Submission to ERMA on the Re-Assessment of Methyl Bromide

February 2010

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Executive Summary

When considering the definitions of 'quarantine' and 'pre-shipment' the Parties to the Montreal Protocol decided: "In applying these definitions, all countries are urged to refrain from use of methyl bromide and to use non-ozone-depleting technologies wherever possible. Where methyl bromide is used, Parties are urged to minimise emissions and use of methyl bromide through containment and recovery and recycling methodologies to the extent possible" [1]

This submission puts forward the case for New Zealand to take a leadership role within the Asia Pacific region by mandating the practicable recovery of methyl bromide used for quarantine and pre-shipment purposes. Such controls have been introduced in many overseas jurisdictions, and indeed have been in place in Nelson, New Zealand for over a year.

While an extremely effective fumigant, when released to the atmosphere, methyl bromide actively contributes to the destruction of the earth's ozone layer. Accordingly, the international agreement to protect the earth's ozone layer (the Montreal Protocol) to which New Zealand is a signatory, has phased out the use of methyl bromide for all uses except quarantine and pre-shipment uses, and a limited number of critical use exemptions. As is widely accepted, there are very few practical alternatives to methyl bromide and the gas is recognised as an essential tool in protecting and maintaining New Zealand's biosecurity.

Further, it is obviously important for New Zealand and its international trade that methyl bromide can continue to be used, in a way that ensures the environmental gains made under the Montreal Protocol can be maintained and progressed, while not jeapodising its workforce and local environmental air quality.

The severe danger to humans of methyl bromide exposure is also widely recognised. Recapture technology ensures that workers who are at risk of being exposed to fumigant gases are given the best available opportunity to work in a safe environment as the danger of toxic emission is greatly reduced.

It is safe to assume that when adequate alternative substances or processes are developed, methyl bromide will be completely phased out, consistent with Montreal Protocol control measures and decisions on QPS MB use. Until this time the challenge is to use methyl bromide responsibly by taking all practicable steps to minimise its release into the atmosphere.

Nations around the globe have already demonstrated that the reduction of emissions of other gases such as fluorocarbon refrigerants can be effectively dealt with by regulation. Nelson, New Zealand, Belgium, Germany and parts of Australia are just a few examples of jurisdictions where there has been widespread use of recapture technology over the last five years. Each of these applications, and others, help to prove that recapture of methyl bromide is a feasible and economically sound option. By adopting recapture technologies, each of these jurisdictions has achieved an effective balance between quarantine requirements, protecting the environment, air quality and occupational health and safety.

Contrary to common thought, a number of alternative technologies for methyl bromide recapture exist around the world, and experience has shown that mandating such a requirement creates the market for this equipment.

Additionally, this submission will put to rest the misconception that large scale recapture is unachievable by reflecting on a number of examples that prove the economic scalability of this technology.

The suggested way forward is to follow the recent example of Belgium by setting a date at which methyl bromide recapture will become mandatory – but doing so progressively, from smaller scale (eg shipping container fumigations) to larger scale applications (eg log stacks under tarpaulin and ship hold fumigations).

Contents

1. Nordiko Quarantine Systems

Nordiko is an Australian company that specialises in providing innovative solutions for the fumigation and gas ventilation industries. With over a decade of experience in this field, Nordiko continues to refine its technology, an example of which can be seen in image 1, and has been able to help many companies and governments around the world to improve their work safety conditions and to take an active step in protecting the ozone layer. This has seen Nordiko collect a number of awards including a 2009 Premier's NSW Export Award, Llloyds DCN Environment and Safety Award and the prestigious US EPA Climate and Stratospheric Ozone Award for 2008. With a strong commitment to responsible practice where fumigation gases (such as methyl bromide) are concerned, Nordiko believes that recapture technology is the solution to fumigant toxicological and environmental concerns and has first hand experience in jurisdictions around the world that have chosen to adopt this technology .

Image 1: Most recent Nordiko filtration module.

2. The OSH Case Supporting Methyl Bromide Recovery

2.1. Exposure Risks

Because of its ability to cause poisonings, neurological damage and reproductive harm, US EPA classifies methyl bromide as a Toxicity Category I compound, the most deadly category of substances. It is commonly known that methyl bromide is toxic to the central nervous system and high levels of exposure can also result in respiratory system failure, as well as specific and severe deleterious actions on the lungs, eyes, and skin. Common initial symptoms after methyl bromide exposure include weakness, despondency, headache, visual disturbances, nausea, and vomiting. Later, central nervous symptoms emerge, including numbness, defective muscular coordination, tremor and muscle spasms, lack of balance, extreme agitation, coma and convulsions. Exposure of pregnant women may result in fetal defects. Depending upon dose, gross permanent disabilities or death may result. Exposed persons have developed respiratory, gastrointestinal, and neurological problems, including inflammation of nerves and organs, and degeneration of eyes. Fumigation related exposures have resulted in significantly higher incidences of throat and eye irritation, skin injuries, shortness of breath, pain in chest, nausea, fatigue, dizziness, numbness, and weakness of extremities. Exposure to high concentrations can and has resulted in a number of human deaths [6], [7].

There is also extensive work being done at Canterbury University, New Zealand, to determine if there is a link between methyl bromide exposure and motor neuron disease. Professor Ian Shaw is confident that early findings of his research support a possible link but there is still a lot of work to be done in this field in order to arrive at conclusive results. The research comes after a number of port workers at Nelson died of motor neuron disease and methyl bromide was suspected, but not proven, as the triggering factor in this case.

The principle of his work is that when cells are exposed to methyl bromide, the gas attacks a protective chemical (glutathione) found inside cells that help to defend against further chemical attack. If this protective chemical is diminished sufficiently, the human cells may be vulnerable to methyl bromide which can react with DNA, proteins or nerve cells which could potentially trigger motor neuron disease. [9]

Even though results are so far still inconclusive, this research clearly presents a solid case that justifies the adoption of responsible fumigation and ventilation practices including the use of recapture technology in order to minimise any risk to vulnerable workers.

Because methyl bromide is colourless, odourless and dissipates rapidly into the atmosphere, workers can be entirely unaware that they are being exposed to the potent neurotoxin. This is particularly applicable to the shipping/cargo industry where a recent study by Professor Xaver Baur (Appendix A) analysed the gas quantities inside 2113 containers imported into the Port of Hamburg. The study revealed that some 70% of containers imported into the port were contaminated with toxic chemicals above chronic reference exposure levels and 36% even exceeded the higher acute reference exposure level thresholds. Where methyl bromide is specifically concerned, traces were discovered in 294 (14%) of the tested containers, some of which exhibited extremely dangerous levels of the fumigant. Graphical representations of these findings are shown below. The findings indicate a concern for the health of dockworkers, container unloaders and by-standers and show that methyl bromide continues to be used all round the world, prompting a need for responsible practice and ventilation technologies at both fumigation sites and at the point of cargo unloading.

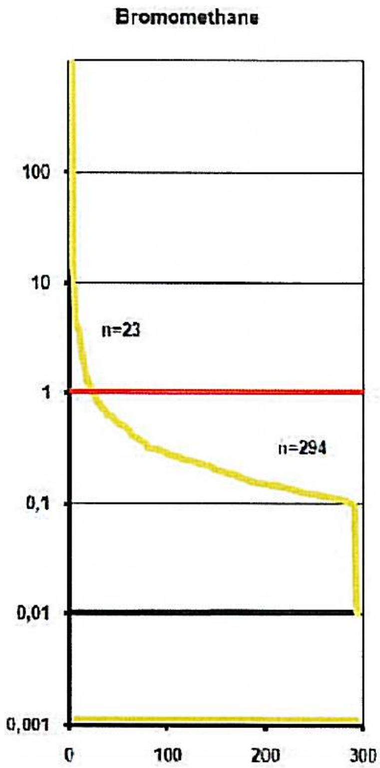
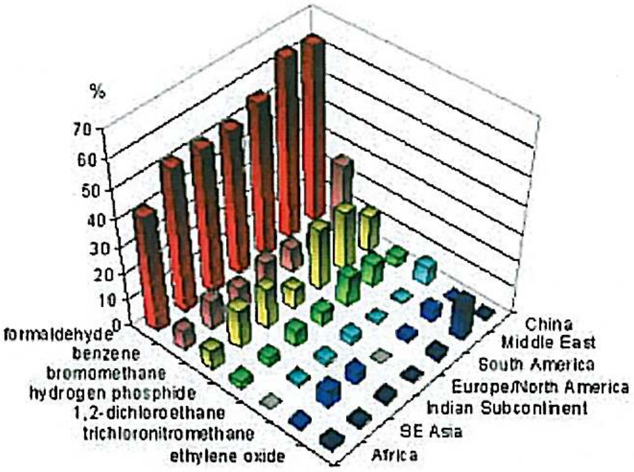
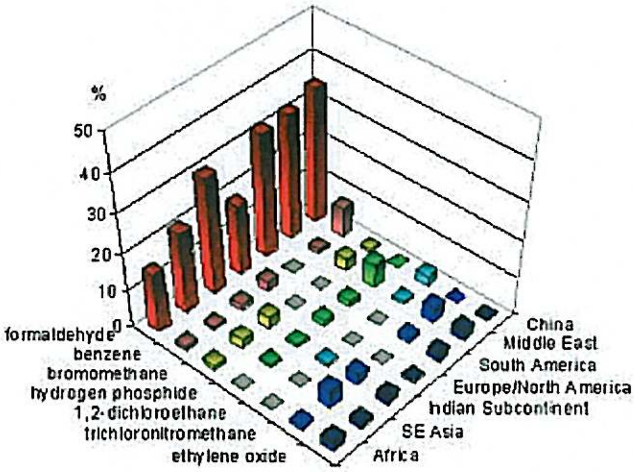


Image 2: Number of containers contaminated with various levels (ppm) of methyl bromide in Port of Hamburg study by Professor Baur.



