Report to the Australian Government
Department of the Environment and Energy

Quarantine and Pre-shipment uses of methyl bromide 2013-2016 and the potential for its replacement

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Glossary

AFAS	Australian Fumigation Accreditation Scheme (DAWR)
AIMS	Australian Import Management System (DAWR)
APVMA	Australian Pesticides and Veterinary Medicines Authority
AWPCS	Australian Wood Packing Certification System (DAWR)
DAWR	Department of Agriculture and Water Resources
DoEE	Department of Environment and Energy
EXDOC	Export Documentation System (DAWR)
BICON	Biosecurity Import Conditions database (DAWR)
IPPC	International Plant Protection Commission
ISPM	International Standard Phytosanitary Measure
MICoR	Manual of Importing Country Requirements (DAWR)
NPPO	National Plant Protection Organisation
QPS	Quarantine and Pre-shipment

The terms 'quarantine', 'pre-shipment' and 'consumption' used in this report follow Montreal Protocol use.

Summary

This survey has identified QPS and Non QPS used in Australia over the period 2013 – 2016 inclusive. Using data obtained from a user survey and the Departments of Agriculture and Water Resources and Environment and Energy, total methyl bromide use over this period was approximately 2,841 tonnes (693 tonnes in 2016) of which, 50% was used for export shipments, 7% for import and 43% for pre-shipment purposes.

The survey shows that methyl bromide use as a percentage of trade has decreased by approximately 6% over the period, a saving of 42t in 2016.

Existing and near market alternatives to methyl bromide include sulfuryl fluoride, phosphine, ethanedinitrile, low oxygen treatments, heat and cold treatments and irradiation. Of these sulfuryl fluoride and ethanedinitrile have the potential to replace almost 210 tonnes (2016 usage) of methyl bromide for timber treatment and the manufacturers are engaged in the process of obtaining appropriate approvals for quarantine use.

Recapture technologies currently exist that over the survey period would have been capable of recapturing 1538 tonnes of the methyl bromide that was used during the period 2013-2016 for disposal. While there are no destruction technologies currently approved under the Montreal Protocol, there are recognised techniques in Australia and elsewhere for disposal by deep burial, thermal destruction or liquid scrubbing.

The impediments to uptake of methyl bromide alternatives and adoption of recapture technology are the requirements for proof of efficacy and approval of alternatives for quarantine purposes by regulatory authorities in Australia, and concomitant acceptance by trading partners; in addition to cost, operational and logistical inconvenience, commercial competitive pressure and lack of regulatory or financial incentives to install recapture systems or change to methyl bromide alternatives. Manufacturers are actively engaged in proving efficacy of a number of alternative fumigants (notably sulfuryl fluoride and ethanedinitrile). There is currently only one company in Australia with a significant presence in recapture systems, however, there are a further three companies known to be developing systems that are intended to be in the market in 2018. Their uptake will be addressed in part through regulatory controls on fumigant emissions to meet air quality standards as they have the potential of creating a level commercial playing field that will facilitate uptake of recapture technologies and alternatives. This is the situation in New Zealand where a ban on emissions from any use of methyl bromide will come into force in 2020 and all parties involved in are working to meet the impending standard.

1.0 Aim of this report

The purpose of this report is to provide the Department of the Environment and Energy (DoEE) with an updated analysis of the status of Quarantine and Pre-shipment (QPS) uses of methyl bromide and adoption of alternatives or reduction measures for such uses. The years covered are 2013 to 2016 inclusive. The report provides information on:

The quantities of methyl bromide used for QPS applications including:

- The total amount used for QPS applications
- A description of the commodities fumigated
- Whether the use was on commodities for import, commodities for export, and/or for target pests
- The amount of methyl bromide used to comply with pre-shipment requirements of destination countries
- The amount of methyl bromide used to comply with Australian quarantine requirements
- Identification and analysis of trends that are apparent from the information collected through this survey and any previous reviews undertaken

Information on alternatives to methyl bromide including:

- Existing and near market alternatives to methyl bromide in QPS uses
- Impediments to uptake in Australia of existing and near market alternatives to methyl bromide for QPS applications which are available internationally and domestically
- Information on alternatives that have been deregistered in Australia during the period of the study.

Recapture of methyl bromide:

- Assessment of existing or new methyl bromide recapture technologies that are available internationally and the barriers which prevent the adoption of those technologies in Australia in QPS applications
- An estimate the amount of methyl bromide available for recapture and the amount recaptured.

