16 May 2019 were used to develop the sorption rate for ship holds fumigation. These measured MB concentrations on ships were measured using sampling lines which samples are extracted from using syringes and are tested in a gas chromatography flame ionisation detector (GC-FID). The recorded initial and final concentrations were used to calculate an average MB concentration drop of 65 %. There was a range of measured reduction of MB from 61 % to 67 % for these log holds. Based on this data an average of 35 % of the used MB was remains in the headspaces after sorption. It has been assumed that the ship holds release headspace MB over the first two hours of venting based on exhaust concentration measurements (see Appendix E).

There are uncertainties in using this approach which can influence the assumed sorption. If the hold is less full of logs sorption is going to be less but they still would have to dose the same as the total volume in of the enclosure has not changed. This could be more pronounced in holds at the ends of the ship as they may be less rectangular in shape possibly making it more difficult to stack logs efficiently to maximize load factor. The diameter of the logs in the hold will also have an effect on sorption as smaller diameter logs will have a larger surface area potentially increasing sorption.

Golder does not have information on the average diameter of logs in the ship holds measured it has been assumed these are representative of an average load. It is uncertain at what time after the fumigation began that the sample was taken. For the purpose of this assessment it has been assumed it happened immediately at the beginning of the fumigation.

A review of a larger number of ship hold fumigation start and end concentration records would help refine the assumed percentage of used MB being sorbed and confirms the robustness of the assumed sorption.

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3.0 DESORPTION

The equation developed by M Hall et al (2016) to describe the change in rate of desorption divided by the dose (Rate/dose) of MB due to desorption is shown in below:

$$\frac{Rate}{dose} = (R_0)\exp\,(-kt^p)$$ Equation 2 (M Hall et al, 2016)

Where t is the time from the start of ventilation, R_0 is the (extrapolated) loss rate at the start of ventilation and parameters k and p describe the shape of the curve thereafter. As discussed, parameters were derived for logs with and without end-grain sealing in M Hall et al (2016)'s experiment. Weight factors of 0.96 (for sealed log) and 0.04 (unsealed log) are applied to calculate the parameters for Genera, as shown in Table 2. The theoretical log load factor of 46.6% is also assumed for both log stacks and ship holds to determine the theoretical MB desorption rate. This theoretical load factor results in a more conservative desorption rate compared with using the actual load factor.

Table 2: Theoretical parameters for the equation used to describe desorption of MB.

Parameters	**Sealed log in** (M Hall et al, 2016)	**Unsealed log in** (M Hall et al, 2016)	Genera's log
R_0	0.077	0.134	0.079
k	0.45	0.84	0.466
p	0.69	0.48	0.681

Given that there are no field data that can be used to determine the actual MB desorption rate, the theoretical desorption rate on every hour was calculated by using Equation 2. For log stacks, it has been assumed that every log stack remains in place for 132 hours as this is sufficiently long that the rate of desorption approaches 0 % according to the equation. By using the Equation 2, the percentage of total used MB which is emitted by desorption over this period is 15 % when calculated using hourly intervals except for the first hour which was based on a half hour interval.

For ship holds, a ventilation of 13 hours is assumed to determine that 13 % of the total MB will be emitted within this period based on Equation 2. This is due to ship's holds being closed after approximately 12 hours of venting.

4.0 SUMMARY

Table 3 summaries the percentage of MB that releases from treated space after sorption and by desorption. The total percentages of released MB are approximately 62 % for log stack and 48 % for ship holds without considering recapture.

Table 3: Proportion of MB released.

MB released	Log stack fumigation	Ship hold fumigation
From treated space (after sorption) #	47 %	35 %
By desorption*	15.4 % (after 132 hr)	13.1 % (after 13 hr)
Total released	62 % (after 132 hr)	48.3 % (after 13 hr)

Note: # without considering any recapture, based on actual measurement. * theoretical desorption rate based on lab scale study, assumes a load factor of 46.4%.

APPENDIX D

CALPUFF Model Inputs

1.0 INTRODUCTION

CALPUFF version 7.2.0 was run from 1 January 2014 to 31 December 2016. Most standard options were used, including the "pdf" function for dispersion under convective conditions. Concentrations of Methyl Bromide (MB) were calculated at the port boundary with 15 m spacing, on a nested grid with 90 m spacing, and on a sampling grid with 180 m spacing.

2.0 GENERIC CALPUFF PARAMETERS

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

Table 1: CALPUFF start and end times.

Parameter		Value	
Start date/time		00:00	1 January 2014
End date/time		23:00	31 December 2016
Base time zone	XBTZ	-12 (NZST)	
Time step	NSECDT	3600 s	

Table 2: Pollutant specifications.

Parameter		Value	
Number of chemical species	NSPEC		1
Number of emitted species	NSE		1
Species; modelled; emitted; deposited?		MeBr	Yes; Yes; No
Chemical mechanism	MCHEM		0 (No chemistry)
Dry deposition	MDRY		0 (No dry deposition)
Wet deposition	MWET		0 (No wet deposition)

Table 3: Technical options.

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

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

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

Table 5: Grid control.

Parameter		Value
SW corner of grid cell (1,1)		(403.35, 5812.6) km (UTM)
Grid dimensions	NX x NY; DGRIDKM	237 x 198 grid cells at spacing 0.18 km
Vertical grid, number of layers		12
Cell-face heights for vertical grid (m)		0, 20, 40, 80, 120, 160, 320, 640, 1000, 1500, 2000, 2500, 3000

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

Parameter	Value
CALPUFF computational grid range E-W	70 to 220 out of NX=237
CALPUFF computational grid range S-N	25 to 175 out of NY=198
Use of nested grid receptors	Yes
Nested grid SW corner	(427.34, 5830.75) km (UTM)
Nested grid box size	1300 m by 2400 m
Nested grid spacing	90 m

3.0 EMISSION SOURCE PARAMETERS

The MB discharges from log stack and ship holds fumigation events were modelled as volume sources. The discharge parameters of each source are presented in Table 7. The approach of deriving the hourly varying MB emissions are detailed in Appendix E.

Table 7: Volume source emission parameters.

Parameters	Source_1 (Location 1)	Source_2 (Location 2)	Source_3 (Location 3)	Source_4 (Location 4)	Source_5 (ship hold)
Coordinates (UTM, km)	427.885, 5832.063	427.891, 5831.48	427.949, 5831.764	427.993, 5832.535	427.776, 5831.904
Source height (m)	6	6	6	6	6
Base elevation (m)	3.77	2.31	3.38	3.51	0

Parameters	Source_1 (Location 1)	Source_2 (Location 2)	Source_3 (Location 3)	Source_4 (Location 4)	Source_5 (ship hold)
Initial sigma Y (m)	23.26	37.21	34.88	32.56	12.79
Initial sigma Z (m)	1.4	1.4	1.4	1.4	1.4

APPENDIX E

Time and Location Varying Emission Rates Calculation

1.0 INTRODUCTION

As the fumigations occur at various different locations and at different times, location and time varying emission rates have been used to approximate the release of MB. These emission rates were calculated based on the fumigation records for the period from June 2018 to May 2019. Sorption, desorption and recapture were also accounted for.

This appendix provides location of fumigation events, the emission rates calculation assumptions and an overview of headspace release.

2.0 LOCATIONS OF FUMIGATIONS

General areas of the port used for fumigations and areas where fumigation is not allowed are shown below in Figure 1 and Figure 2. These figures are sourced from the fumigation management plan prepared by Beca (2019).

Figure 1: Map showing fumigation and no fumigation areas at the southern end of the Port of Tauranga (Baca 2019).

Figure 2: Map showing fumigation and no fumigation areas at the northern end of the Port of Tauranga (Beca 2019).

Analysis of mass MB used at each of the numbered locations was carried out and this distribution of MB usage is represented in Figure 3. As the vast majority of MB usage for log stack/container were in locations 1, 2, 3 and 6 it has been assumed all fumigations happen in these locations for the purpose of modelling. The redistributed MB usage assumed for the modelling assessment is shown in Figure 4.

The log stack/container and ship hold fumigations were modelled as volume sources. A maximum area for each area has been set to ensure that the volume source would not exceed the area where fumigation was carried out.

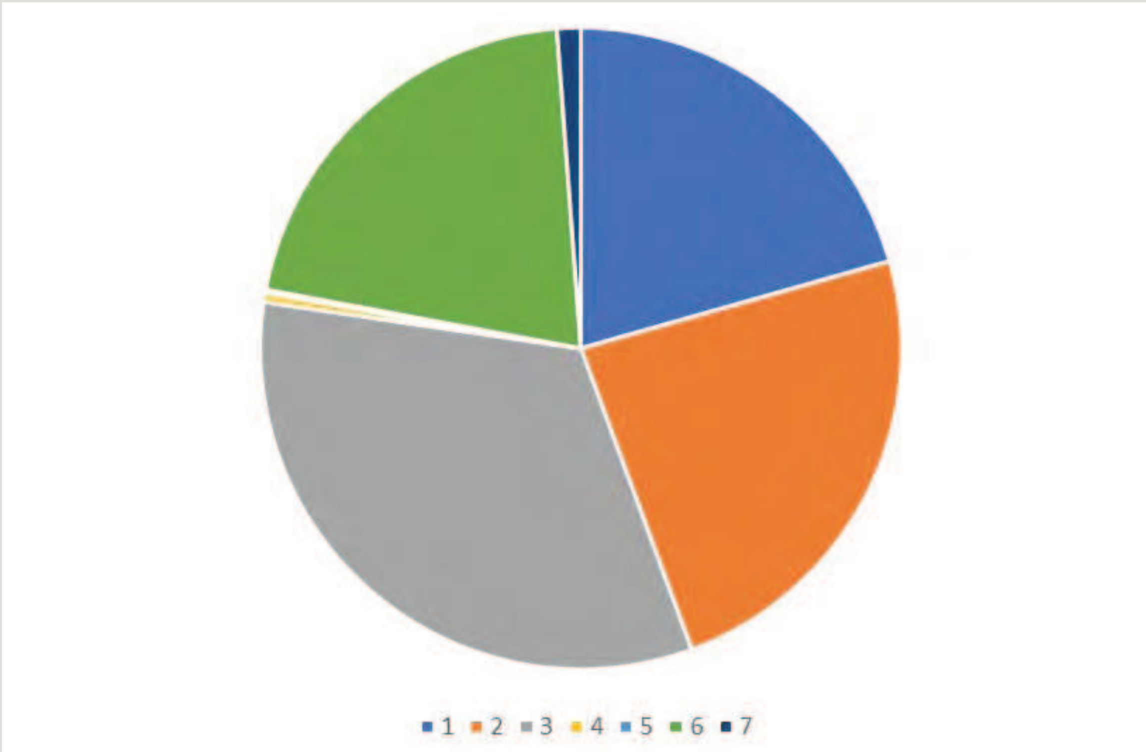

Figure 3: Graph of distribution of mass used for fumigation at each location. (not including holds).

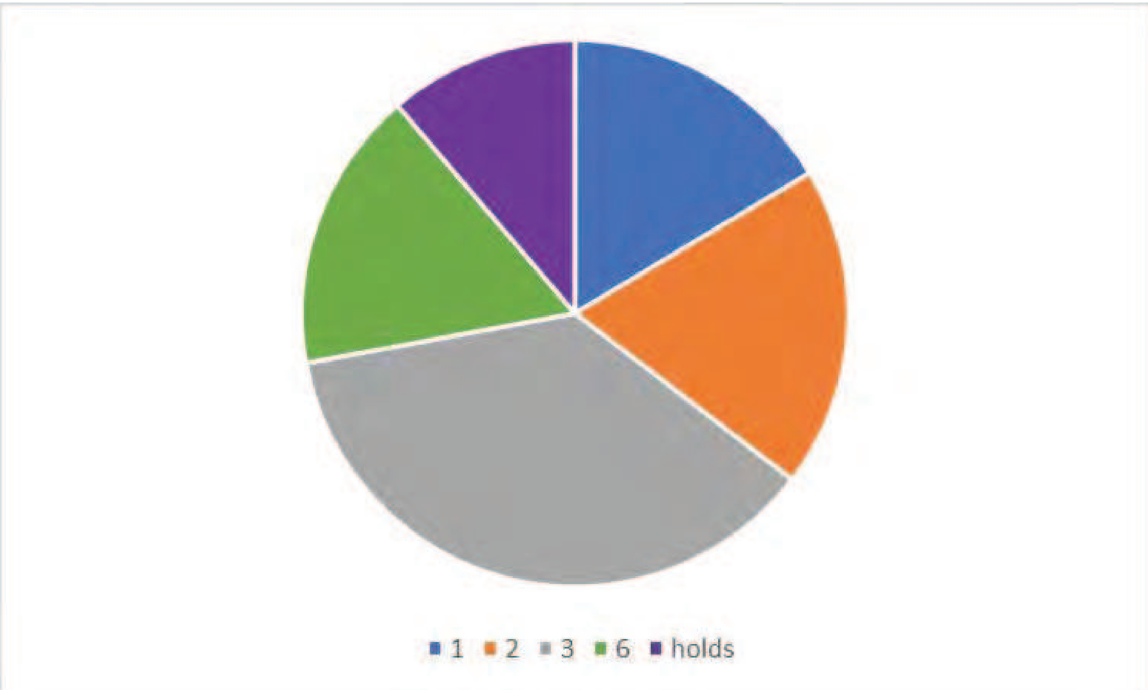

Figure 4: Distribution of locations assuming any not in 1, 2 or 6 occur in 3. (including holds).

3.0 HOURLY EMISSION CALCULATION ASSUMPTIONS

Information on fumigation types, locations, initial mass of MB used, and ventilation times for every job undertaken during May 2018 to April 2019 was provided by Genera. Based on this data, an hourly varying emission file for each location was prepared. This was developed by considering fumigations at every location and time.

For the log/container fumigations the following assumptions were made:

- The final headspace mass of MB was released at an average rate over the recorded ventilation time.
- If multiple locations were listed for one fumigation job then the mass of MB used was split evenly between locations.
- If on the record of log fumigation, no location or a location other than the main four locations (1, 2, 3 or 6) were listed then it was assumed the fumigation happened at location 3.
- To maintain the historical total of MB usage in combination with the proposed emission limit, if more than 450 kg initial loading per hour of MB was recorded to be used at a location, then the extra MB was assumed to be vented in the next hour. This can be repeated for several times until the end hour usage is less than 450 kg/hour.
- 80 % of all fumigations had recapture undertaken and 80 % of the headspace MB was recaptured.
- All of the reduction in MB headspace is caused by sorption or recapture i.e., no leakage.
- Log stacks are covered by tarpaulins before ventilation occurs. It is estimated that taking off the tarpaulins to allow ventilation takes approximately 10 minutes per log stack. For the whole fumigation area, it is assumed that the removal of tarpaulins is completed within the hour. Therefore, the initial headspace MB is assumed to be released within the first hour of ventilation.