>chronic RELs
(1478 containers)



>acute RELs
(761 containers)

Image 3: Number of containers contaminated by various other VOC's, many of which can be recaptured using methyl bromide recovery technologies.

This data makes it clear that long term exposure to chronic levels of methyl bromide is a real possibility. Even if New Zealand banned the use of methyl bromide for export cargo and onshore fumigation of imported cargoes, overseas use of methyl bromide would still endanger the health and safety of New Zealand workers unloading containers. An example of exposure to this risk is evidenced by the New Zealand Customs Service, who use Nordiko ventilation and recapture technology in Auckland to protect their container inspection staff.

Picture:: Nordiko Ventilation System at Auckland Customs Site

The work of Suwanlaong and Phanthumchinda [2] (Appendix B) describes a case study of a fumigation worker with a 3-year history of working in a warehouse of imported vegetables that had been fumigated with methyl bromide. Two weeks before admission, the 24-year-old healthy man developed paresthesia of both legs, progressive unstable gait and vertigo. His fourteen co-workers also developed the same symptoms but less in severity. Neurological examination revealed ataxic gait, decreased pain and vibratory sense on both feet, impaired cerebellar signs and hyperactive reflex in all extremities.

The patient was monitored and it was noted that termination of gas exposure resulted in gradual improvement. After a full 3 months, only mild gait imbalance on tandem walking, paresthesia of lower extremities, reduced propioceptive pain, and touch sensation in the feet were detected. MRI of the brain also revealed signs and symptoms of cerebellar and brainstem abnormalities.

It is clear that long term chronic exposure to methyl bromide can be severely detrimental to human health.

The authors also note the acute and chronic exposure incidents reported over the past 10 years and the symptoms experienced by these patients (Table 1).

Whilst there has been no extensive studies done on the risks and outcomes of long term chronic exposure to methyl bromide, evidence suggests that there is a real danger to this type of exposure. In these situations, human health needs to be given the benefit of the doubt until conclusive evidence of the contrary is presented.

Patient no. (Ref)	Sex/Age (yr)	Duration/ Route	Symptoms and signs	Serum bromide level (microgram/ml)	Neuroimaging
1 (3)	M/32	A/D	Dermal burns,vesicles, weakness-brisk deep tendon reflex, paresthesia lower extrimities, Babinski signs, ataxia	12	-
2 (4)	-	A/I	Seizure, fever, multiorgan failure, dead	270	-
3 (5)	F/12		Ataxia, severe action myoclonus, dysarthria	113.0	-
4 (8)	M/39	A/I	Dizziness, vomiting, myoclonus, akinetic mutism	72.9	-
5 (8)	F/34	A/I	Dizziness, vomiting, myoclonus, akinetic mutism, derilium, convulsion, behavioral changes	67.8	-
6 (8)	F/5	A/I	Dizziness, vomiting, myoclonus, convulsion	91.5	CT - enlarged sulci, cerebral atrophy
7 (14)	M/30	A/I	Paresthesia feet, unstable gait, blephaloptosis	43.7	MRI - high SI at putamen, subthalamic nuclei, dorsal medulla oblongata, inferior colliculi, periaqueductal gray
8 (15)	M/30	C/I	Ataxia, acral paresthesias, vertigo, horizontal diplopia, pain-vibratory sense loss, absent ankle reflexes	29	MRI - high SI on T2 and FLAIR in dentate nuclei, periaqueductal grey, dorsal midbrain, pons, inferior olives
9 (16)	M/31	C/I	Dizziness, vomiting, walking difficulty, urinary incontinence, paresthesia extremitie simpaired comprehension of language	-	MRI - high SI on T2 at splenium of corpus callosum
10 (16)	M/32	C/I	Dizziness, vomiting, headache, dysarthria, confusion, seizure	-	MRI - bilateral symmetric high SI on T2 in splenium of corpus callusum, globus pallidus, periaqueductal grey, pontine tegmentum, dentate nuclei, medulla oblongata
11 (28)	M/45	C/I	Visual disturbance, dysarthria, decreased muscle strength, gait disturbance, erectile dysfunction	11.2	-
12 (present case)	M/24	C/I	Vertigo, cerebellar ataxia, paresthesia, spasticity all extrimities	8.18	MRI - High SI T2wI FLAIR bilateral arcuate-dentate nuclei, periventricular of 4th ventricle, inferior olivary nuclei, periaquiductal grey, superior-inferior colliculi

A = acute, C = chronic, I = inhalation, D = dermal exposure, M = male, F = female, Ref = reference

Table 1: An overview of methyl bromide acute and chronic exposure incidents and the symptoms experienced by the patient.

2.2. Plume Model Study

Plume models are an accurate method used to determine the direct risk to fumigation and dock workers as well as the surrounding community. Images 4, 5 and 6 present a plume model for Wellington (container fumigations), Tauranga (log stack fumigations) and Auckland (container fumigations) respectively. The Wellington plot assumes containers are fumigated under gas-proof sheets with 30% of the added fumigant remaining at the end of exposure with most released over five minutes during ventilation at the end of the fumigation. The scenario modeled assumes 3 or 6 containers are opened every fifteen minutes which equates to 9.5 and 19 grams per second respectively for a five minute release. A full list of weather conditions and assumptions for this plot can be found in Appendix C. As can be seen, the plot shows the expected concentration gradients (ppm) if wind prevails from one direction.

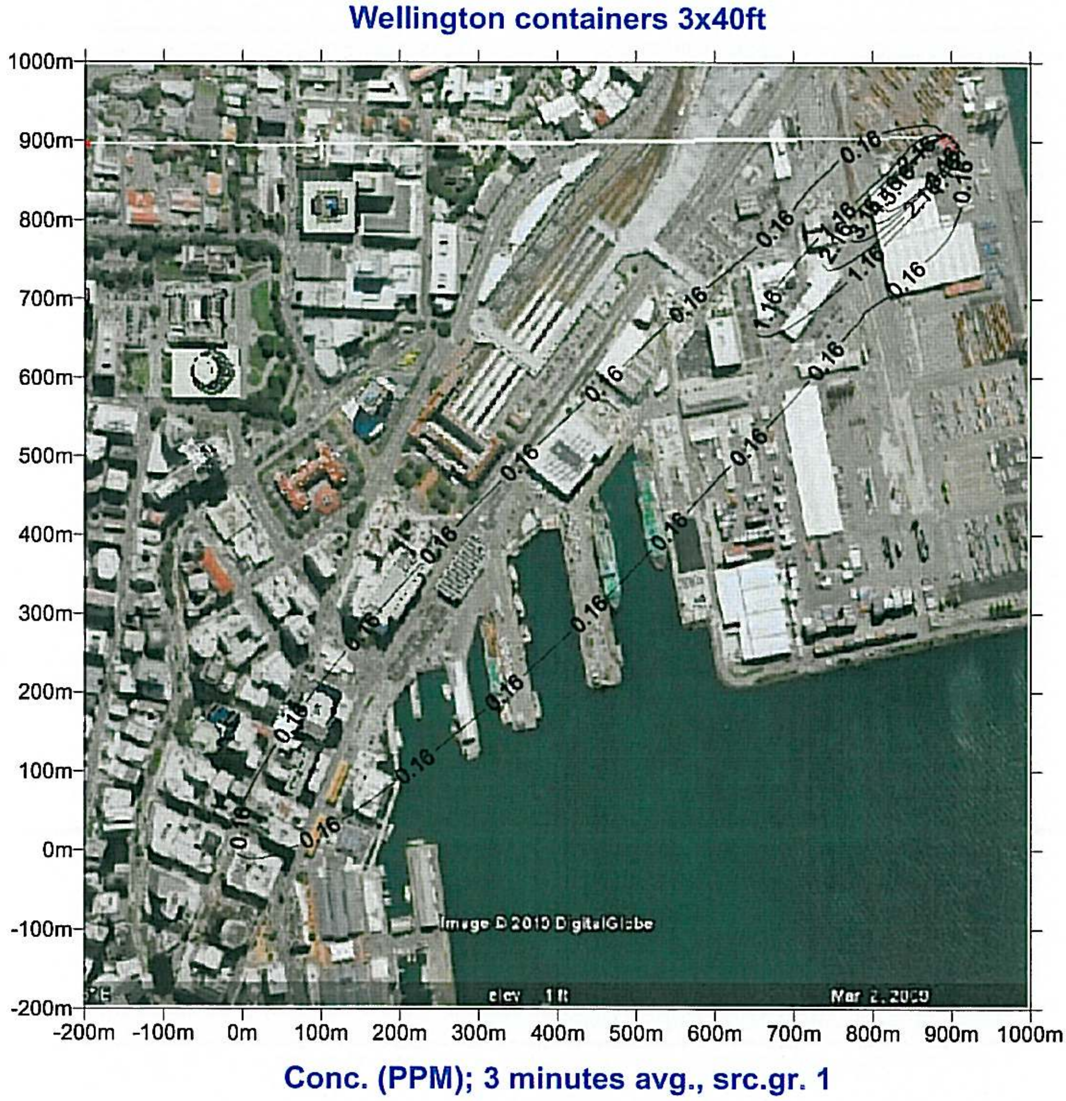


Image 4: Plume model for methyl bromide release at Wellington.