The following assumptions were made for ship holds:

- It has been assumed that the holds release the initial headspace MB over the first two hours of ventilation. This is based on the ship hold release carried out by Genera (see details in Appendix C).
- The rate of initial headspace MB release was determined by a measurement records of the final enclosure concentration. A total of 35 % of used MB was assumed to be initially released within the first two hours of ventilation (see details in Appendix C). The initial release rate was evenly distributed for the first two hours (i.e., 17 % release for each hour).
- Subsequently, a total of 13 % used MB is assumed to be emitted over 13 hours of ventilation. Combined with the initial release, a total of 48 % of the used MB will be released into the atmosphere within the period of ventilation.

Assumptions in relation to the percentage of headspace MB and desorption rate are derived from fumigation records in conjunction with a MB sorption and desorption study (M Hall et al) which are presented in Appendix C.

4.0 HEADSPACE RELEASES

4.1 Overview

It is understood that tarpaulins that cover the log stacks are removed and all the log stacks are exposed to the air when the ventilation starts. The removal of the covered tarpaulins is considered to add some air turbulences around the log stacks, as such this may improve the dispersion of the headspace MB. Therefore, it is reasonable to assume that all the headspace MB is released into the atmosphere within the first hour of venting.

However, the ship hold only has a much smaller area (ship hold hatch) open to air when ventilation starts, and the characteristics of the headspace MB release is unclear (i.e., at what time the headspace MB is released). Given that, Genera has carried out a ship hold fumigation monitoring programme to assist in understanding the trend of headspace MB release.

4.2 Ship Hold Fumigation Monitoring

Monitoring of ship hold fumigations were carried out from 21:13 on 17 May to 9:37 on 18 May 2019. Five PID monitors were set up on the deck level of the ship to measure the initial headspace MB release from the ships hold before ship hold ventilation had taken place. As shown in Figure 11, the PID monitors were set up at deck level of the first hold being released at the end of the ship so that it would have limited influence from other holds being vented. All the monitors had filters replaced and were calibrated immediately prior to conducting measurement trial to reduce chance of filter contamination.

The concentrations of total volatile organic compounds (VOCs) were recorded every ten seconds at each monitor during the monitoring period. While there are limitations in using PID monitors in this way, the recorded VOCs concentrations provide indications of how MB concentration changes during 12 hours of ventilation.

Figure 5: PID monitors set up for measurement of ship hold venting.

4.3 Monitoring Results

The monitoring results from the five PID monitors are presented in Figure 12. It is found that there are two spikes in measured VOC concentrations occurred over the first two hours of the ventilation, and then the concentrations dropped down to a lower level immediately after the second hour. After that the VOC concentrations decreased slowly with concentrations close to zero ppm at the end of the ventilation (at hour 12). It is acknowledged that this release will be a function of the meteorological conditions at the time of venting. However, in the absence of further data this assumption has been used for all ship hold ventings.

Based on the above, it has been assumed that the initial headspace MB is released over the first two hours of ventilation. The monitoring results also confirm that the MB concentration reduction rate after the two-hour point looks very similar to the desorption rate curve described by M Hall et al (2016). It is also assumed that the MB continues to desorb over the 12 hours that the hold is open, then after the ship hold is closed, the emission is so low as to be negligible.

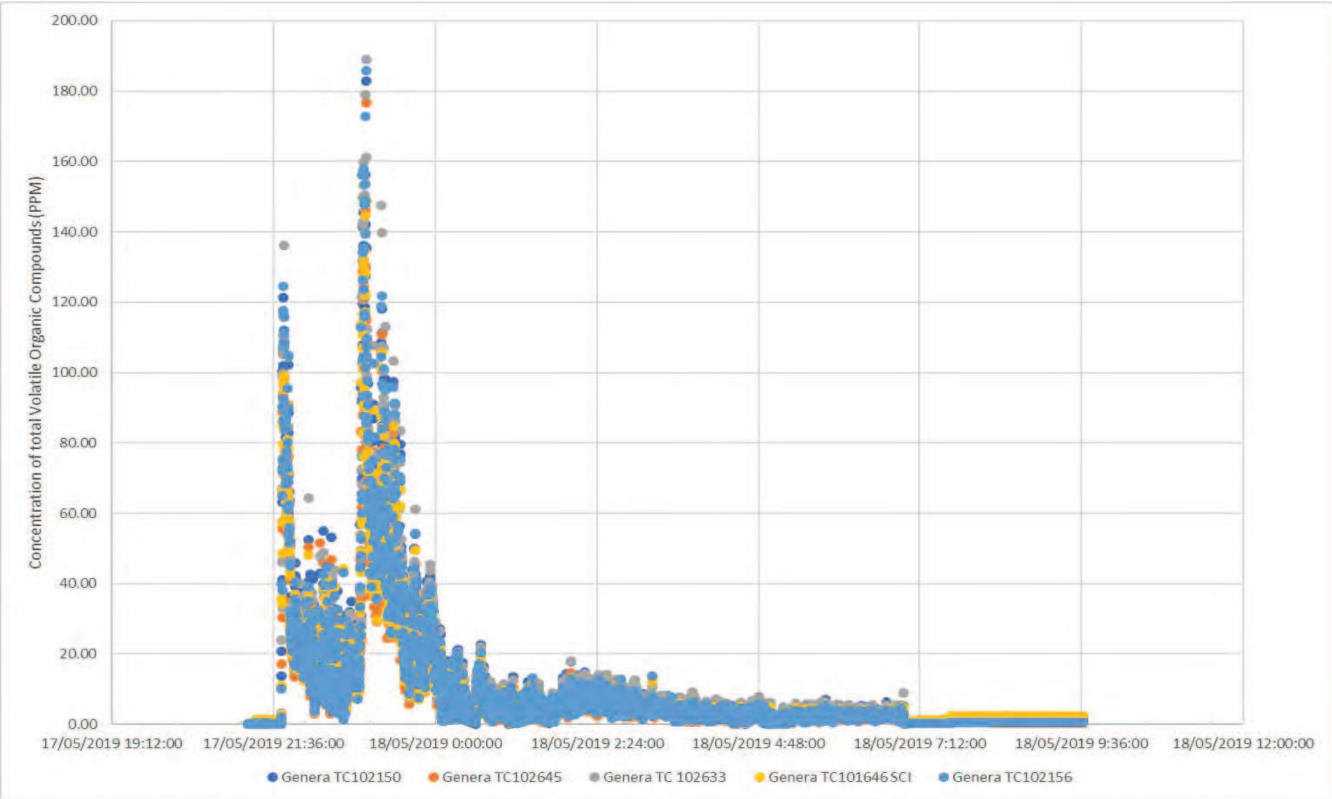

Figure 6: Graph of monitoring results from ship hold ventilation.

5.0 REFERENCES

Beca 2019. *Fumigation Management Plan. Prepared by Beca Limited for Bay of Plenty Regional Council. April 2019.*

M Hall et al, A. n.-R. (2016). *Sorption and desorption characteristics of methyl bromide during and after fumigation of pine (Pinus radiataD. Don) logs*. Wiley Online Library, Society of Chemical Industry.

APPENDIX F

Monitoring Results and Analysis

1.0 METHYL BROMIDE MONITORING

1.1 Overview

As part of the assessment of Methyl Bromide (MB) concentrations, Golder developed a MB monitoring programme. The MB monitoring programme began on 30 May 2019 and is ongoing as of 15 October 2019. Air samples were collected using whole air sampling canisters (canisters). These are specially coated stainless-steel containers which capture whole air samples which can be analysed for many different compounds including MB. All samples were collected by Genera Limited (Genera) staff. Samples were analysed by a National Association of Testing Authorities, Australia (NATA) accredited laboratory using the analytical methods described in the United States Environmental Protection Agency (USEPA) Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air TO14a and TO15. The benefit of using canisters for this study was that they can achieve a sufficiently low detection limit and can be used for both 1-hour and 24-hour sampling periods.

Genera currently uses a photoionization detector (PID) device called a Cub[1] which monitors total Volatile Organic Compounds (VOC) for both worker OSH measurements and in line with their fumigation management plan (Beca, April 2019). This includes measurements at the edge of their cordoned off area of the port (monitored safety zone) and at three locations on the port boundary (one directly downwind of the venting location and the other two 45 degrees to either side of this unit. Every VOC has a different voltage response which corresponds to a different concentration on the PID and, since MB is a VOC, the PID will also detect it, but the concentrations measured by the PID are not necessarily all MB. Also, as the Cubs do not have a sampling pump, they are not likely to be ideal for static measurements. The PID devices are useful for indicating MB in real time (provided they are calibrated for MB response), whereas canisters only give an average and results only become available after analysis at a lab, which can take weeks from taking the sample to receiving the results. Where the PIDs are used in static situations, e.g., at a boundary location, a PID with a sampling pump is likely to provide a more reliable measurement.

There are two objectives of the MB monitoring programme. The first was to investigate the relationship between Genera's Cub PID's measured VOC concentrations and the canister's measured MB concentrations. The second objective was to gather robust measured data which could be compared with the dispersion model predictions. Having measurement data to compare to modelled predictions of ambient MB is especially useful when the emission source has an irregular release mechanism which is at ground level and variable - which is the case in this situation.

1.2 Monitoring Setup

1.2.1 Sample collection and analysis

For this monitoring program 6 L canisters were used to collect the samples. Each canister has a regulator attached to the inlet which restricts the flow of air. For 1-hour and 24-hour samples, the regulator is set to approximately 83 mL/min and 4 mL/min respectively. Golder provided Genera instructions for sampling based on the method provided by Eurofins (Eurofins, 2014) – an excerpt is provided in Section 4.0. The test sheet used to capture monitoring data is provided in Section 5.0. Samples are stable for up to 30 days after sampling and were all sent back to the lab for analysis with enough time for transport and analysis within this timeframe. Samples were analysed by Eurofins Environment Testing Australia Pty Ltd (Eurofins).

The aim of the programme was to undertake sampling downwind of ventilations. Therefore, when a ventilation was planned, the fumigators would alert the monitoring team so that the canisters could be set up

[1] "Cub" is the model name of the Ion Science Ltd PID unit used by Genera at the Port of Tauranga.

while the monitored safety zone was being set up. The samples were placed in a downwind position based on observed wind direction at the start time of the sample. The canister was attached at the same height as a co-located PID. The sample was set to begin collecting immediately before ventilations began.

1.2.2 Sampling programme kick off site visit

Golder staff visited the site on 30 May 2019 to begin the monitoring programme, instruct site staff in the use of the canisters, confirm suitable off-site monitoring locations, identify council monitoring station locations and to observe canister monitoring during a ventilation.

1.2.3 Sample locations

To satisfy the sampling objectives, the monitoring programme involved measurements at three different locations (plus a background location) and for two different sampling durations. Monitoring locations are shown in Figure 3 and Figure 4.

The first location is a site co-located with a PID unit on the edge of the monitored safety zone that is inside the dock area. These samples ran for a sampling period of 1 hour. The sampling at this location is primarily to assist in understanding the relationship between the PID measuring total VOCs (TVOCs) and MB concentrations. There were three sampling rounds completed to date at the edge of the monitored safety zone. An example canister setup is shown in Figure 1.

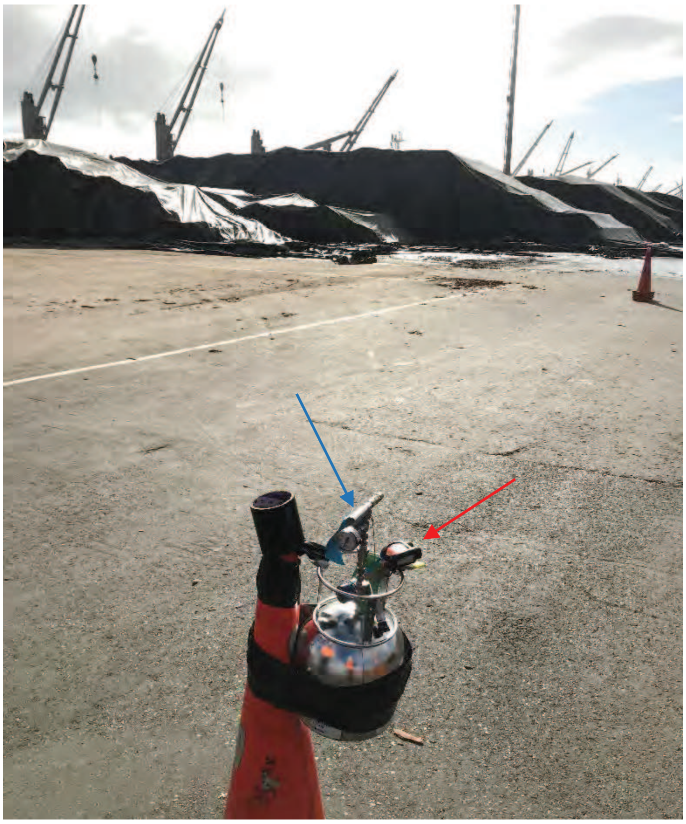

Figure 1: Example of first location Canister (blue arrow) and PID (red arrow) downwind of Log Stack fumigations.

The second sample location is a port boundary location, co-located with the directly downwind PID, and had a sample duration of 1-hour. This location is intended to provide an indication of the MB dilution with distance and provide further MB/TVOC relationships at lower concentrations than expected for the first location. Three rounds of sampling have been completed at the port boundary location.

The third location is at one of two fixed locations which were either on the boundary of the Dominion Salt site, approximately 160 m from the port boundary, or at the corner of Waimarie and Totara Streets, approximately 220 m from the port boundary. These locations were chosen as suitable 24-hour sampling locations based on analysis of the last 5 years of meteorological data collected at Tauranga airport. These sites are downwind during prevailing onshore winds from the majority of fumigation areas and had the least obstructed paths between the port boundary and the sampling location. At these locations, 24-hour samples were planned to be collected on days when fumigation was happening, and when it was likely that this location was in a generally downwind position of the fumigation site for significant portions of the day. Three 24-hour samples have been collected to date. The 24-hour sampling campaign was designed to assist in determining representative longer-term MB concentrations. Three 1-hour samples at this location were collected to determine the extent of concentration reduction with distance.

A background sample was collected in a rural area approximately 2 km to the south of Katikati[2]. This location was chosen as it would not be influenced by any port activities.

1.2.4 Genera fumigation details

For each round of testing, site operational data was collected including the location(s) of the fumigation, details of the amount of MB used, initial and final enclosure MB concentrations, volumes of logs, volumes of the enclosures and log stack specific vent times. It was also recorded which log stacks had recapture[3] technology used on them as this impacts the amount of MB released.

Cub PID monitoring results were provided to Golder for each fumigation event. This included at least one Cub PID at the monitored safety zone and three boundary monitors.

1.3 Meteorology

On days when ventilations were taking place, the weather forecast was checked to see if wind was forecasted to be blowing towards the landward boundaries and if they were, sampling was undertaken if possible. When sampling was conducted, observations of weather conditions including precipitation, wind speed and wind direction were recorded at the start and end of sampling. Wind speed and direction data was obtained from the NIWA meteorological station at the Tauranga airport. Data from the nearby BoPRC monitoring stations were also considered to aid analysis. The locations of these monitoring stations are shown on the BoPRC supplied map (Figure 2).

[2] GPS location: -37.578678, 175.903139
[3] Recapture is explained in Section 3.4 of the report.

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MAGNETIC NORTH on this map is 22½° (400 mils) EAST of GRID NORTH during 2009 increasing at the rate of approximately ½° (9 mils) over 18 years.

HORIZONTAL DATUM:
New Zealand Geodetic Datum 2000 (NZGD2000)
For practical purposes, NZGD2000 equates to WGS84

VERTICAL DATUM:
Moturiki

PROJECTION:
New Zealand Transverse Mercator 2000 (NZTM2000)

Scale 1:4783 (A0)

100 0 100 200 300 400 500 600 700 800 900 1,000
Metres

DRAFT 19/11/2018

MOUNT MAUNGANUI INDUSTRIAL AREA
2017 Bay of Plenty Orthorectified Aerials

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Sheet 1 of 1
Printed 19/11/2018

2.0 MONITORING RECORDS

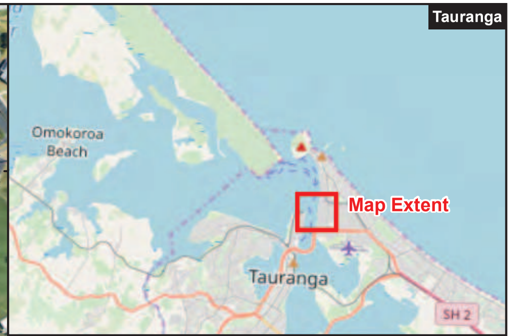
2.1 Introduction

As of 15 October 2019, there have been 13 canister samples collected. The sampling times, locations and meteorological conditions for each of these samples are summarised in Table 1. No samples were collected in July 2019 as due to market conditions, there were few fumigation events in July and when fumigations did occur, wind conditions were not conducive to sampling. The average emission rate when downwind has been calculated using the emission rates that occurred while the sample was downwind of ventilation and an emission rate of zero for times when the sample is not downwind of venting giving a full sample period average. See section 3.1 for emission rate assumptions.

Table 1: Sampling details.

Canister Serial Number	Id No.	Sample location	Start date/time	Duration (hr:min)	Downwind Ranges (°)	Time Downwind (%)	Genera Job No	*Recapture used?	Average emission rate when downwind (g/s)
N2908	1A	Monitored safety zone	30/05/2019 13:47	1:13	315 - 360	100%	106276	14/17	38.7
N2911	2A	Port Boundary	30/05/2019 13:59	1:07	326 - 343	71%	106276	14/17	21.0
N2437	1B	Monitored safety zone	14/06/2019 9:00	1:00	235 – 280 260 - 325	33%	107195	5/8	0.5
N2897	2B	Port Boundary	14/06/2019 9:00	1:04	205 - 235	60%	107195	5/8	16.7
N2439	3B	Salt works	14/06/2019 9:08	0:55	225 - 245	67%	107195	5/8	7.2
N2457	4B	Salt works	13/06/2019 13:42	23:26	216 – 239	17%	106983	15/19	2.0
N2446	1C	Monitored safety zone	8/08/2019 13:28	1:02	190 - 220 300 - 345	57%	108566	7/7	12.2
N2441	2C	Port boundary	8/08/2019 13:37	1:08	206 – 224 290 - 330	43%	108566	7/7	12.2
N2450	3C	Salt works	8/08/2019 13:31	1:01	273 – 287 310 - 326	29%	108566	7/7	4.8
N2440	4C	Waimarie street	8/08/2019 13:45	23:52	340 - 350	2%	108566	7/7	0.1
N2898	1D	Waimarie street	22/08/2019 11:22	0:58	279 - 310	14%	108554, 108642	1/3 7/7	13.8
N2907	2D	Waimarie street	22/08/2019 10:33	23:49	279 - 310 325 - 340 300 - 315 260 - 275	5%	108554, 108642	18/23 9/9	3.0
N2901	BG	Rural Background	13/06/2019 20:49	0:59	N/A	N/A	N/A	N/A	N/A

Note:*These fractions are the fraction of log stacks in the job when recapture occurred.



LEGEND

- Site boundary
- Monitoring points

Monitoring locations:

- Venting locations 30 May
- Venting locations 13/14 June
- Venting locations 8 August

NOTES

1. Aerial: LINZ 2019, CC-BY-3.0-NZ.
2. Map image: © OpenStreetMap (and) contributors, CC-BY-SA Sourced from the LINZ Data Service and licensed for re-use under the Creative Commons Attribution 4.0 New Zealand licence
3. Schematic only, not to be interpreted as an engineering design or construction drawing.

0 100 200 METRES

REFERENCE SCALE: 1:6,000 (at A3)

PROJECTION: NZGD 2000 New Zealand Transverse Mercator

CLIENT
GENERA LTD

PROJECT
AIR QUALITY ASSESSMENT

TITLE
VENTING AND MONITORING LOCATIONS

CONSULTANT: GOLDER

YYYY-MM-DD	2019-10-15
PREPARED	AE
REVIEW	MW
APPROVED	CN

PROJECT NO.	REPORT	REV.	FIGURE
1898728	008	2	03

LEGEND

- Monitoring points selection
- Site boundary
- Venting locations 22 August 2019

NOTES

1. Aerial: LINZ 2019, CC-BY-3.0-NZ.
2. Map image: © OpenStreetMap (and) contributors, CC-BY-SA Sourced from the LINZ Data Service and licensed for re-use under the Creative Commons Attribution 4.0 New Zealand licence
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0 100 200 METRES

REFERENCE SCALE: 1:6,000 (at A3)

PROJECTION: NZGD 2000 New Zealand Transverse Mercator

CLIENT
GENERA LTD

PROJECT
AIR QUALITY ASSESSMENT

TITLE
VENTING AND MONITORING LOCATIONS 22 AUGUST 2019

CONSULTANT	YYYY-MM-DD	2019-10-15
GOLDER	PREPARED	AE
	REVIEW	MW
	APPROVED	XX

PROJECT NO.	REPORT	REV.	FIGURE
1898728	008	2	04

2.2 Monitoring Results

Laboratory results of samples completed to date are provided in Table 2 below.

Table 2: Canister monitoring results.

Start Sample Date	Location	Sample duration (Hours)	ID No.	Cannister concentration		Paired Cub PID		Max Port boundary concentration (PID)	
				mg/m³	ppm	ID	Conc. (ppm)	location	Conc. (ppm)
30/05/2019	Monitored safety zone	1	1A	140	35.9	RA1	11	Direct downwind	0.92
30/05/2019	port boundary	1	2A	8.6	2.2	PB9	0.92		
14/06/2019	Monitored safety zone	1	1B	0.75	0.19	RA1	0.49	Direct downwind	0.35
14/06/2019	port boundary	1	2B	<0.035	<0.01	PB1	0.16		
14/06/2019	Salt works	1	3B	<0.033	<0.01	N/A	N/A		
13/06/2019	Salt works	24	4B	0.2	0.05	N/A	N/A		
8/08/2019	Monitored safety zone	1	1C	25	6.4	RA1	2.9	Direct downwind	1.1
8/08/2019	port boundary	1	2C	8.9	2.3	PB1	1.1		
8/08/2019	Salt works	1	3C	0.043	0.01	N/A	N/A		
8/08/2019	Waimarie street	24	4C	<0.035	<0.01	N/A	N/A		
22/08/2019	Waimarie street	1	1D	0.26	0.07	N/A	N/A	45° Left of assumed starting downwind	1.1
22/08/2019	Waimarie street	24	2D	0.062	0.02	N/A	N/A		
13/06/2019	background	1	BG	<0.043	<0.01	N/A	N/A	N/A	N/A

Note: values with "<" are below the limit of detection. If not applicable (N/A), it means the sample was either not paired with a PID or not at the port boundary.

3.0 MONITORING ANALYSIS

3.1 Introduction

For each day of sampling, there is wind data, sample and venting locations and emissions data collected for the same period. This information has been used to analyse sampling conditions to assist in understanding what has influenced the measurements. The analysis has taken into consideration how long the sample was downwind during the main releases of MB.

Emission rates of ventilations during monitoring were determined in a similar manner to that used for determining the modelled emissions but with more refined ventilation data used. Emissions have been calculated per log stack with the recapture of specific log stacks used. When recapture was undertaken, 80 % of the headspace MB was assumed to be recaptured. Desorption has been determined on a 5-minute basis from the time of release for a period of 3 hours. The same assumptions as for the modelling have been made for release of MB by desorption see Section 3.0 of the main body of the report and Appendix C. Emission rates have then been determined using the sum of MB released from all log stacks on a half hour basis.

The downwind direction ranges have been estimated by taking the angle from the sample location to the edges of the venting location. If there are multiple 1-hour samples, then the downwind direction range has been calculated for them all individually and presented in Table 1. On the graphs below the downwind direction of the nearest 1-hour sample has been presented. Downwind direction ranges can change if the venting location or monitoring location changes. This has been indicated on the graphs by the lines showing downwind range changing. Wind data has been sourced from the NIWA meteorological station at the nearby Tauranga airport.

3.2 Monitoring 30 May 2019

Monitoring was conducted on the 30th of May during ventilation of Genera job number 106276, where 14/17 of the log stacks had recapture of MB. There was a total of 1,398 kg of MB used for the fumigations. Samples 1A and 2A (1-hour) were located to the south-east of the venting as indicated in Figure 3. The MB concentration result for sample 1A, at the monitored safety zone, was 35.9 ppm and for sample 2A, at the port boundary, it was 2.2 ppm. The co-located Cub PIDs for the same period measured total VOC concentrations of 11 ppm and 0.92 ppm for the same 1-hour averages respectively. Figure 5 below shows the calculated emission rate of MB, wind direction and range of wind directions where samples would be downwind of the ventilation.

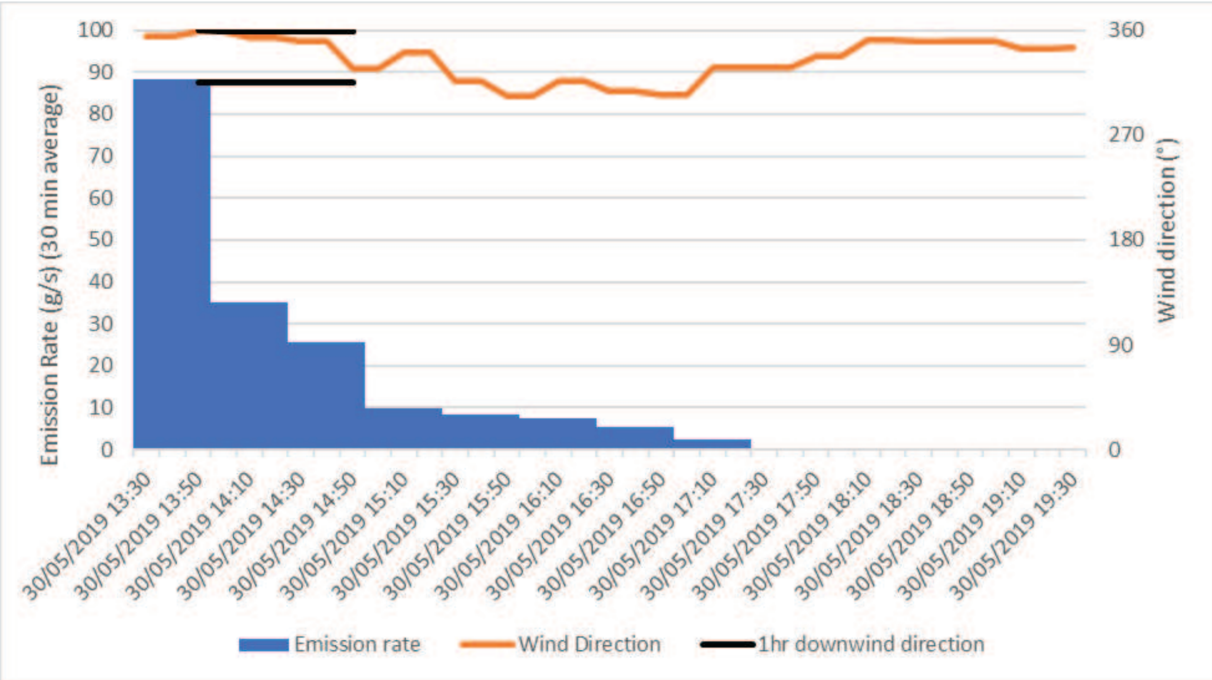

Figure 5: General downwind direction range from ventilation to monitoring location, wind direction, and MB emission rate for 30 May 2019.

Based on the data presented in Figure 5, the sample was downwind of the ventilation for the majority of the sampling hour and during or just after the peak release rate which was 88 g/s (30-min average) between 13:30 and 14:00. The first ventilation started at 1:35 pm and the nearest sample was started at 1:47 pm. The average wind speed during the sampling period was 4.4m/s.