The Tauranga plot assumes log stacks are fumigated under gas-proof sheets with 30% of the added fumigant remaining at the end of exposure with most released over five minutes during ventilation at the end of the fumigation when tarps are removed. This means that with 100kg of methyl bromide added 30kg remains to be released at the end of the fumigation over about five minutes or 100 grams per second for a five minute release. A full list of weather conditions and assumptions for this plot can be found in Appendix D. As can be seen, the plot shows the expected concentration gradients (ppm) if wind prevails from one direction.

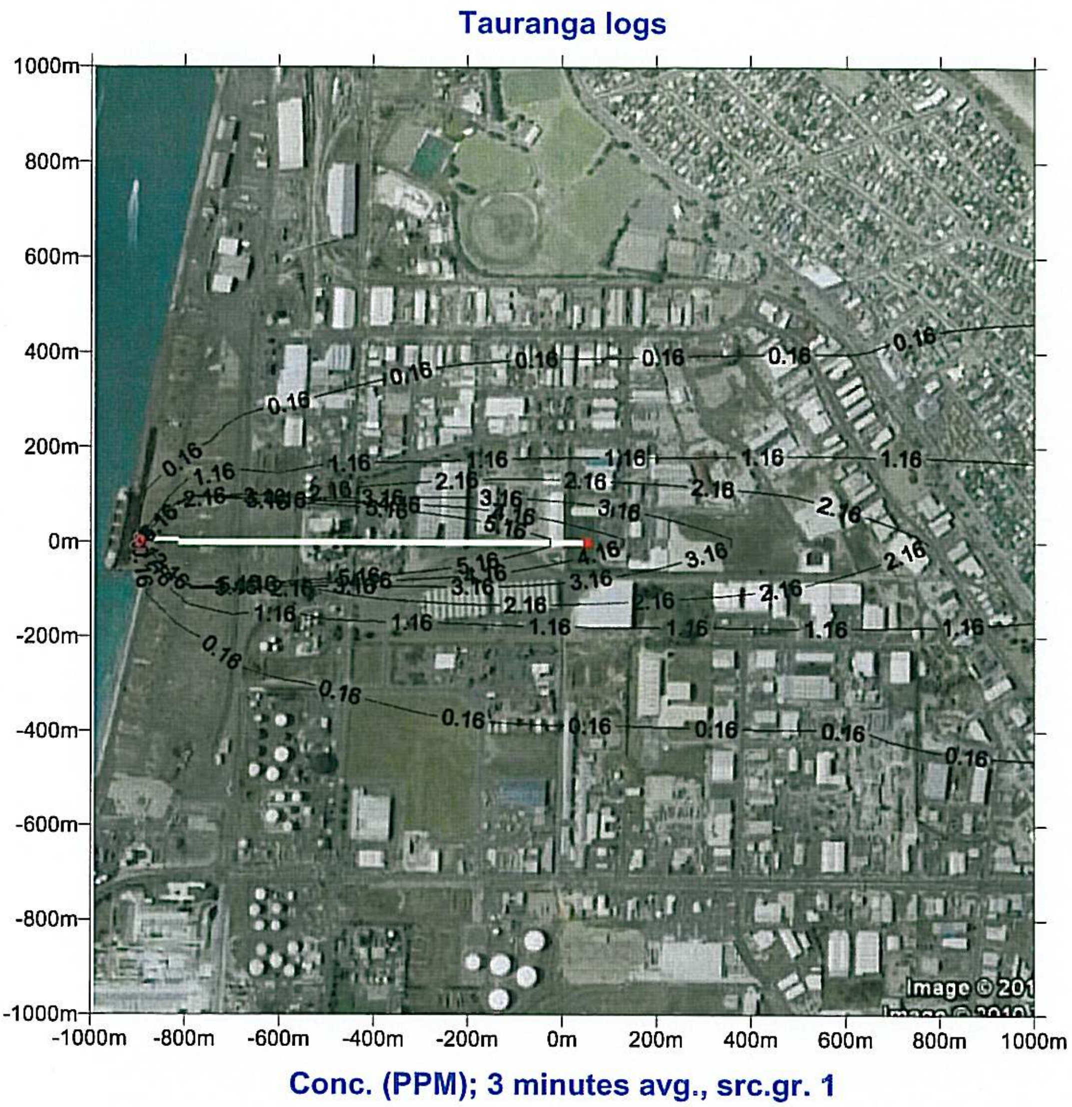


Image 5: Plume model for methyl bromide release at Tauranga.

The Auckland plot assumes containers are fumigated under gas-proof sheets with 30% of the added fumigant released over five minutes during ventilation at the end of the fumigation. Two scenarios are modeled, three and six 40ft containers. The ventilation time is between 8 am and 6 pm which are typical release times during a fumigation schedule over a week. A full list of weather conditions and assumptions can be found in Appendix E. As above, this plot shows the expected concentration gradient from the scenario described.

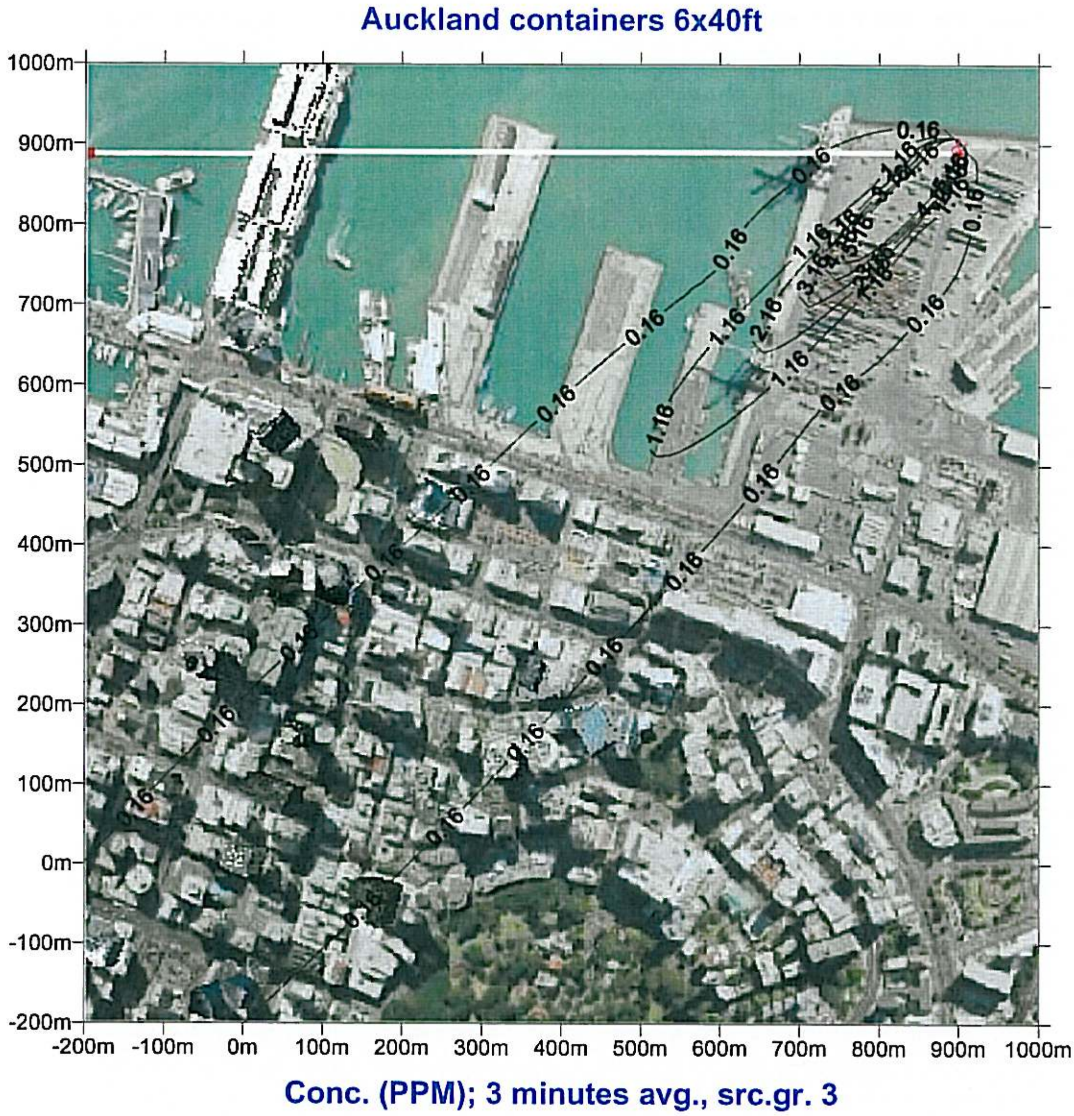


Image 6: Plume model for methyl bromide release at Auckland.

These plots clearly show the often unrecognised risk posed to the wider community from fumigations using methyl bromide. Whilst these plots include concentration profiles down to 0.16ppm, it can be noted that much more potentially harmful concentrations (1-3ppm) are similarly wide spread across the community and this should be closely considered when reviewing the reclassification of methyl bromide.