3.3 Monitoring 13-14 June 2019

Monitoring was conducted on 13-14 June during ventilation of Genera job numbers 106983 and 107195, where 15/19 and 5/8 of the log stacks had recapture of MB respectively. There was a total of 1,905 kg and 601 kg of MB used for each of the fumigation jobs respectively. Samples 1B, 2B, 3B (1 hour) and 4B (24 hour) were located to the east and north-east of the venting as indicated in Figure 3. The MB concentration result for sample 1B at the monitored safety zone was 0.19 ppm and samples 2B and 3B at the port boundary and salt works were below the detection limit. The 24-hour sample 4B concentration was 0.05 ppm. The Cub PID co-located with sample 1B at the monitored safety zone measured a total VOC concentration of 0.49 ppm (1-hour average) for the same period. The following hour (10am -11am) the same PID measured a total VOC concentration of 2.8 ppm (1-hour average). The Cub PID co-located with sample 2B at the port boundary for the same period measured a VOC concentration of 0.16 ppm (1-hour average). Figure 6 below shows the calculated emission rate of MB, wind direction and range of wind directions where samples would be down wind of the ventilation.

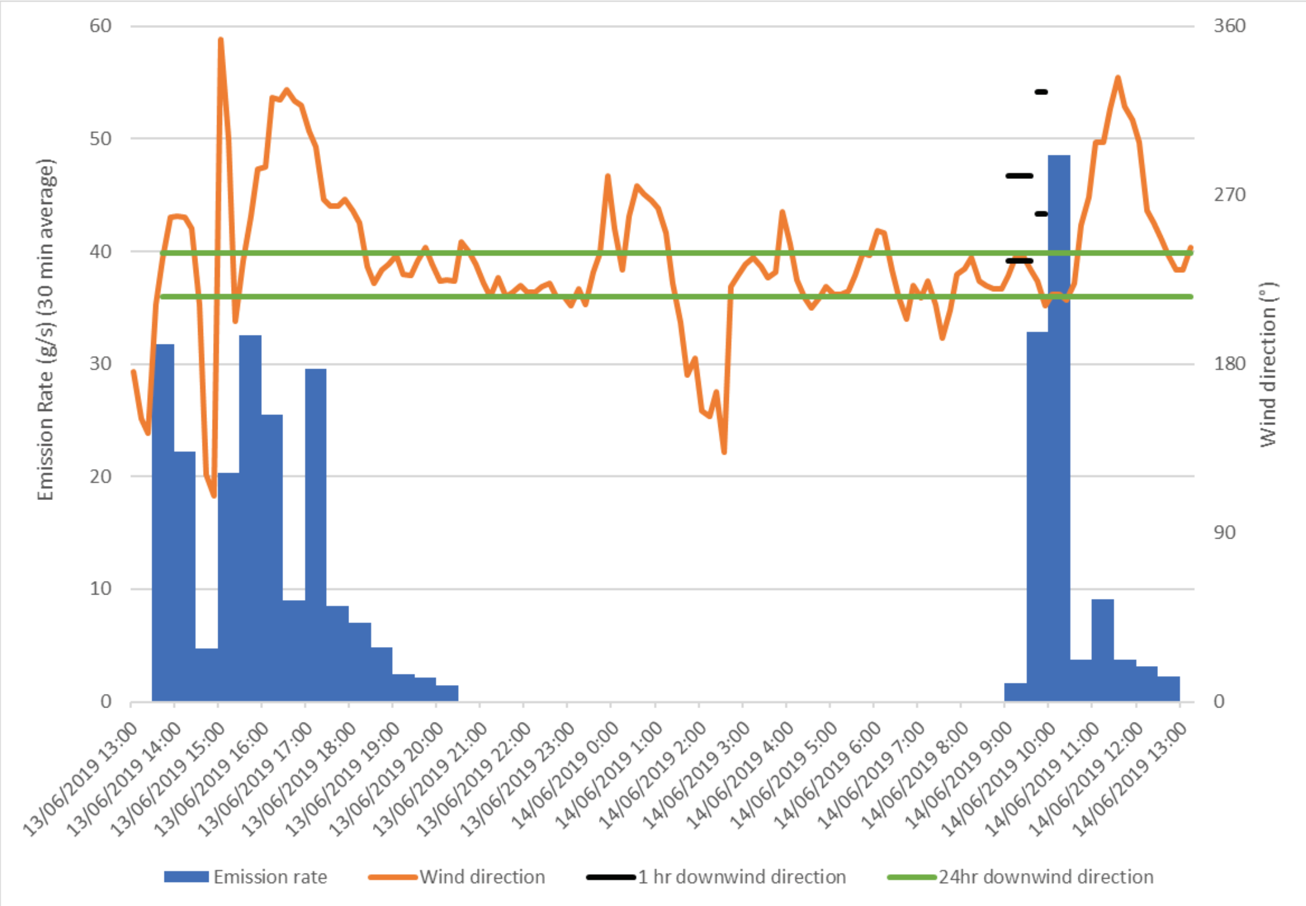

Figure 6: General downwind direction ranges from ventilation to monitoring locations, wind direction, and MB emission rate for 13/14 June 2019.

The first ventilation for 14 June started at 9:00 am, but no further stacks were ventilated until 9:40. Two of the three log stacks which did not have recapture were vented at 10:00 am. There were 4 log row releases which contributed to the half hour emission rate between 9:30 and 10:00 am, two of which happened at 9:40 am and two at 9:45 am. The 1-hour sample canisters were started from 9:00 am. This means the peak release started at the same time the 1-hour samples finished being collected, meaning that the peak release was missed. The nearest sample (1B) co-located with the PID was moved approximately 100 m to the south at 9:40 am in an attempt to maintain it downwind as the venting progressed southward. The movement of the sample to the south does not appear to have helped increase the time it was downwind of the venting and the 1B sample was not downwind for the majority of the sampling time. This combination of not being downwind and a low MB discharge during sampling is consistent with the low amount of MB detected at the monitored safety zone. Sample 2B at the port boundary had a higher percentage calculated downwind time but also missed the main release time of 10 am. As 2B was approximately 230 m from venting the sample would have been exposed to only a short period of actual MB release. Sample 3B had a calculated downwind time percentage of 67 % however this occurred between the times of 9:10 am and 9:40 am which only coincides with one recaptured row venting and therefore a low MB release rate. The average wind speed during this sampling period was 2.7 m/s.

Over the sampling period for the 24-hour sample (4B), the sample was downwind intermittently for parts of the fumigations. The calculated downwind time during which estimated emissions were above zero for sample 4B was 4 hours, with an average emission rate during this period of 11.6 g/s and 2 g/s on average over the sampling period. The peak emission rate over the full period was 49 g/s (30-min average) which occurred between 10am – 10:30am on 14 June.

3.4 Monitoring 8 August 2019

Monitoring was conducted on 8 August during ventilation of Genera job number 108556, where 7/7 of the log stacks had recapture of MB. There was a total of 558 kg of MB used for the fumigation. Samples 1C, 2C, 3C (1-hour) and 4C (24-hour) were located to the south-east of the northern venting location, as indicated in Figure 3. The MB result for sample 1C at the monitored safety zone was 6.4 ppm and for sample 2C at the port boundary was 2.3 ppm. The MB result for sample 3C at the salt works was 0.01 ppm. The MB concentration at the 24-hour sample 4C located at Waimarie street was below the detection limit. The Cub PID co-located with sample 1C at the monitored safety zone measured a total VOC concentration of 2.9 ppm (1-hour average) for the same period. The Cub PID co-located with sample 2C at the port boundary for the same period measured a total VOC concentration of 1.1 ppm (1-hour average). Figure 7 below shows the calculated emission rate of MB, wind direction and range of wind directions where samples would be downwind of the ventilation.

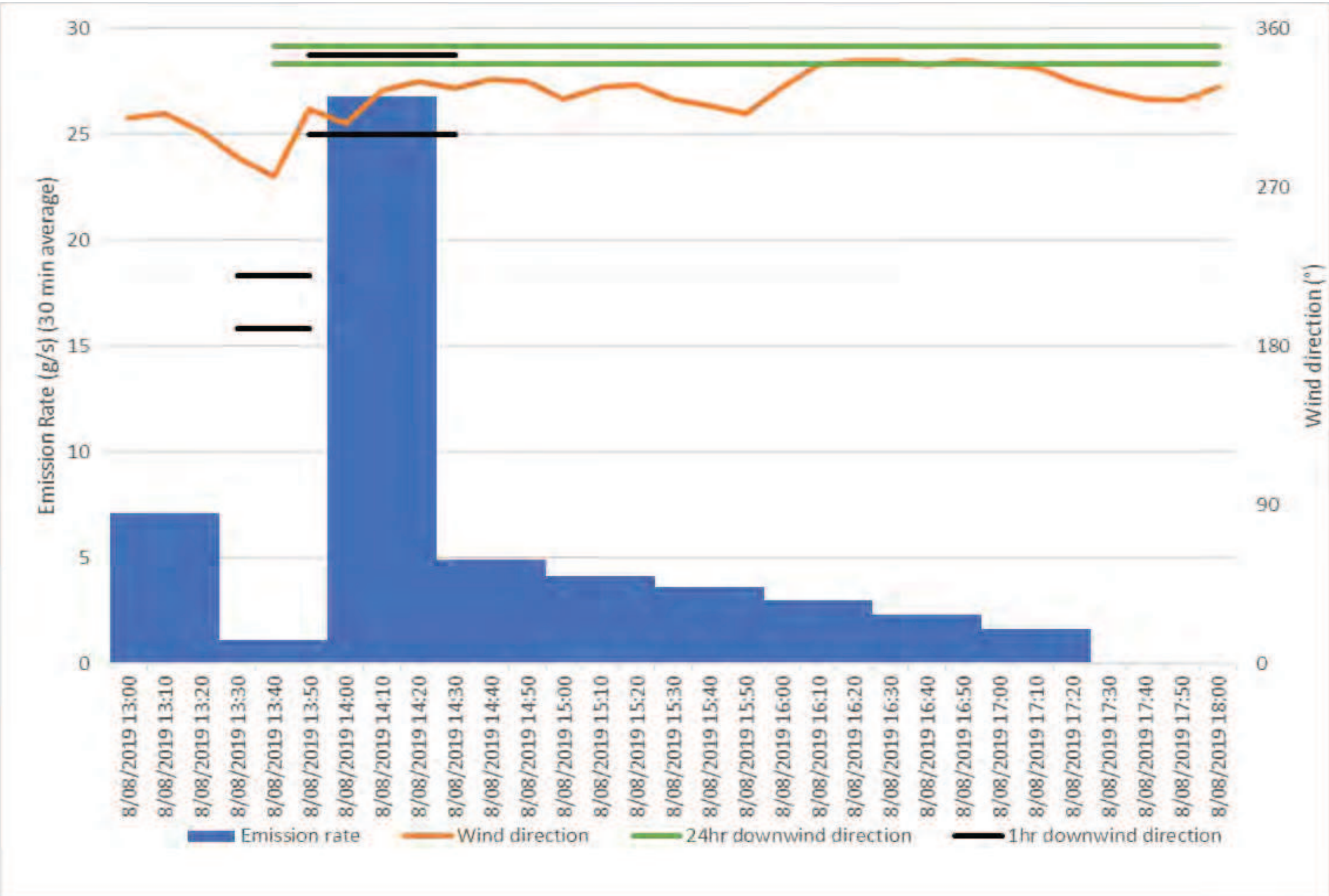

Figure 7: General downwind direction ranges from ventilation to monitoring locations, wind direction, and MB emission rate for 8 August 2019.

There were two log stacks ventilated at the southern location at 1:15 pm, and the other five log stacks were ventilated at the northern location between 2:15 pm and 2:25 pm. The 1-hour sample canisters were started from 1:30 pm. This means the peak release occurred during sampling and while the samples were downwind of the main venting location. The cannister was not downwind of the venting from the southern site and therefore it does not appear to have contributed to the sample. Sample 2C at the port boundary was approximately 130 m from the nearest upwind venting which is relatively close (all log stack venting must be at a minimum distance of 100 m from the port boundary). The average wind speeds during this 1-hour sampling period was 2.6 m/s.

Sample 4C was located at the corner of Waimarie street and Totara street and is represented by the green lines in Figure 7 above. This sample was not downwind during venting. The period is not shown in full on Figure 1 as there were no further ventilations over the rest of the time it ran.

3.5 Monitoring 22 August 2019

Monitoring was conducted on 22 August during ventilation of Genera job numbers 108554 and 108642, where 18/23 and 9/9 of the log stacks had recapture of MB respectively. These jobs were vented at 5 different locations at the port, as shown in Figure 4 where the venting time is also shown. Genera Job number 108556 was vented on the same day but in the early hours of the morning. Genera job 108556 was a ship hold fumigation, but due to the timing of MB release it is not likely to have significantly contributed to MB concentrations at the time of monitoring. For the jobs 108554 and 108642 there was a total of 1,409 kg and 1,561 kg of MB used for the fumigations respectively.

Sample 1D (1-hour) and 2D (24-hour) were located to the east of the venting locations as indicated in Figure 4. The MB concentration measured for sample 1D at Waimarie street was 0.07 ppm. The 24-hour sample 2D at Waimarie street measured a concentration of MB of 0.02 ppm. There were no PID units co-located with these samples. The maximum 1-hour total VOC concentration measured on a PID during this period was 1.1 ppm, this PID was located on Tasman quay at the south eastern corner of the port. Figure 8 below shows the calculated emission rate of MB, wind direction and range of wind directions where samples would be downwind of the ventilation.

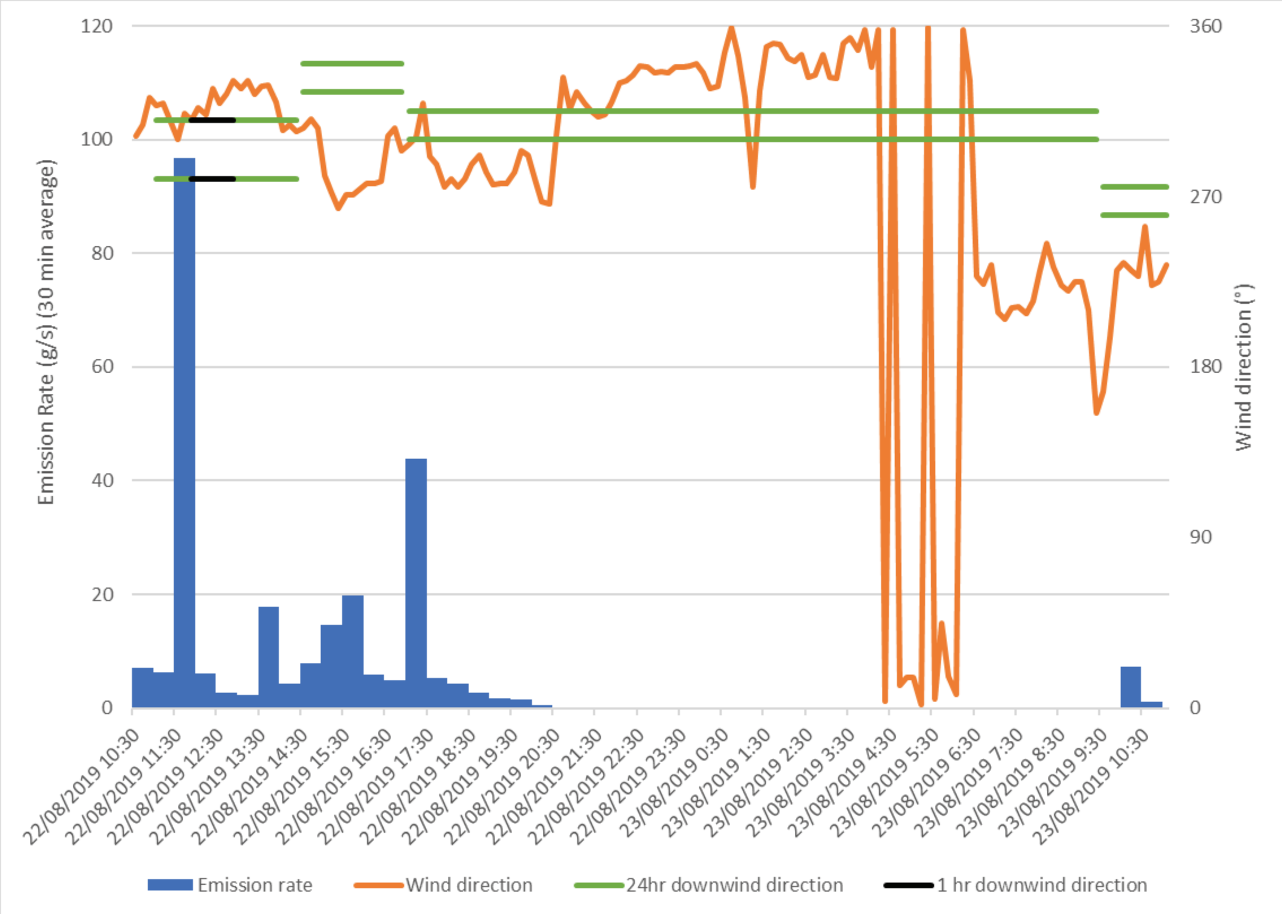

Figure 8: General downwind direction ranges from ventilation to monitoring locations, wind direction, and MB emission rate for 22 August 2019.

Downwind directions have been determined for each of the different venting locations. The 1-hour sample canister was started at 11:22 am. This means the peak release occurred just before sampling was started with the wind blowing towards the samplers for part of this time. The peak release happened between 11am and 11:30am when 3 of the log rows which did not have recapture were vented with a calculated emission rate of approximately 97 g/s (30-min average). The average wind speed during the 1-hour sampling period was 3.8 m/s.

There was one 24-hour sample collected over this period. Sample 2D was located at the corner of Waimarie and Totara streets. Overall, the 24-hour sample was downwind for only short periods during some of the venting times. The calculated downwind time during which estimated emissions were above zero for sample 2D was 70 minutes, with an average emission rate during this time of 37 g/s and 3 g/s on average over the sampling period.

3.6 Summary

The canister measurements of MB were generally in the order of two to three times higher than total VOC measurements by the Cub PIDs. This indicates that the Cub PID monitors are under reporting MB concentrations. From the monitoring data currently available, there is insufficient evidence to indicate that a correction factor could be applied to PIDs to give more realistic MB concentrations.

Samples which were downwind of ventilations and provide useful comparison to modelled results are displayed in Table 3. The other samples taken, as described in Section 3.0 were not downwind during significant releases of MB.

Table 3: Monitoring results suitable for comparison with modelling.

Id No. (1-hour unless noted)	Approximate time Downwind of venting	Average Release rate during downwind period (g/s)	Average Release rate while downwind over total monitoring period (g/s)	Distance from Venting (m)	Concentration (ppm)
1A (onsite)	100 %	38.7	38.7	60	35.9
2A	71 %	29.5	21.0	330	2.2
1B	33 %	1.6	0.5	60	0.19
2B	67 %	25.0	16.7	230	<0.01
4B (24 hour)	17 %	11.6	2.0	450	0.05
1C (onsite)	57 %	21.3	12.2	80	6.4
2C	57 %	21.3	12.2	130	2.3
3C	57 %	8.5	4.8	290 -340	0.01
1D	14 %	96.8	13.8	420	0.07
2D	5 %	36.7	3.0	420 -650	0.02

4.0 CANISTER INSTRUCTIONS

Considerations for Integrated Sampling with Canisters
Collecting an integrated air sample is more involved than collecting a grab sample. Sampling considerations include verifying that the sampling train is properly configured, monitoring the integrated sampling progress, and avoiding contamination.

- **Avoid Leaks in the Sampling Train**: A leak in any one of these connections means that some air will be pulled in through the leak and not through the flow controller. (Follow the leak check step #4 in 3.2.6).
- **Verify Initial Vacuum of Canister:** See Section 3.1.1 for instructions on verifying initial canister vacuum. A separate gauge is not necessary as both the mass flow controllers and critical orifice flow controllers have built-in rough gauges.
- **Monitor Integrated Sampling Progress**: When feasible, it is a good practice to monitor the progress of the integrated sampling during the sampling interval. The volume of air sampled is a linear function of the canister vacuum. For example, when using a 24-hour mass flow controller, at a quarter of the way (6 hours) into a 24-hour sampling interval, the canister should be a quarter filled (1.25 L) and the gauge should read approximately 6 in Hg lower than the starting vacuum (~22 in Hg). More vacuum indicates that the canister is filling too slowly; less vacuum means the canister is filling too quickly. If the canister is filling too slowly, a valid sample can still be collected (see Section 3.2.4). If the canister is filling too quickly because of a leak or incorrect flow controller setting, corrective action can be taken. Ensuring all connections are tight may eliminate a leak. It is possible to take an intermittent sample; the time interval need not be continuous.
- **Avoid Contamination**: Flow controllers should be cleaned between uses. This is done by returning them to the laboratory.
- **CautionWhen Sampling in Extreme Temperatures**: Field temperatures can affect the performance of the mass flow controllers. Laboratory studies have shown that flow rates can increase slightly with decreasing temperatures. A flow rate increase of approximately 10% is expected when sampling at field temperatures of 5 to 10°C.

3.2.6 Step-by-Step Procedures for Integrated Sampling
These procedures are for a typical ambient air sampling application; actual field conditions and procedures may vary.

Before you get to the field:
1. Verify contents of the shipped package (e.g., chain-of-custody, canister, and flow controller)
2. Make sure you include a 9/16” and 1/2” wrench in your field tool kit.
3. Verify the gauge is working properly
4. Verify the initial vacuum of canister as below:

Verify Initial Vacuum of the Canister: Prior to shipment, each canister is checked for mechanical integrity. However, it is still important to check the vacuum of the canister prior to use. Eurofins Air Toxics recommends doing this before going to the field if possible. The initial vacuum of the canister should be greater than 25 in Hg. If the canister vacuum is less than 25 in Hg, ambient air may have leaked into the canister during storage or transport and the sample may be compromised. Contact your Project Manager if you have any questions on whether to proceed with sample collection. The procedure to verify the initial vacuum of a canister is simple but unforgiving.

1. Confirm that valve is closed (knob should already be tightened clockwise).
2. Remove the brass cap.
3. Attach gauge.
4. Attach brass cap to side of gauge tee fitting to ensure a closed train.
5. Open and close valve quickly (a few seconds).
6. Read vacuum on the gauge.
7. Record gauge reading on “Initial Vacuum” column of chain-of-custody.
8. Verify that canister valve is closed and remove gauge.
9. Replace the brass cap.

When ready to sample:
1. Confirm that valve is closed (knob should already be tightened clockwise).
2. Remove brass cap from canister.
3. Attach flow controller to canister. The flow controller is securely attached if the flow controller body does not rotate.
4. Place the brass cap at the end of the flow controller creating an air tight train, and quickly open and close the canister valve in order to check for leaks. If the needle on the gauge drops, your train is not airtight. In this case, try refitting your connections and/or tightening them until the needle holds steady.
5. Once the sample train is airtight remove the brass cap from the flow controller and open the canister valve a ½ turn.
6. Monitor integrated sampling progress periodically.
7. Verify and record final vacuum of canister (simply read built-in gauge).
8. When sampling is complete, close valve by hand tightening knob clockwise.
9. Detach flow controller and replace brass cap on canister.
10. Fill out canister sample tag (make sure the sample ID and date of collection recorded on the sample tag matches what is recorded on the COC exactly).
11. Return canisters and associated media in boxes provided. **Failure to return all of the provided equipment will result in a replacement charge as outlined in the media agreement.**
12. Fill out chain-of-custody and relinquish samples properly (it is important to note the canister serial numbers on the chain-of-custody).
13. Place chain-of-custody in box and retain pink copy.
14. Tape box shut and affix custody seal at each opening (if applicable).
15. Ship accordingly to meet method holding times (30 days).

5.0 CANISTER TEST SHEET TEMPLATE

METHYL BROMIDE SAMPLING FORM (USING CANISTERS)

GOLDER

PROJECT INFORMATION

Project No: 1898728

Client: Genera Ltd

Site Address: Port of Tauranga

Date: ____________

Field Personnel: ____________

METEOROLOGICAL CONDITIONS

Ambient Temp: (°C) ____________

Barometric Pressure: (kPa) ____________

Rain: Dry / Light / Heavy

Relative Humidity: (%) ____________

Wind direction/speed (m/s) start: ____________

Wind direction/speed (m/s) end: ____________

LABORATORY REFERENCE NO's

Canister Barcode: ____________

Canister Volume: 6L

Regulator Id: ____________

Serial number of Canister: ____________

SAMPLE COLLECTION

Do NOT fill canister completely during sampling (leave approximately - 5 Hg) -

Sampling Period flow rates:

example 1 hour sample rate: 83.3 ml/min

example 24 Hour sample rate: 3.8 ml/min

Actual sample rate: ____________

Sampling Start Time/date: ____________ ____________

Sampling End Time/date: ____________ ____________

Gauge Reading pre Sampling: ____________

Gauge Reading post Sampling: ____________

Sample Location/coordinates: ____________

Sample No: ____________

Genera Information

Genera Job number: ____________

Cub/PID Id: ____________

how much recapture was used?: ____________

Venting Start Time/date: ____________

Venting End Time/date: ____________

Venting Location/coordinates: ____________

COMMENTS

____

____

____

Mark sample with an x and fumigation location with a box

6.0 REFERENCES

Beca. (April 2019). *Fumigation Management plan.*

Eurofins. (2014). *Guide to Air Sampling - Canisters and Bags Revision 27 june 2014.*

Golder. (2019). *Technical Air Quality Assessment (Genera Limited).*

M Hall et al, A. n.-R. (2016). Sorption and desorption characteristics of methyl bromide during and after fumigation of pine (Pinus radiataD. Don) logs. *Wiley Online Library*, Society of Chemical Industry.

APPENDIX G

CALPUFF Contour Maps

Predicted maximum (100th percentile) results

The predicted maximum (100th percentile) results for MB are presented in Figure 1 to Figure 7. Figure 1 shows the predicted maximum 1-hour GLCs due to the MB emission from log stack/containers and Figure 2 shows the predictions for ship holds only. Figure 3 presents the maximum predicted 1-hour MB ground level concentrations (GLCs) due to both log stack and ship hold emissions.

Figure 4, Figure 5 and Figure 6 show the predicted maximum 24-hour MB GLCs arising from log stacks, ship holds, and from both log stack and ship hold fumigations respectively. Figure 7 presents the predicted maximum annual impact from both log stack and ship hold emissions.

Figure 4 shows the predicted contour of the 24-hour assessment criteria (0.33 ppm or 1300 µg/m³) only extends onto the sea to the west of the site, where exposure over a 24-hour is not so relevant. Combined with the effects from ship hold fumigation, Figure 6 shows the predicted contour of assessment criteria extends approximately 250 m beyond the east of the site boundary, just into the neighbouring industrial zone. This is also driven by the ship hold emissions.

Predicted 99.9th percentile results (1-hour, 24-hour)

The predicted 99.9th percentile 1-hour contour plots are presented in Figure 8 (for log fumigation only) and Figure 9 (for both log and ship hold fumigations), while the 24-hour contours are shown in Figure 10 (for log fumigation only) and Figure 11 (for both log and ship hold fumigations).