In contrast to the plots above, Images 7, 8 and 9 on Appendix N, show plume models of scenarios where recapture technology is adopted for Wellington, Tauranga and Auckland respectively. As above, a full list of weather conditions and assumptions can be found in Appendices C, D and E. As can be seen, recapture technology ensures that health risks presented by fumigant gas emissions are minimised.

2.3 Modeling Vs Measurement of Plumes Resulting from Fumigant Ventilation

Fumigators are familiar with measuring fumigation concentrations within fumigation enclosures and ensuring concentrations do not exceed workspace levels outside the placarded risk area. They are less equipped to assess the impact of emissions and resulting plumes downwind during ventilation when the residual fumigant is released into the atmosphere at the end of fumigation. This results from two factors, the random nature of prevailing weather conditions at the time of ventilation which leads to an uncertainty as to where the centre of the plume is at any time and the lower permissible concentration that is often scheduled in environmental legislation which make accurate and repeated measurement difficult. So how can fumigators assess the impact of their business activities on the environment in the most cost effective and environmentally responsible way?

Two options are traditionally available. The first is direct measurement downwind of a release to assess whether concentrations of concern are being generated and the second is modeling of plumes resulting from emissions based on release rates, weather and terrain. Both have their place and are often used together for large industrial emitters of pollutants to manage emission levels and validate compliance. Industrial emissions are often assessed at the boundary of the site and are continuously measured by a suitably sensitive and accurate analytical method with strict protocols to follow if the permissible concentration is exceeded. For example a large mining concern in Australia is currently assessing an issue where some of the monitors recorded concentrations of lead that exceeded permissible limits. However, measurement at the boundary is only effective if the plume passes through one of the sampling points and has no responsibility for effects off-site that can trap and recirculate plumes.

Measurement also requires an approved analytical method that will measure the emission of interest at the regulatory level. For many pollutants of interest this is not available unless very expensive methods such as mass spectrometry, gas chromatography, NIR spectroscopy and the like which require trained staff to operate and interpret the output. This approach applies well to large industrial polluters where the costs of measurement can easily be absorbed into the costs of doing business. Often it is used to validate compliance with a permit to pollute which has previously been modeled. For fumigators measuring fumigants at or below permissible environmental levels during the short periods of ventilation together with the challenges of sampling make the problem of measurement even more difficult. With the vagaries of weather where is the plume now? Where to measure? The boundary, or further downwind? How often? How do you interpret the data? What do you do if any concentration measured exceeds the permissible concentration?

The second option is to model known emissions using air pollution modeling software. For fumigators this can be more attractive as the inputs can be assessed and validated more easily. For example the treatment rate is known the final concentration can easily be measured giving a solid estimate of the starting conditions of the ventilation and the release rate in say grams per second can be estimated.

Dispersion modeling has been a requirement of air quality regulatory agencies for over 20 years and the task of performing this modeling has shifted to the applicant. The purpose of modeling is to show that air quality standards or air toxic guidelines will not be exceeded when a proposed modification is implemented or a new facility constructed. The role of modeling is to reliably estimate the maximum concentrations likely to occur beyond the boundary of the facility at any given time when the pollutant is being emitted.

Modeling is often a one off cost at the time of seeking a permit to carry on a business where a proscribed emission or odour needs to be assessed. A fundamental question on modeling has to do with its purpose, a frequently overlooked subject. Is the purpose of modeling to replicate reality in space and time with confidence or is it simply a screening tool that provides a yes/no answer to a permit applicant? The power of modeling should be predicated on its ability to forecast the magnitude of the maximum likely concentrations occurring sometime, somewhere.

A second issue is to define a "level of significance" or the proscribed permissible ground level concentration. If modeled concentrations fall below this level then the emission can be considered trivial. Modeling is a very efficient way to show what effect changes in emission rates have for particular ventilation parameters i.e. will a planned mediation work.

Models often used include the following.

AUSPLUME is an Australian standard air dispersion model for modeling basic air emissions. Ausplume is excellent for screening applications and is used extensively for straightforward applications. Its inputs include release rate data; meteorological conditions such as temperature, wind speed and direction, stability classes and mixing heights. As a steady-state Gaussian plume model it has some limitations that need to be seriously considered in any modeling application where non steady state conditions are a significant feature.

CALPUFF is an advanced non-steady state meteorological and air quality modeling system used especially for complex terrain and meteorology. The meteorological module is known as CALMET. Used widely in the USA

TAPM a 3-dimensional prognostic meteorological model and dispersion model that includes basic photochemistry capabilities, developed by the CSIRO (Australia).

As the complexity of the model increases more care and understanding of the input meteorology, terrain and building downwash issues need to be considered. Building wake effects are said to be the cause of worst-case concentrations in well over 90 percent of modeling and most regulatory models contain a well-verified building wake algorithm. Comparison with more complex models such as TAPM show that Ausplume can under estimates ground level concentrations particularly near the coast were sea breeze effects can cause fumigation by constricting the plume. Building wake downwash has the effect of bringing elevated plumes to the ground more quickly. But for short range ground level dispersion, such as fumigant release, simple Gaussian dispersion as offered by Ausplume should be sufficient to estimate ground level concentrations downwind of the release.

Measurement pros and cons.	
Pro	Con
Specific to the target emission	Some analytical processes not specific
Shows actual concentration at point sampled	Multiple sample points required to give good coverage of plumes.
When used effectively provides validation for safe levels of industrial emissions	Can be very expensive to achieve effective sampling density.
	Requires highly trained personnel to conduct analysis and interpret data gathered.
	Samples taken for analysis may not be representative of actual concentration(sampling error)
	May require to be continuous to ensure compliance

Modeling Pros and cons	
Pro	Con
Generic to all emissions	Modeled concentration not actual concentrations i.e. requires a level of confidence in model assumptions
Emission inputs easily assessed	Requires extensive validation to gain confidence in mathematical assumptions
Results available immediately	
Risky scenarios can be modeled without environmental effects.	Requires highly trained personnel to set up model and interpret output.
Mediation can be modeled before implementation	Input data may not be adequate to the modeled scenario
Backed by sound scientific principles both chemical and physical	

2.4. Skin Cancer Prevalence

It can be predicted that recapturing or immediately stopping the use of ozone depleting substances (ODP's) such as methyl bromide will see the ozone layer regenerate. Of all the Ozone Deleting Substances (ODS's) methyl bromide recapture provides one of the most immediate means to positively impact on stratospheric ozone regeneration, due to the relatively short time frame for the impact of methyl bromide on the ozone layer. Whereas a reduction in emissions of other gases such as CFC's and HCFC's can take decades to have a positive impact, the shorter half-life of methyl bromide means that reduced emissions of this gas creates benefits in 6-12 months. With every year that the industry is entitled to the continual emission of methyl bromide, this process slows even further. One of the major concerns related to the thinning of the ozone layer is the increased exposure to UV radiation which can lead to skin cancers and other illnesses such as eye diseases.

According to Te Ara Encyclopedia of New Zealand, New Zealand's summertime ozone has decreased by about 10% since 1970. [3] The same source also explains the following;

"Decreased ozone can have serious environmental impacts by increasing UV radiation at the ground. In humans, this causes eye damage (cataracts) and skin damage (sunburn and skin cancer). It has been calculated that for each 1% reduction in ozone there is an increase in UV radiation of about 1.2%, which could lead to a 2% increase in skin cancers. It also harms plants and animals, and damages materials such as plastics and paints."

"New Zealand's death rate from skin cancer is about 300 per year, the highest in the world relative to population (and over half that from road accidents). This is due to the relatively high UV exposures and the high number of fair-skinned people. Peak UV intensities in New Zealand are about 40% greater than at comparable latitudes in Europe."

"Living in what has been called the melanoma capital of the world; Aucklanders face a 5.7% chance of developing skin cancer. Although the city's climate encourages outdoor activities, in summer UV intensities are high due to the low ozone and clean air, and because the earth is closer to the sun."

The improvement in OSH standards that could be obtained following adoption of recapture technology is obvious. The technology will help to avoid short and long term exposure as well as ensuring that the local community is safe from low concentration exposure. The repair of the ozone layer will also ensure a lower rate of skin cancer incidents.

Image 10: Typical skin melanoma. [10]

3. The Environmental Case Supporting Methyl Bromide Recovery

3.1. Ozone Layer Protection

It is commonly known that methyl bromide is an ozone depleting substance. In fact, bromine is 50-60 times more effective than chlorine in causing ozone depletion. Methyl bromide also has an impact on the bromine loading in the troposphere in a relatively short time frame – of the order of 6 months – compared with decades for some other Ozone Depleting Substances. (Banks 2006)

As can be seen in image 11, UV radiation acts to break down methyl bromide which results in the formation of a destructive bromine radical. This will result in excess UV radiation penetrating the Earth's atmosphere which is harmful to plants and animals. The shorter wavelengths, mainly UV-B, are known to harm the biological and chemical processes of myriad living organisms. Zooplankton and phytoplankton, the foundation of the ocean food chain, lack protection from UV-B radiation and thus are particularly sensitive to the effects of ozone depletion. UV-B radiation can adversely affect the early developmental stages of aquatic organisms, decrease reproductive capacity and impair larval development.