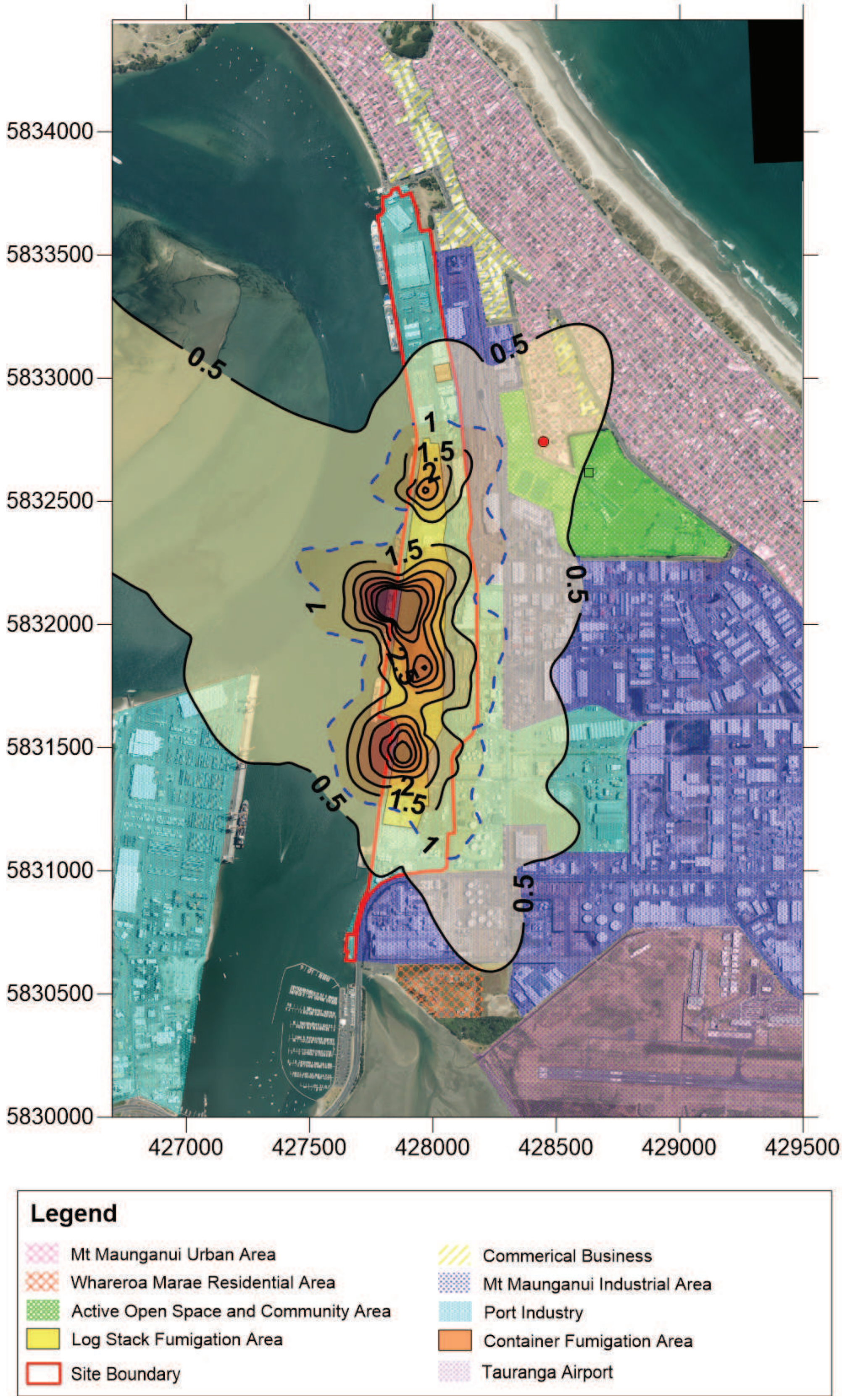

Figure 1: Predicted maximum 1-hour average (100 % percentile) MB GLCs (ppm). Coordinates system: UTM (m). Meteorological year modelled 2014, 2015 and 2016. Log stack fumigation only. Criteria 1 ppm represented as a blue dotted line.

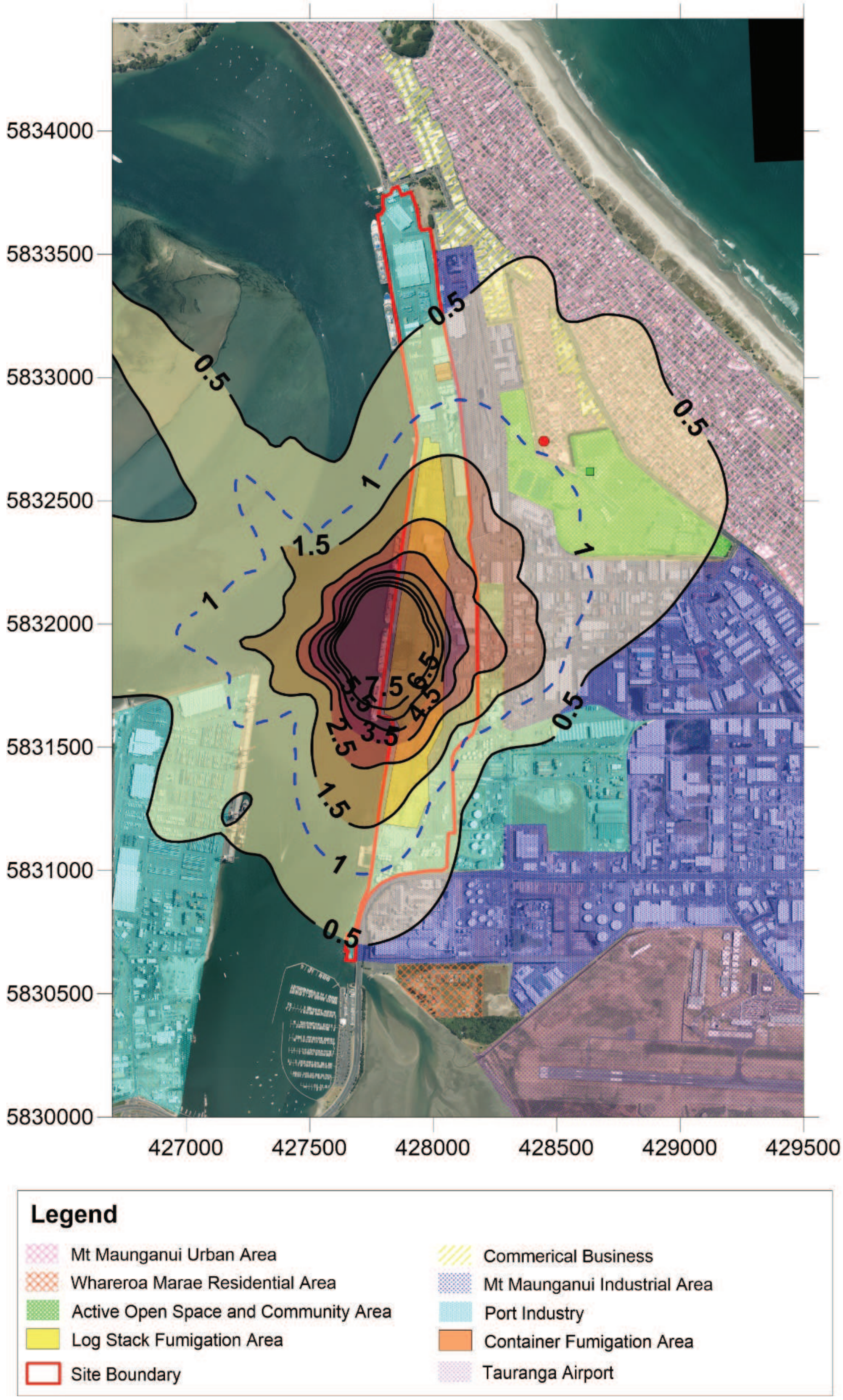

Figure 2: Predicted maximum 1-hour average (100 % percentile) MB GLCs (ppm). Coordinates system: UTM (m). Meteorological year modelled 2014, 2015 and 2016. Ship hold fumigation only. Criteria 1 ppm represented as a blue dotted line.

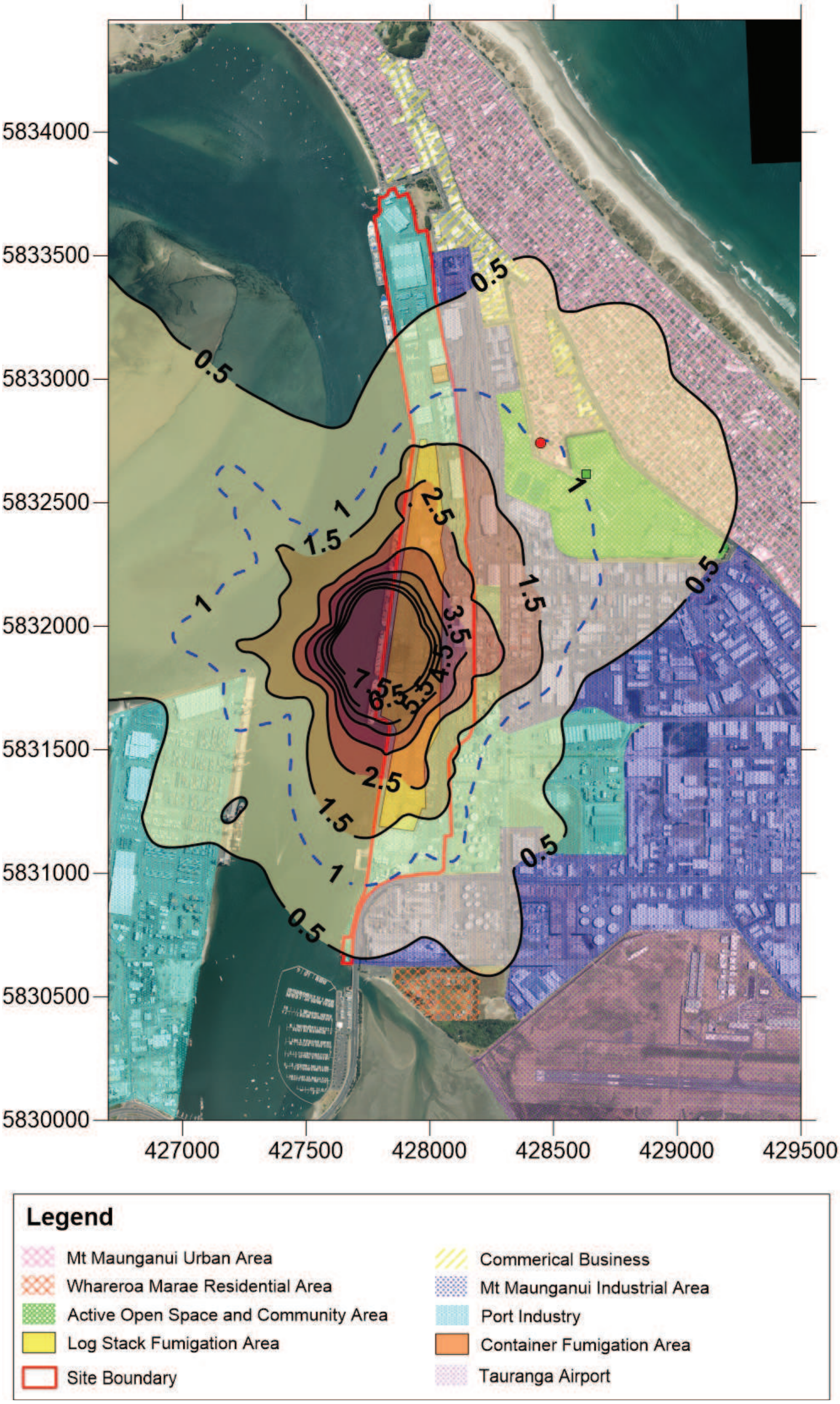

Figure 3: Predicted maximum 1-hour average (100 % percentile) MB GLCs (ppm). Coordinates system: UTM (m). Meteorological year modelled 2014, 2015 and 2016. Includes log stacks and ship holds Criteria 1 ppm represented as a blue dotted line.

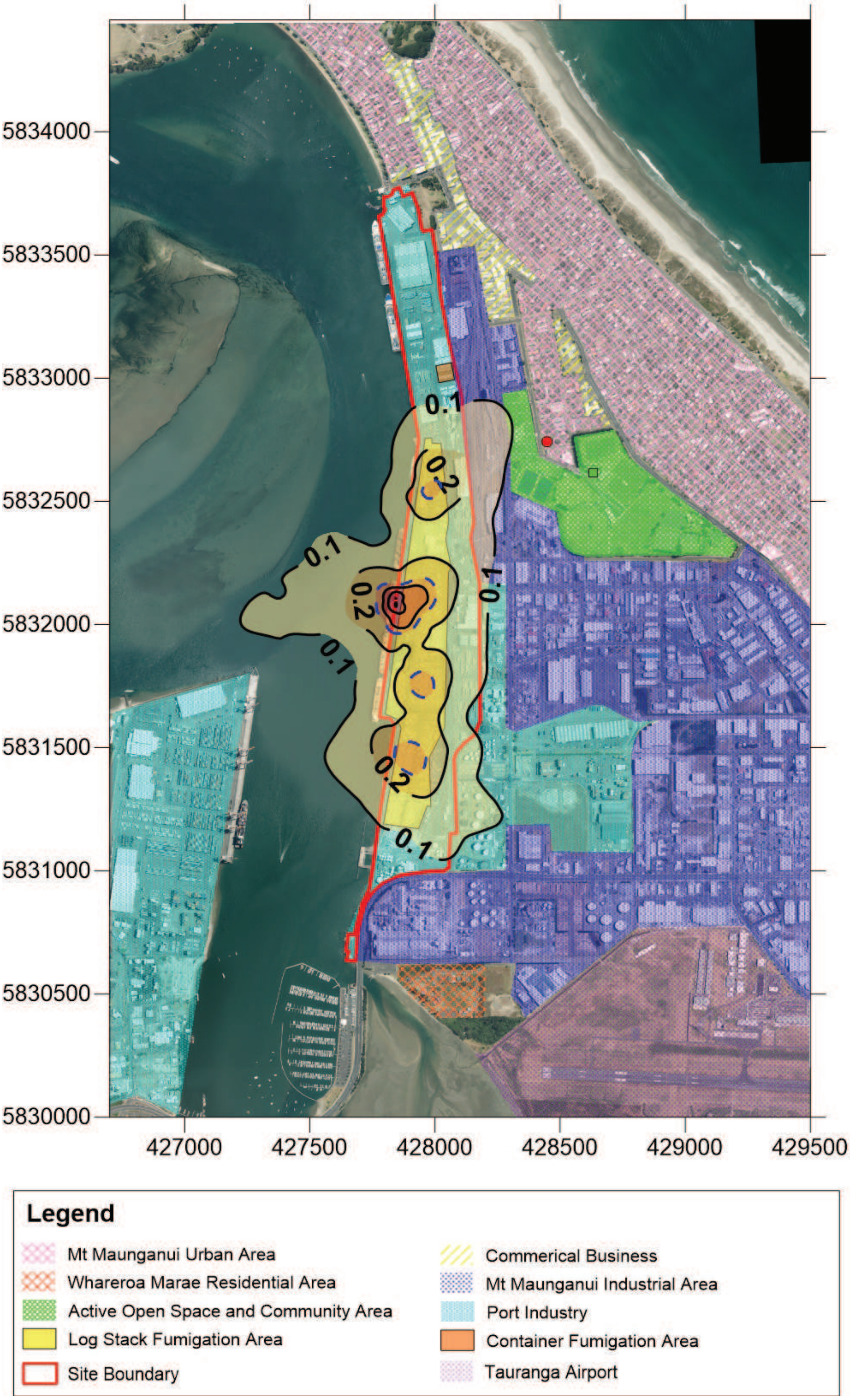

Figure 4: Predicted maximum 24-hour average MB GLCs (ppm). Coordinates system: UTM (m). Meteorological year modelled 2014, 2015 and 2016. Log stack fumigation only. Criteria 0.333 ppm represented as a blue dotted line.

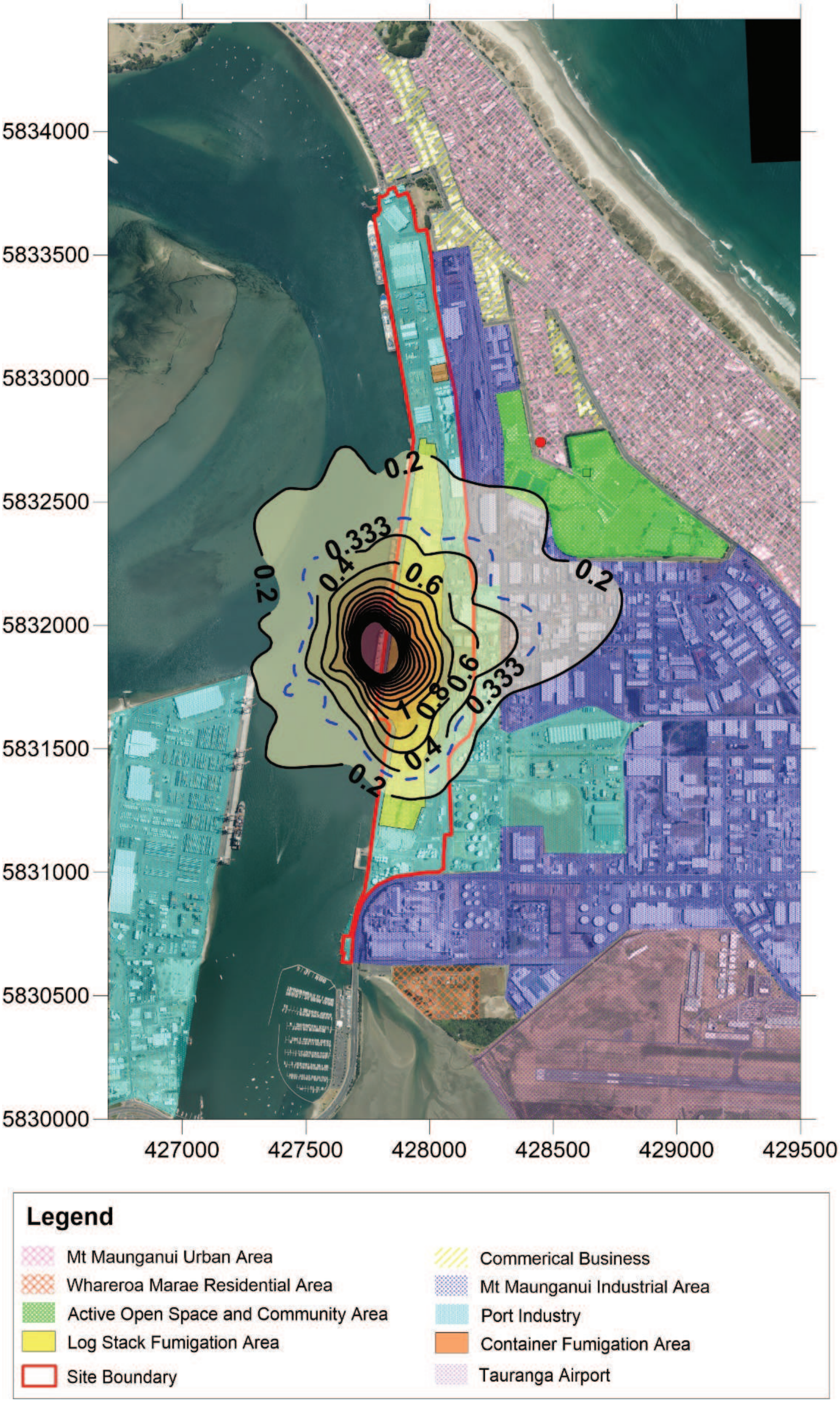

Figure 5: Predicted maximum 24-hour average MB GLCs (ppm). Coordinates system: UTM (m). Meteorological year modelled 2014, 2015 and 2016. Ship hold fumigation only. Criteria 0.333 ppm represented as a blue dotted line.

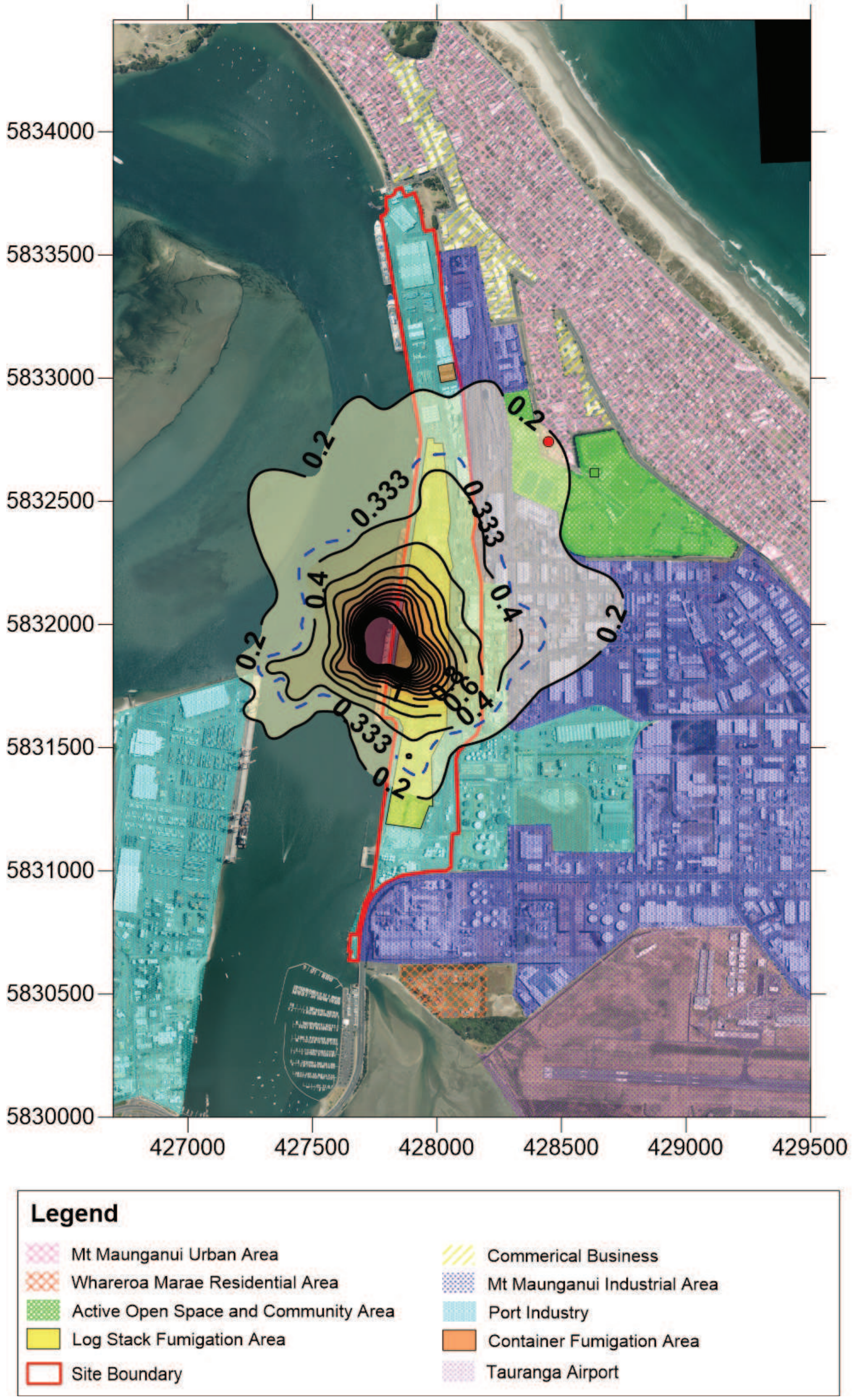

Figure 6: Predicted maximum 24-hour average MB GLCs (ppm). Coordinates system: UTM (m). Meteorological year modelled 2014, 2015 and 2016. Includes log stacks and ship holds. Criteria 0.333 ppm represented as a blue dotted line.

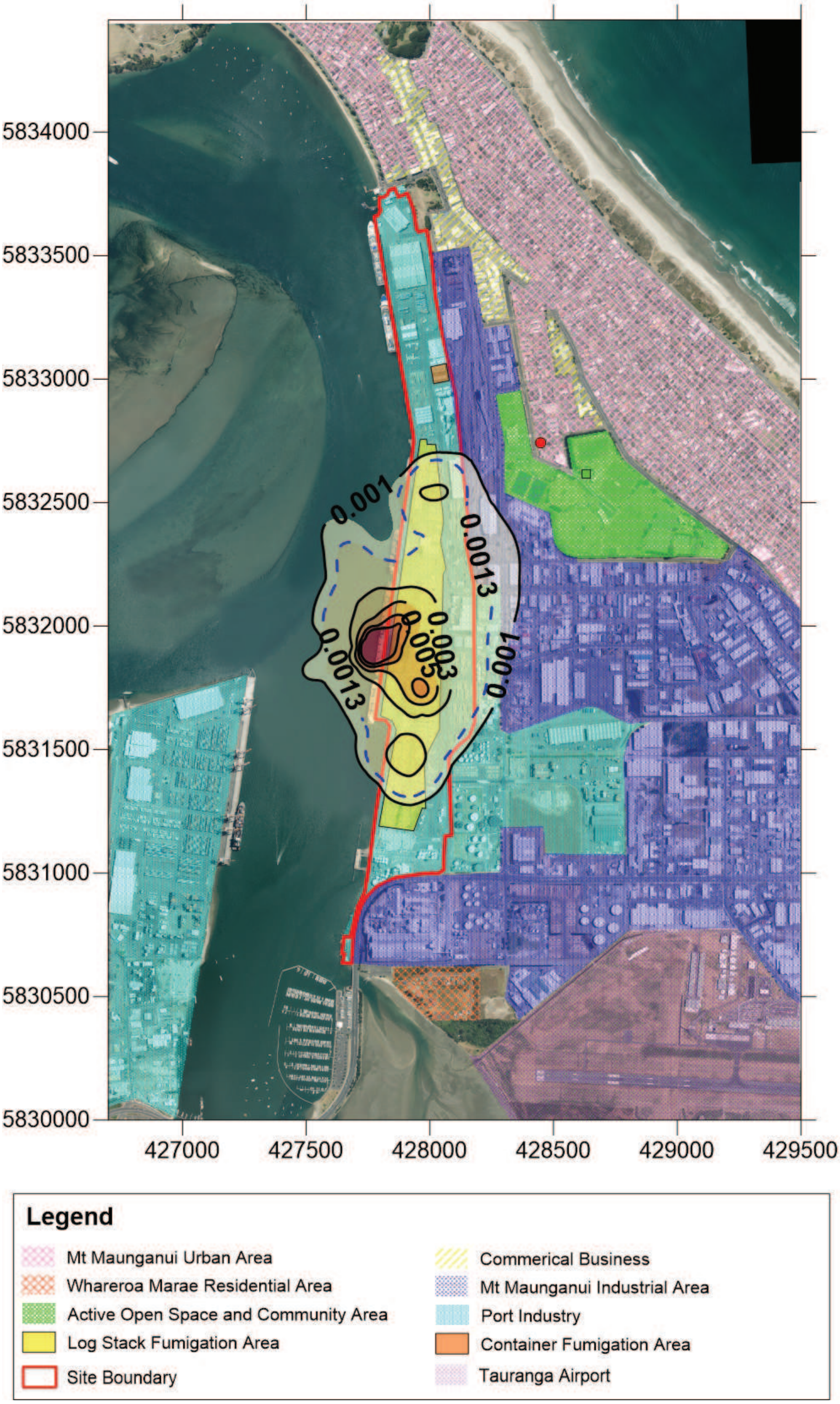

Figure 7: Predicted maximum annual average MB GLCs (ppm). Maximum of the modelling results predicted for three annual emission datasets. Coordinates system: UTM (m). Meteorological year modelled 2014, 2015 and 2016. Includes log stacks and ship holds. Criteria 0.0013 ppm represented as a blue dotted line.