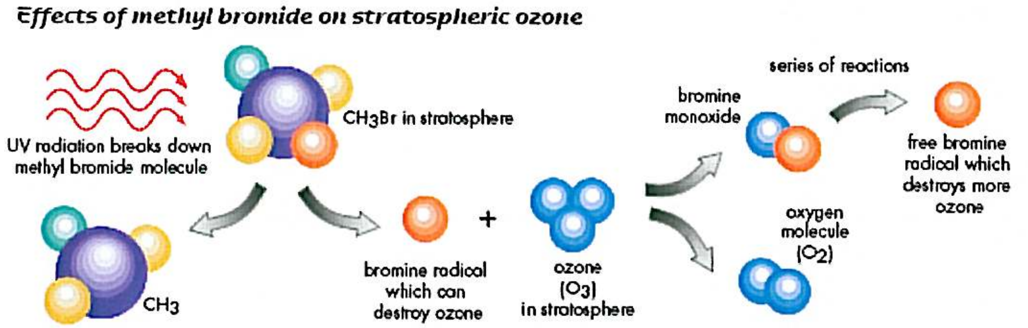


Image 11: The chemistry of methyl bromide in the atmosphere as it acts to destroy the ozone layer.

Studies of plant species – including trees and agricultural crops – show that some are sensitive to increased UV radiation levels, which can result in reduced plant height, changes in tissue composition and reductions in foliage area. Such changes have serious implications for biodiversity and agricultural productivity.

In the absence of a valid replacement for methyl bromide, the only way to protect the ozone layer from destruction by methyl bromide is to recapture, thus preventing it from being released into the atmosphere. By adopting this responsible use of methyl bromide, it will allow this very efficient gas to continue to be used in the interim period, until a real alternative to methyl bromide is found.

In Australia, recent figures obtained from the Department of the Environment and Heritage reveal that QPS consumption has increased since 2004, after a steady decline during the years 2000-2004. This increase is mainly attributable to the increases in trade and biosecurity measures required to protect Australian industries.

3.2. Waste Disposal Options

One of the stages of the recapture process is the management of filter mediums that have been saturated with methyl bromide. It is important to ensure that this is completed in an environmentally friendly manner.

There is never one solution to waste management concerns in any industry and fumigant recapture is no different. The exact technique adopted depends on local and national jurisdictions and guidelines and currently the various management methods include landfill, chemical treatments and high temperature incinerations. It should also be noted that there are new technologies emerging that apply to this field including Plasma Arc Destruction which is an accredited halon destruction method and will be discussed briefly in this section.

There are currently a number of jurisdictions (e.g. New South Wales, Australia and Port of Nelson, New Zealand) that dispose of contaminated carbon in landfill. The carbon is shut in a waste specific sack or a water tight drum that is buried in specific landfill sites. Where ground water contamination and is concerned, there has been sufficient work done to show that both the relatively short half life and the interactions of methyl bromide with soil bacteria ensure that this environmental issues can be avoided. The work of Gan and Yates [4] helped to show that;

"In soil, chemical reactions, likely nucleophilic substitutions on soil organic matter, were identified as the predominate pathway through which methyl bromide was degraded. For example, methyl bromide reacts rapidly with aniline (a model used to simulate reactions with organic matter in soil) compared to direct hydrolysis with water; the degradation half-life of methyl bromide with water and aniline are 20 days and 2.9 days at 24 deg C, respectively."

With this in mind and with the correct precautions taken, land filling of methyl bromide contaminated carbon proves to be an environmentally sound method of waste management after recapture technology is adopted.

Another method of waste management is chemical treatment of saturated carbon with a solution of sodium thiosulfate. There are a number of advantages to chemical treatment including the forced production of non-toxic salts and the availability to reuse treated carbon. A cost efficient central treatment facility can be adopted to carry out the following reaction;

$$CH_3Br + Na_2S_2O_3 \rightarrow NaCH_3S_2O_3 + Na^+ + Br^-$$

The products of this reaction (sodium methyl thiosulfate and sodium bromide) were tested and determined to be non toxic according to waste water guidelines in California. The full report that arrives at this conclusion and shows that chemically treated methyl bromide can be safely disposed of can be found in Appendix G.

As mentioned previously, Plasma Arc Destruction is a relatively new and extremely efficient method of dealing with ozone depleting substances as waste products. The Plascon® process utilises a compact plasma torch that acts to pyrolise high concentrations of dangerous and toxic gases. This method has proven to be >99.9999% efficient in destroying many halons to date and the exact science of the process can be found in Appendix H. Whilst there is no current application of this technology directly with methyl bromide, it can be noted that UNEP has recognised Plascon® as an appropriate method of dealing with waste halons [5] and estimates it's cost at around US$3-4/kg of methyl bromide (NOTE: this is not per kg of carbon). This is an incredibly competitive price where waste management is concerned. It should be noted that there are plascon facilities currently in action around the world including installations in Australia, USA, Japan and Mexico.

An added advantage of Plascon® destruction will be the potential to recycle activated carbon after methyl bromide has been desorbed for destruction and this will act to drastically decrease the overall cost of recapture technology. It should also be noted that Plascon® will involve a central treatment plant (seen below) that can be justified by a large supply of halon waste that will no doubt be brought about by any decision to mandate the recapture of methyl bromide for QPS use in New Zealand.

Image 12: Electric Arc Plasma treatment facility.

4. The Economic Case Supporting Methyl Bromide Recovery

4.1. Direct Costs

There are many current applications of recapture technology that can be cited to determine the approximate cost of the equipment per fumigation. This section will utilise data from numerous sites as well as estimates for future sites and take into account not only the estimated capital costs required for the installation of recovery technology but also the expenses involved in carbon replacement, disposal and transport, as well as labor and power. The variation in value and availability (carbon disposal method) of each of these factors across different jurisdictions explains the variation in total estimated costs as seen below. It should be noted that these estimations are calculated on a lease based agreement of equipment that has an estimated life time of five years. Obviously greater care/lower use environments will ensure longer lifetimes of the equipment which will decrease the estimated cost per fumigation. It is important to realise that these estimations provide the *additional* cost only for recapture technology. That is, these reasonable values must be added to the cost of a regular fumigation that does not utilise the recapture equipment. It should also be noted that a number of these estimations assume a 10% loading factor of the carbon filter. In reality, greater loading efficiencies (up to 20% in some cases) and hence more cost efficient filters can be achieved depending on atmospheric temperatures and relative humidity's.

As can be seen in the Table below, the estimates provided in the original submission by STMBR are unreasonable with the major differences coming in the capital cost of equipment and the cost for replacing and managing waste carbon (Table below). Also, we believe that Option 4, will still have a methyl bromide cost due to inefficiencies in recycling

	Option 1 Vent	Option 2 Adsorb and Landfill	Option 3 Adsorb and Destroy	Option 4 Adsorb and Recycle
Estimated Operating Costs ($/y)				
Methyl Bromide	57,500	57,500	57,500	-
Sodium Thiosulfate			99,150	
Steam				15,000
Electricity	1,000	4,000	6,000	4,000
Labour	30,000	60,000	120,000	120,000
Makeup Carbon	2,000	200,000	2,000	2,000
Capital Charges	3,000	66,000	105,000	360,000
Total ($/y)	**93,500**	**387,500**	**389,650**	**501,000**
Specific Cost (NZ$/kg MeBr used)	**18.7**	**77.5**	**77.9**	**100.2**
Specific Cost (NZ$/container)	**94**	**388**	**390**	**501**

Table Showing Original Costing Submission by STIMBR

Cost Estimates at Various Locations

For a more detailed break down of actual cost estimation refer to Appendix I.

Port of Nelson Containers and Under-tarp Fumigations

The table below provides cost estimates for the adopted recapture technology in Port of Nelson, New Zealand. This estimation takes into account 50:50 ratio of $33m^3$ and $66m^3$ containers and a dosage rate of $48g/m^3$ for 75% of the fumigations and $56g/m^3$ for the remaining fumigations (Based on weather/temperature estimates). The facility at Port of Nelson manages its waste carbon by landfill and a more precise breakdown of the cost analysis is outlines in Appendix I.

	Under tarp (400m3)	Container (33m3 and 66m3)
Cost Per Fumigation	$291	$68

Table 2: Estimation for current application of recapture technology in Port of Nelson, New Zealand.

N.S.W. Large Scale Rice Fumigations

A current client in NSW has adopted the Nordiko System for large scale fumigation of rice stocks. The fumigations take place in vessels that are $300m^3$ and $400m^3$ in size and waste carbon is managed using treatment with sodium thiosulfate and subsequent landfill which has been approved by the local ruling body. Using thiosulfate treatment, carbon can be reused approximately four times and this is considered in the cost analysis outlined in Appendix I.

It has been estimated that the cost per fumigation for this application of recapture technology is $328 per fumigation (based on a reasonable average of four fumigations per week).

Belgium Container Fumigations

The table below provides estimates for a current client in Belgium who has adopted the use of recapture technology. It is known that the cost per fumigation will vary greatly according to the loading capacity of the carbon (which is impacted by temperature/weather) and hence the values provided below compare 1:10 and 1:5 carbon loading ratios. The client has however reported loading efficiencies of up to 1:3 at times which would drop the cost per fumigation to even lower amounts. See Appendix I for a detailed overview of these estimations.

MeBr:Carbon Loading efficiency	1kg MeBr : 10kg Carbon	1kg MeBr : 5kg Carbon
Cost Per Container Fumigation	€ 55	€ 44

Table 3: Estimations for recapture technology for a current client in Belgium.

Hong Kong Container Fumigations

The Environment Protection Department in Hong Kong recently commissioned an assessment of methyl bromide recapture technology. The table below provides annual cost estimates for adopting recapture technology for methyl bromide fumigations (at a dosage rate of $96g/m^3$) of standard 20ft containers. Note that a 10% carbon loading efficiency is assumed. Additionally, it should be noted that under Hong Kong jurisdiction, the method of waste management selected in the cost model is by Plascon Destruction. See Appendix I for a detailed overview.