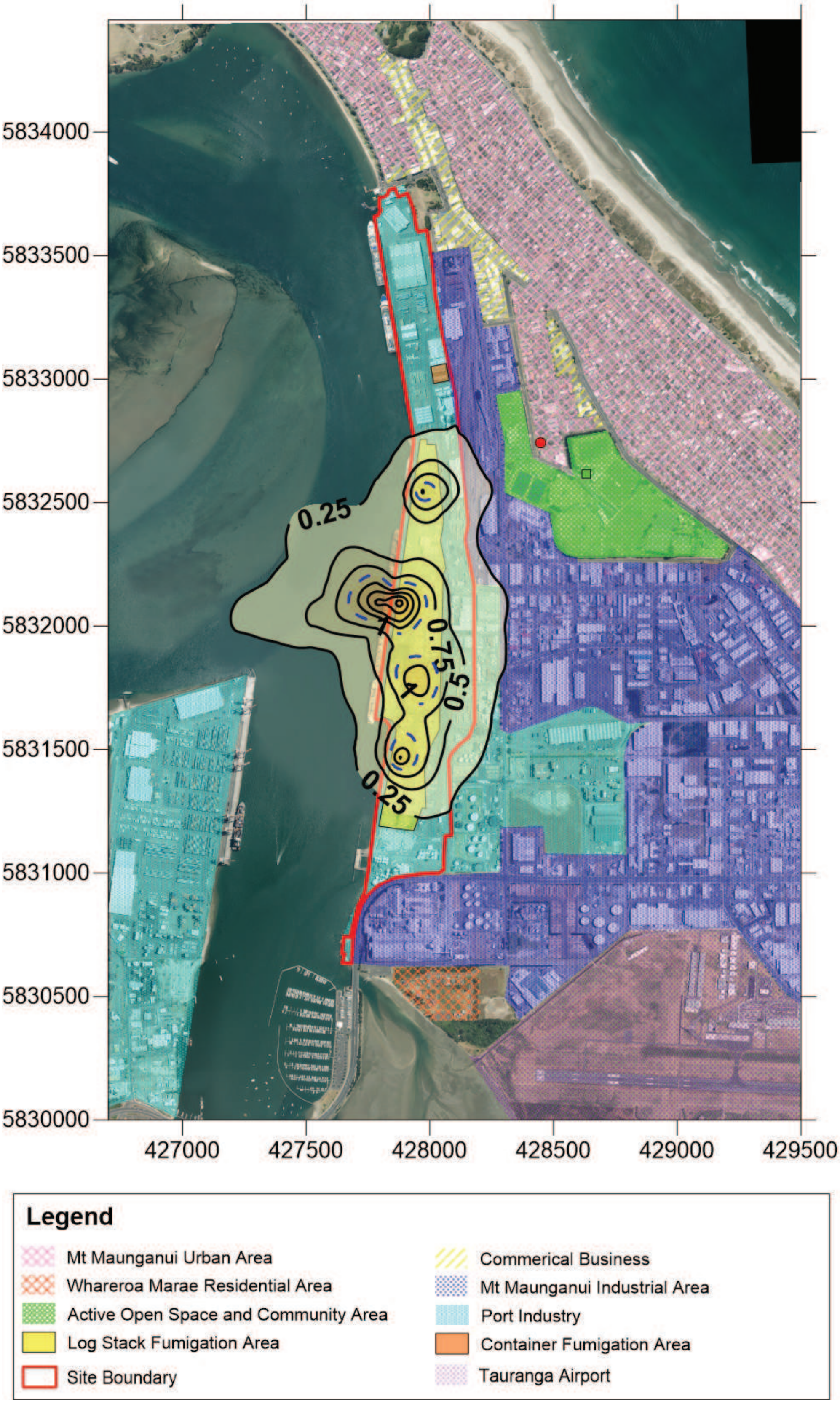

Figure 8: Predicted 99.9th percentile 1-hour average MB GLCs (ppm). Coordinates system: UTM (m). Meteorological year modelled 2014, 2015 and 2016. 80 % recapture scenario. Log stack fumigation only. Criteria 1 ppm represented as a blue dotted line.

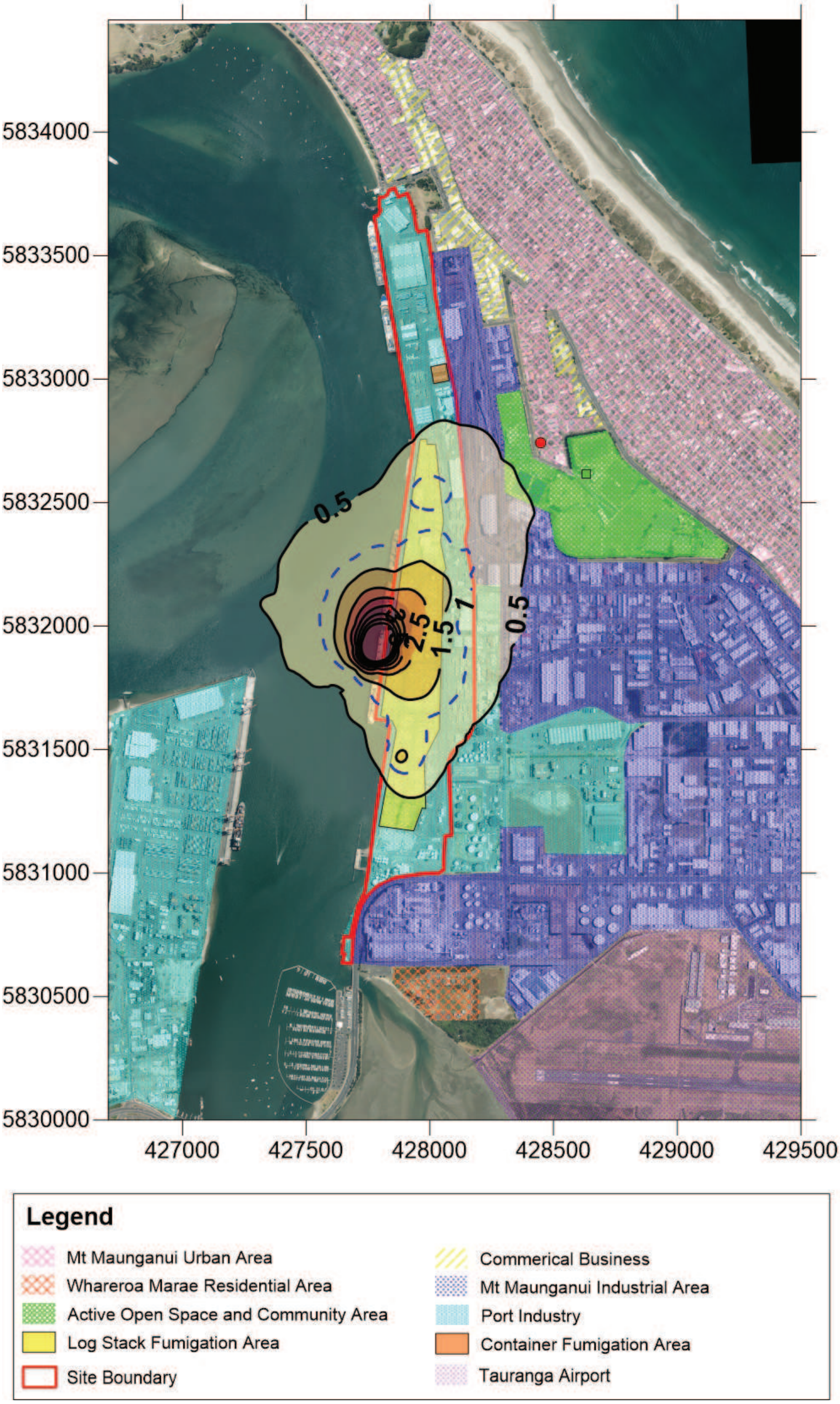

Figure 9: Predicted 99.9th percentile 1-hour average MB GLCs (ppm). Coordinates system: UTM (m). Meteorological year modelled 2014, 2015 and 2016. 80 % recapture scenario for log stacks. Includes ship holds. Criteria 1 ppm represented as a blue dotted line.

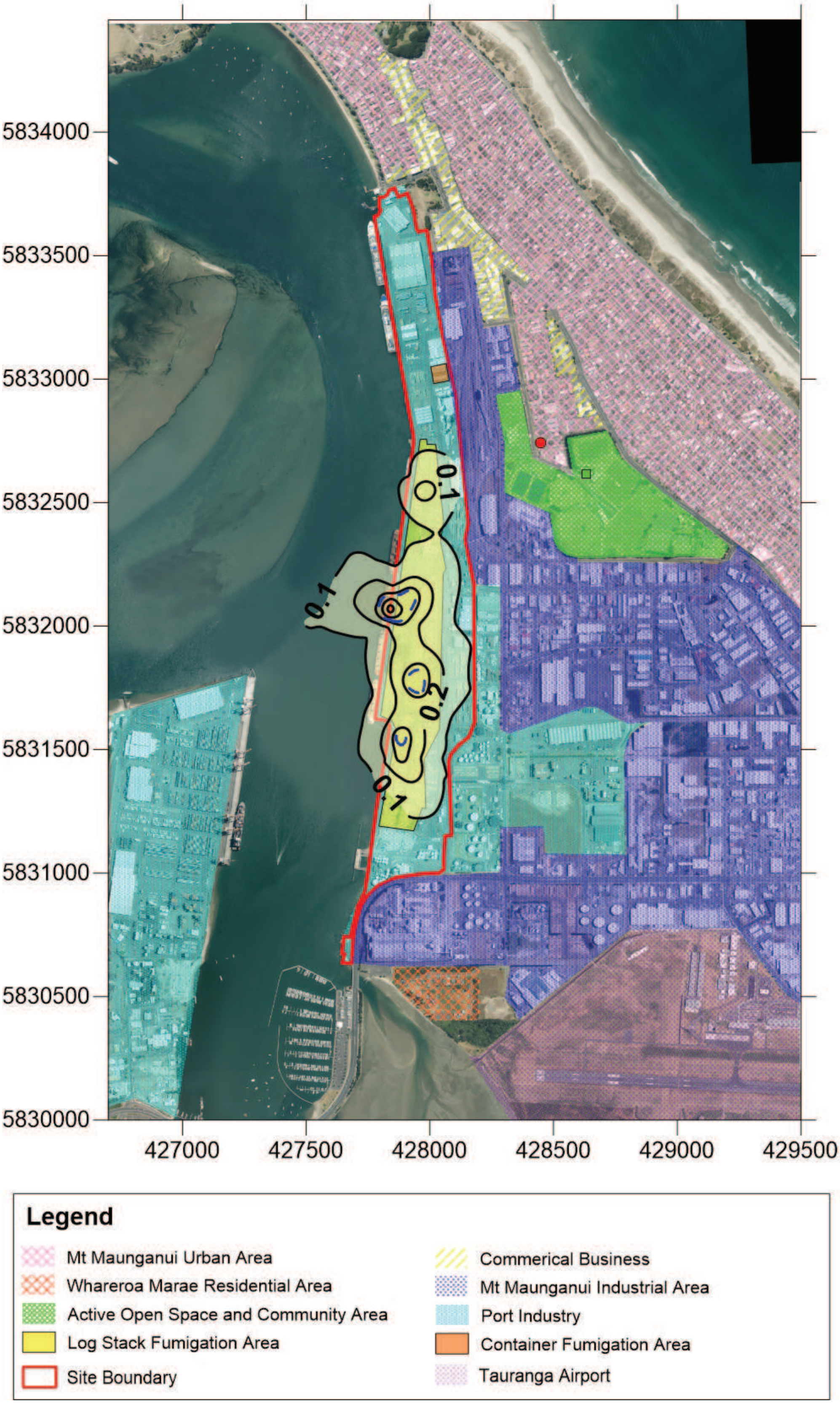

Figure 10: Predicted 99.9th percentile 24-hour average MB GLCs (ppm). Coordinates system: UTM (m). Meteorological year modelled 2014, 2015 and 2016. 80 % recapture scenario. Log stack fumigation only. Criteria 0.333 ppm represented as a blue dotted line.

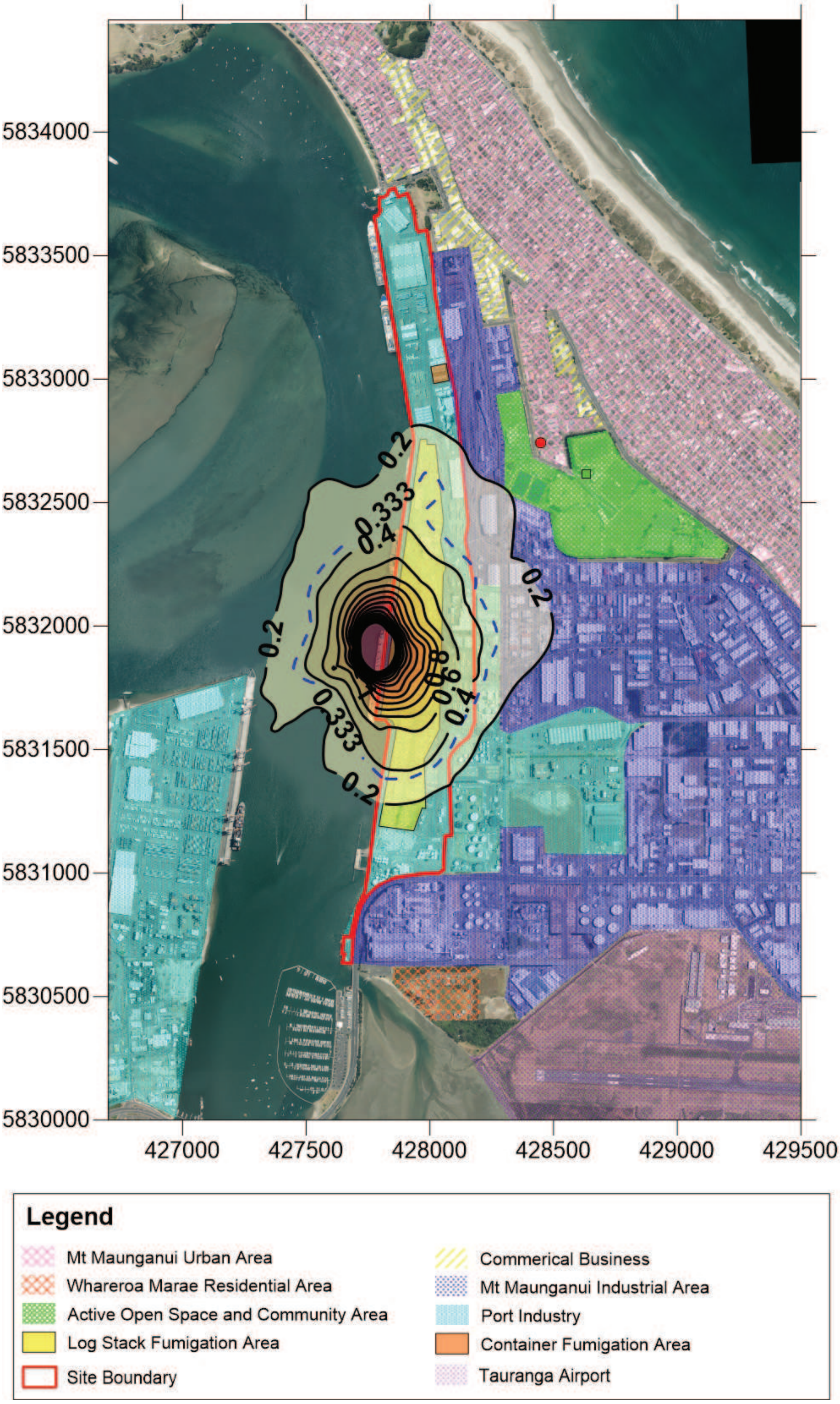

Figure 11: Predicted 99.9th percentile 24-hour average MB GLCs (ppm). Coordinates system: UTM (m). Meteorological year modelled 2014, 2015 and 2016. 80 % recapture scenario for log stacks. Includes ship holds. Criteria 0.333 ppm represented as a blue dotted line.

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