Number of Fumigations	15,000
Cost per Fumigation	US$41

Table 4: Estimation for recapture technology for container fumigations in Hong Kong.

U.S.A. Large Scale Under-tarp Fumigations

The following table provides annual estimates for adopting recapture technology for methyl bromide fumigations of soft and hardwood (dosage rates of 48g/m^3 and 240g/m^3 respectively) in under-tarpaulin environments of approximately 1100m^3. Under this particular jurisdiction, landfill and high temperature incineration are viable methods of waste disposal and hence they are compared below. An estimated 65 fumigations per year are assumed for this estimation and weather conditions at this particular site could see carbon loading efficiencies improve to around 20%. See Appendix I for a detailed analysis of these estimations.

	10% Carbon Loading	20% Carbon Loading
Cost per Fumigation (landfill as disposal method)	$2,402	$1,442
Cost per Fumigation (incineration as disposal method)	$2,628	$1,565

Table 5: Comparison of estimations for under-tarp large scale fumigations for hard/soft wood in U.S.A.

Australian Large Scale (eg 8000m3) Fumigation

The table below provides estimations for large scale recapture systems that are capable of treating fumigation volumes up to 8000m3. The dosage rate is 48g/m^3 and landfill is provided as the method of disposal. Again, variations in carbon loading efficiency and other factors will impact on the exact cost. Obviously, with increased usage, the cost per fumigation will drop and the estimated use of the system has been chosen to model a system used for house fumigations (5 fumigations per year) and for industrial applications such as log stacks (50 fumigations per year). Systems of this scale are currently being utilised and the prime example is the recent Western Australia house fumigation unit as described in section 6 below.

Fumigations Per Year	5	50
Cost Per Fumigation	$4,653	$2,043

Table 6: Estimations for recapture technology to be applied on a large scale.

4.2. Savings from Product Throughput

Recapture technology also provides a notable advantage when it comes to evacuation/ventilation times required to clear methyl bromide within the fumigated region to below accepted exposure limits. Rapid clearance of gas from shipping containers, typically well under 1 hour, to a safe level can be achieved with recapture technology. As is commonly accepted, this process can take upwards of 48 hours when open door ventilation is adopted. With rapid gas clearance comes the potential for much faster turnaround of containers and more efficient use of the limited port/depot space available at many sites. Whilst these benefits are difficult to quantify, they are definitely tangible offsets to the small cost surcharge which necessarily applies when recapture equipment is supplied.

The following plots help to outline the rapid evacuation times that can be possible when adopting recovery technology.

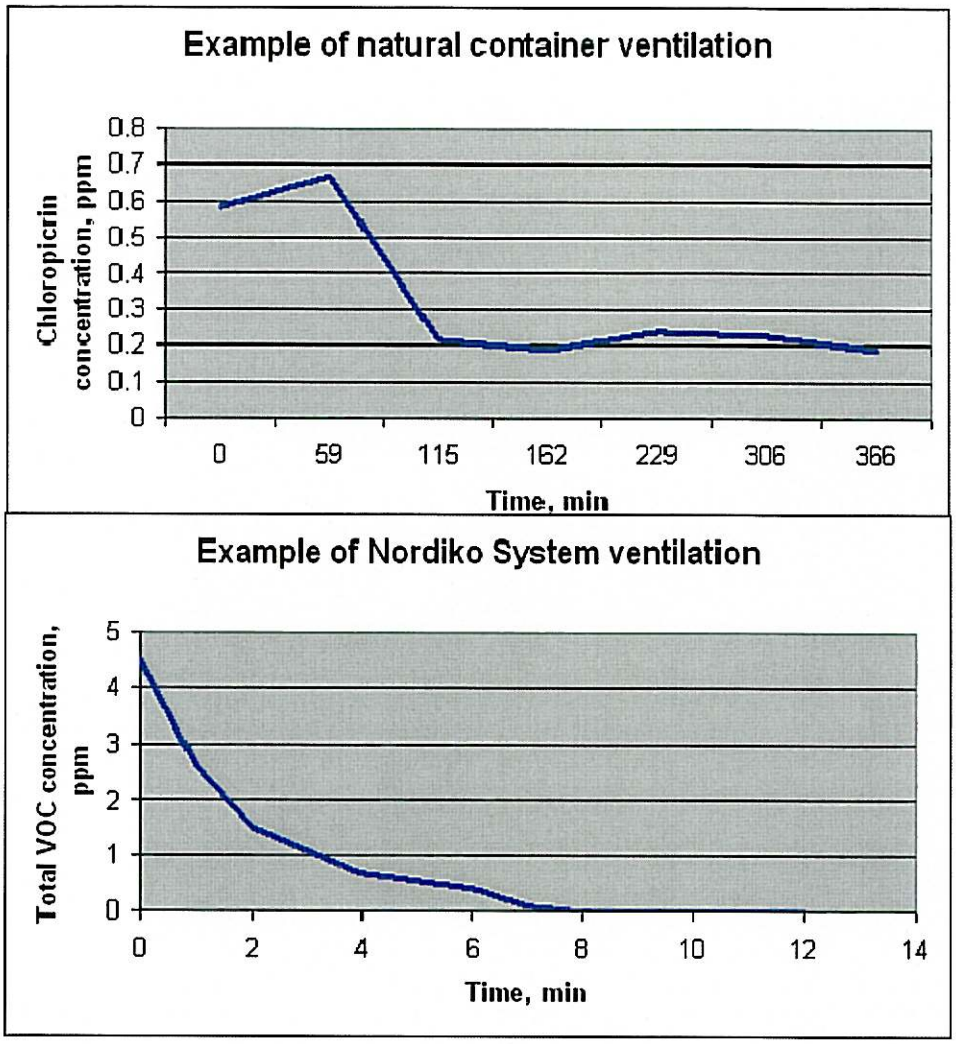


Image 13: These plots help to compare open-door ventilation to recapture ventilation times. The first plot shows the time taken to ventilate chloropicrin (TWA of 0.1ppm) using open-door ventilation. The second plot shows a typical plot of the concentration of all VOC's (includes chloropicrin) during a Nordiko assisted ventilation.

It is important to note that although the graphs above show a reducing trend line, there is a tendency for fumigants to desorb from commodities after the evacuation/ventilation procedure at a rate dependant on ambient temperature, relative humidity and the type of commodity. This is due to the properties of methyl bromide and its tendency to be adsorbed into the commodity during fumigation.

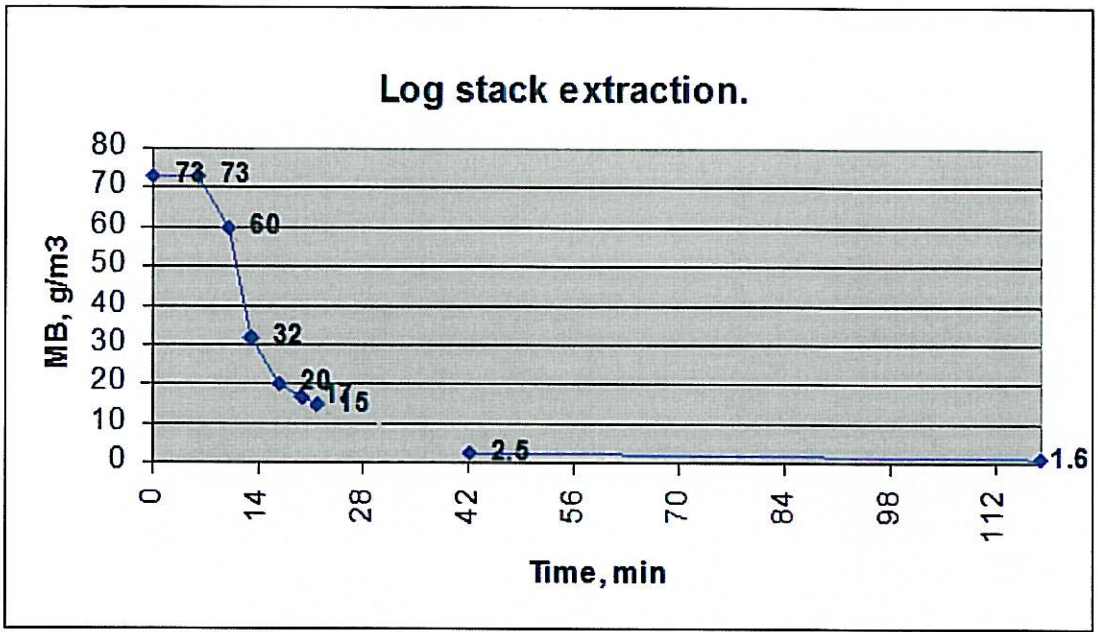


Image 14: A typical plot of methyl bromide over time when a Nordiko system is adopted.

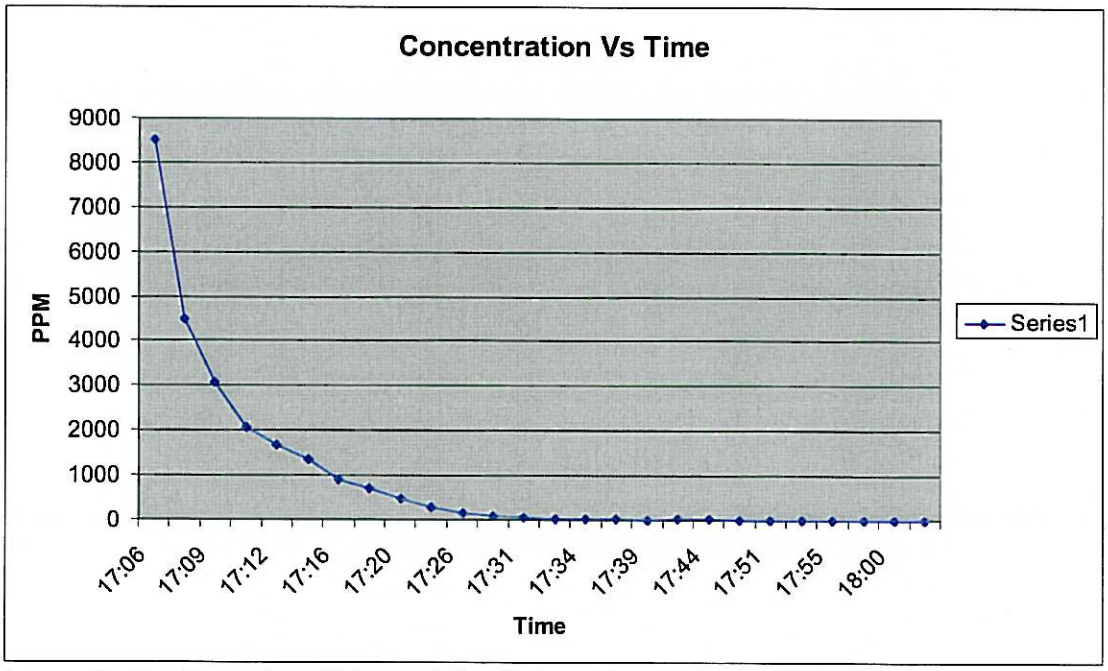


Image 15: The degassing efficiency of Nordiko's system as observed at a demonstration in Hong Kong.

5. The Ongoing Need for Methyl Bromide

5.1 The Montreal Protocol and Methyl Bromide Use

The Montreal Protocol is recognised as one of the most successful global environmental treaties in the world.

Established in 1987, the Protocol set out to initially limit then phase out the production and consumption of substances known to deplete the ozone layer, with potentially disastrous consequences for life on earth.

Methyl bromide was added to the list of substances to be phased out under the Protocol in the 1990s, and in 2005 its use was phased out in all applications except for quarantine and pre-shipment and feedstock purposes, as well as a small number of UN-approved 'critical uses'.

Quarantine and pre-shipment uses are strictly controlled, and must be authorised by the appropriate authorities. In Australia the Ozone Protection and Synthetic Greenhouse Gas Management Regulations 1995 state that methyl bromide is used for quarantine and pre-shipment purposes:

- If it is applied by, or with the authorisation of, a Commonwealth, State or Territory authority to prevent the introduction, establishment or spread of a pest or disease in Australia, a state or territory or
- If it is applied to a commodity before it is exported to meet the requirements of the importing country or a law of the Commonwealth.

Growth in world economies has seen a steady increase in the amount of methyl bromide used for these purposes. This trend is concerning, and requires an effective policy response to ensure that gains in minimising the emissions of ozone-depleting substances are not compromised.

This submission puts forward a practical and economic proposal to minimise the emissions of methyl bromide in quarantine and pre-shipment applications.

5.2 Alternatives to Methyl Bromide

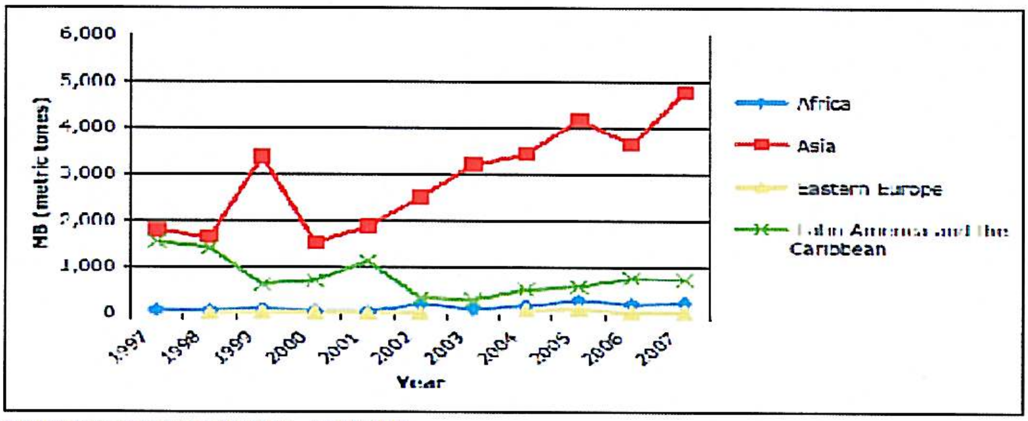
Parties to the Montreal Protocol agree that, in the absence of a suitable alternative, there is a need for the continued use of methyl bromide in areas such as quarantine and pre-shipment (QPS) and certain critical use exemptions (CUE).

In the case of quarantine there is a need for a fumigant gas which is capable of killing all life stages of arthropods, fungal spores, seeds, plant and animal pathogens etc. For quarantine purposes this treatment must be fast (i.e. 24 hours), due to the need for a quick turnaround on the wharf or at depots. One of the alternatives to methyl bromide, phosphine, takes 7 to 10 days for treatment and is subject to tolerance by some insects, together with being very unstable and flammable which poses a great risk to certain applications such as in-transit use, for example in ships. Another chemical, sulfuryl fluoride doesn't kill all life stages of insects and has a very high Global Warming Potential (GWP 4800).

Other alternatives that are in existence do not have the broad range of treatment exhibited by methyl bromide, for example ethyl formate. Whilst certain chemical alternatives under review such as, ethanedinitrile (EDN) and carbonyl sulphide have yet to be field tested and registered, which may take a considerable amount of time. Other treatment alternatives, such as heat treatment are only viable for certain applications and do not have the ease of application as methyl bromide. In addition, the Methyl Bromide Technical Options Committee (MBTOC) had not identified available and technically effective alternatives for many products and components, thereby necessitating an ongoing use of methyl bromide for post-harvest applications.

5.3 Increasing Use of Methyl Bromide in Quarantine and Pre-shipment

Methyl bromide usage for Quarantine and Preshipment applications is increasing. The latest progress report released by the Technology & Economic Assessment Panel (TEAP) provides a comprehensive summary on the international usage of methyl bromide. The global consumption of methyl bromide for QPS has been steady at around 11,000 metric tonnes, with A5 countries (Emerging Economies) show an increase in their consumption while non-A5 countries (Developed Countries) experience a decrease in consumption. USA is still the major user of methyl bromide for QPS (27% of global usage), followed by China (17%) and Japan (10%). European Community has significantly reduced their QPS usage. Other countries, including Australia and New Zealand have been keeping their consumption below 500 metric tonnes. Note that China is still a member of Article 5 countries The graph below summarises regional QPS consumption for A5 parties.



Source: Ozone Secretariat Data. April 2009

6. Exposure to Residual Methyl Bromide

Residues of pesticide fumigants, including methyl bromide and toxic industrial chemicals in freight containers represent a health hazard to employees and consumers, especially since freight containers are sealed for transport and distributed widely throughout the importing countries before being opened for unloading. Studies have shown that over 50% of shipped containers are contaminated with toxic chemicals above chronic reference exposure levels (RELs), > 30% even exceed the higher acute REL thresholds.

This poses an obvious health risk for dockworkers, container unloaders and even end-consumers, especially as many of the carcinogenic or toxic gases elude subjective detection. Results from a study of residual gases in containers identified seven major fumigant or toxic industrial chemicals that were detected at concentrations above chronic RELs.[1] One of them being methyl bromide or bromomethane.

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[1] *High Frequency of Fumigants and Other Toxic Gases in Imported Freight Containers*, Xaver Baur, Bernd Poschadel and Lygia Therese Budnik

Clearly, even if the use of methyl bromide ceases in New Zealand, there will still be an issue with toxic residual gas emissions due to imported containers, which can be addressed with monitoring, ventilation and recapture technology.

7. Precedents in Other Jurisdictions

The practice of recapture technology is increasing around the world. It is encouraging to note that responsible organisations in some developing countries (e.g. Malaysia, New Caledonia and areas of China) have recognised the environmental and occupational risk that the continued use of methyl bromide presents and have joined the list of developed nations who are acting responsibly to recapture their methyl bromide used in QPS applications.

Additionally, it is clear that the issues with using methyl bromide are becoming more recognised on a political level around the world. As an example, Assembly Member Bonnie Lowenthal in California is focusing on Bill AB 21 that requires the Department of Pesticide Regulation to issue a report on emerging technologies for controlling industrial methyl bromide emissions [11].

This section will outline national and international areas that have officially recognised the hazards involved when using methyl bromide and have acted to minimise these hazards with the use of recapture technology.

Belgium

Like many EU countries, Belgium has taken significant steps to reduce its use of methyl bromide. However, in order to meet quarantine requirements for international trade, it continues to allow usage of methyl bromide for ISPM 15 treatments as a quarantine and pre-shipment requirement for exports to Canada, USA, Australia, China and other countries.

The Belgian Government took the initiative to mandate that any use of methyl bromide from July 1 2007 must include the use of a validated recovery system. (Belgian Federal Department of Health, Food Chain Safety and Environment 2007) This applies to all uses, including quarantine and pre-shipment applications such as ISPM 15 treatments which are presently exempt from phase-out under the terms of the Montreal Protocol.

The validation protocol required that the recovery system captures at least 80% of the available gas from inside the fumigation enclosure at the conclusion of the fumigation. (Belgian Federal Department of Health, Food Chain Safety and Environment 2007) In future, it is understood that the government wishes to raise this standard of efficiency to 80% of the amount of gas initially injected into the fumigation enclosure. However, this is complicated by the fact that many commodities (including timber) absorb a certain amount of gas, and this can be chemically altered during the period of fumigation by reaction with other compounds.

Prior to mandating recapture, the Belgian Authorisation Committee for Pesticides established a rigorous test protocol in order to determine the appropriateness and validity of recapture technology. Nordiko completed these tests in 2006 under the independent supervision of SGS Environmental Services. Immediately following this, demonstration units were sent for display, training and testing in Antwerp. A copy of both the governmental protocols and the experimentation to meet them are contained in Appendix J and K respectively.

The Belgian experience is very important as it proves the imperative of biosecurity requirements which require methyl bromide treatments can be achieved, whilst at the same time minimising emissions of these ozone-depleting substances to atmosphere.

Image 16: Demonstration of Nordiko system in Antwerp, June 2007

Port of Nelson

A significant development in quarantine fumigation practice took place in Nelson on August 12th, 2008. Nordiko supplied equipment to Genera - the largest fumigation firm in NZ - to recapture methyl bromide fumigant used to dis-infest shipping containers.

This was the first use of this technology in NZ and occurred in advance of the regulatory requirement established by the Environment Court that was implemented at the end of 2008 (see Appendix L for the interim report based on an appeal against the Nelson Air Quality Plan).

Public concerns over the unfettered use of methyl bromide had earlier prompted a petition to parliament on this issue. The position established by the court decision balances the need for an effective biosecurity agent to facilitate international trade, whilst addressing environmental and safety issues through the use of recapture technology, until an effective replacement for methyl bromide can be found.

A note should be made where port equity issues are concerned. The localized nature of this decision can mean the movement of business from one port to the next which can result in the loss of many jobs and a valuable source of income for a local community. It is important for wider adoption of recapture technology to ensure that the problems of methyl bromide emissions and residual gas occupational exposure are nullified and not just relocated.

Image 17: Commissioning recapture systems at Port of Nelson, New Zealand.

Tasmania

Tasmania has unique quarantine requirements due its status as Australia's only island state. At the same time it has a precious natural environment which attracts an increasing volume of tourism, and has successfully built export industries around its reputation as a clean and green environment.

Given the importance of export trade to Tasmania's economy, in particular the export of Fuji apples to Japan, Quarantine Tasmania in conjunction with the major Tasmanian fumigation company agreed in 2004 on recapture as world's best practice in fumigation. Since that time it has been a recommendation to use the latest technology in Tasmania.

The fumigation firms which remained all successfully made investments in recapture technology in Hobart, Burnie, Launceston and other locations..

Image 18: Morris Pest Control (Prospect, Tasmania) adopts a Nordiko Recapture Device.

Hamburg

The Port of Hamburg made the decision in September 2008 to make recapture of methyl bromide and other fumigant gases (from quarantine fumigations) mandatory.

At that time, operators had to apply for new permission. The application must include a recapture unit. This follows the recent (July 2007) decision by the Belgian Government to make recapture mandatory.

Nordiko attended the Port of Hamburg on June 3rd 2008 to demonstrate its systems to an audience comprising the fumigation companies, environment, port, health and related authorities.

As well as providing for safe recapture of gas, the same systems can also be used for fast and efficient removal of residual gases from inside imported shipping containers. The growing trend to regulate the recapture of methyl bromide and other toxic gases injurious to worker health and the environment is gaining momentum in many parts of the world.

Image 19: Nordiko recapture system in use in Hamburg (one of the top 10 container ports in the world).

Perth

Perth International Airport has set strict controls on the emission of toxic gases such as methyl bromide anywhere on its premises. The Fumilink fumigation operation at the airport has been operating since 2006, and uses a chemical treatment process supplied by Nordiko to breakdown the gas into non-toxic salts, which are approved for sewer disposal, before the activated carbon is reused.

Image 20: Fumilink filter treatment site at Perth International Airport.

New Caledonia

Like most Pacific Islands, New Caledonia enjoys an enviable environment. In order to meet export requirements and to protect their ecosystem from invasive species, New Caledonia has taken delivery in September 09 of their first Nordiko system. Responsible quarantine treatment with recapture also provides protection to workers and local air quality.

With the utilisation of the first Nordiko fumigation chamber, together with scrubbing system and filters, fumigation of commodities can be done in a safe and controlled environment. New Caledonia is the first Pacific island territory to perform responsible quarantine treatment by using recapture systems. There has been growing interests from the whole Pacific region in this technology.

Image 21: Nordiko recapture system and chamber at Noumea Airport

8. Large Scale Recapture Systems

NSW Riverina – Rice Fumigations

SunRice utilise methyl bromide recapture technology for their large scale rice fumigations in the Riverina region of NSW. Fumigation tents of 672 m3 and 552 m3 have been fitted to provide for recapture of gas onto carbon filters, which are then treated prior to reuse.

Image 22: Large scale fumigation recapture and treatment.

Western Australia House Fumigation

In December 2009 the West Australian Government awarded a tender for the supply of a very large scale fumigant gas recapture system to Nordiko. This is to be used to capture large quantities of fumigant gases such as methyl bromide, from structural fumigations of residential houses. The first use of the system is anticipated during March/April 2010 at a large (8,000 m3) home on the outskirts of Perth, where methyl bromide will be used to treat an infestation of European House Borer.

This system will be the largest practical application of gas recapture technology implemented in Australia, and possibly worldwide. The scale of the fumigation enclosure is comparable with many large grain silos, log fumigations and even ship holds. This system shows a responsible approach to the use of toxic fumigants on a large scale and shows that the misconception that large scale recapture is not feasible is false.

Image 23: A typical tarp application for house fumigations [8].

Image 24: Preparation of components of W.A. large scale recapture system.

Australian Log Fumigations

Nordiko is building a trailer mounted methyl bromide recapture system for a major Australian log exporter. The log stacks to be fumigated are 1,800 m3 in size. The exporter expects to fumigate around 100 stacks per year.

The log exporter was not under any mandate to recapture, but chose to do so while conducting a risk assessment of their operations. They concluded that recapturing increased both occupational and non occupational safety of the fumigation site. Additionally the environmental benefits were deemed to be significant.

9. Recapture Industry

Nordiko is not the only methyl bromide recovery system available, although it is arguably one of the most commercially advanced. There are alternative systems in operation in Europe (Belgium and the Netherlands) as well as the USA.

Similar to other industries, in the absence of any mandate to recapture, there has generally been a lack of incentive for new suppliers to enter the market. As has been shown in Belgium, spirited competition occurred to meet the new benchmark set by the regulations, and three suppliers of recapture systems passed the accreditation process.

Appendix M contains an overview of some alternative systems that are currently available in the market. To the best of Nordiko's knowledge, there are also systems available in Poland, China and in other parts of America.

10. Conclusion

When community concerns about the danger of methyl bromide to human health and the ozone layer are considered, recapture technology provides a feasible solution. Export income and the large number of jobs dependant on industries involved, highlights the importance of meeting overseas quarantine requirements.

Adopting recapture technology until suitable replacements for methyl bromide are tested, proven and implemented, will mean methyl bromide can continue to be used in a responsible manner which will ensure that New Zealand's own national biosecurity is not threatened while at the same time ensuring a safe working environment for those at risk to fumigant exposure. When the cost approximations for this technology are considered, it can be seen that it is not only used increasingly world wide, but also in an affordable manner..

Choosing to mandate the use of recapture technology and hence the responsible use of methyl bromide would see New Zealand lead the way in the Pacific region, in environmental and occupational policy where this fumigant gas is concerned.

11. References

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12. Appendix

Appendix A:	Baur, X., High frequency of fumigants and other toxic gases in imported freight containers – an underestimated occupational and community health risk, *Occupational and Environmental Medicine*, Oct 26, 2009.
Appendix B:	Suwanlaong, K. & Phanthumchinda K., Neurological Manifestation of Methyl Bromide Intoxication, *J Med Assoc Thai*, 2008, 91, 421-6.
Appendix C:	Plume model study for Wellington container fumigations.
Appendix D:	Plume model study for Tauranga log stack fumigations.
Appendix E:	Plume model study for Auckland container fumigations.
Appendix F:	Comparative commentary between plume studies and direct monitoring.
Appendix G:	Leeder Consulting report on the Detoxification of Methyl Bromide Impregnated Carbon.
Appendix H:	SRL Plasma brochure on the science of the Plascon process.
Appendix I:	Detailed cost estimations for applications discussed in section 4.1.
Appendix J:	Belgian Protocol to Validate Methyl Bromide Recovery Technology.
Appendix K:	SGS Methyl Bromide Mass Balance Trials.
Appendix L:	Environmental Court of New Zealand's decision on methyl bromide in Port of Nelson.
Appendix M:	Overview of recapture technologies other than Nordiko's systems.
Appendix N:	Plume diagrams with Recapture Systems at Wellington, Tauranga and Auckland