2.0 Quantities of methyl bromide used for QPS purposes in Australia

2.1 Methodology

A survey was used to provide the primary data source for QPS methyl bromide use in Australia. The survey requested fumigation providers to supply information on their annual use of methyl bromide according to a set of categories as specified in the DoEE contract. (Appendix A).

There is no publicly available complete list of methyl bromide fumigation service providers. Fumigation service providers are required to be licensed in individual states and territories, but listings of these licensed providers are not publicly accessible. Methyl bromide service providers were located through several data sources, including an update to the fumigator listing developed by Banks (2010), personal contacts of the contractor and internet searches; all crosschecked against a listing of methyl bromide suppliers and purchasers provided by DoEE.

A total of 121 companies providing fumigation services were identified and provided with survey forms. The majority, including all major users by volume of methyl bromide, were contacted by phone. Responses to the survey were received from 35% of the service providers; this included phoned-in responses and aggregated data from companies with multiple branches.

The main public data sources used were:

- Register of accredited methyl bromide service providers for the Australian Wood Packing Certification Scheme (AWPCS, DAWR a. (2017)). These accredited providers are permitted to treat wood packing material, including pallets and dunnage, and certify it meets the requirements of the international standard for wood packing material (ISPM 15).
- Listing of fumigation service providers having a Compliance Agreement for quarantine treatments (DAWR) for treatment of imports according to the methyl bromide fumigation standard.
- Listings of fumigators in the 'White and Yellow Pages', 'Hotfrog' business websites and 'Google' website searches.
- The Australian Business Register listing of Australian Business Numbers (ABN) to locate and confirm company details.

2.2 AIMS database

The AIMS database is a restricted access database of quarantine fumigations applied to imported cargo under instructions from DAWR. A listing of over 170,000 fumigation directions covering the survey period was analysed in a relational database to extract information by import cargo category and treatment rate.

The directions are listed by dosage rate and exposure time at a standard temperature of 21ºC or above, therefore the reason for the direction can be deduced from the exposure rate. Because the dosage rates are often specific to particular situations, the reasons for the fumigations can usually be inferred (*e.g.* fumigation against risk of importation of Giant African Snail (*lissachitina fulica*) at 128 g/m^3 for 24h, fumigation of some perishables at 24 g/m^3 for 2h against risk of susceptible quarantine pests, standard fumigation of a wide range of commodities, at 48 g/m^3 for 24h for various quarantine pests, including pests of wood).

A summary of quarantine fumigations of imports was constructed from the database based on the categories in the format used in previous surveys, using dosage rates as a guide to the material treated or reasons for the fumigations. Actual applied methyl bromide is increased by 8 g/m^3 for each 5ºC that the ambient temperature in the fumigation enclosure lies below the standard temperature. Because this adjustment is not recorded in the AIMS database, the database gives the lower limit of methyl bromide used.

Use of the relational database has allowed for a more detailed analysis of import categories and quarantine treatments than has been previously possible. The information derived from this exercise provided an independent estimate that was used to supplement and cross check responses from the user survey on the use of methyl bromide for quarantine treatments on imported goods.

2.3 Export records

The export of certain goods from Australia is controlled under the Export Control Act – 2011 and the DAWR must be advised of the export of goods prescribed under the Act. This information is recorded in the Export Documentation System (EXDOC) and it includes the goods description, quantity, destination country, shipment method and any prescribed treatment to meet Importing country requirements. This latter information, which include methyl bromide treatment rates and alternatives (if permitted) is publicly available in the Manual of Importing Country Requirements (MICoR).

Information drawn from EXDOC was used to estimate methyl bromide use based on importing country requirements for the major destination countries over the survey period. As these application rates are typically temperature dependent, the standard temperature was used to develop the estimate. The resulting figures can be considered as the lowest possible use and provide a useful and reliable cross check and supplement to the results obtained from the user survey.

2.4 Methyl bromide sales and use records

The import and use of methyl bromide is managed by DoEE under the Ozone Protection and Synthetic Greenhouse Gas Management Regulations 1995. Company reports compiled under these regulations provide a record of imports and sales and a benchmark against reporting under the survey. Official figures for methyl bromide use for QPS purposes in Australia as reported by DoEE to the Ozone Secretariat in accordance with Article 7 of the Montreal Protocol were used to benchmark the methyl bromide study for completeness of coverage of use within Australia.

2.5 Confidentiality

All the data obtained from the above sources has been consolidated in this report for the purposes of confidentiality.

3 Overview of the Survey

3.1 Survey use results

Set out in Table 1 is the total annual methyl bromide use in Australia for QPS purposes estimated from licensed imports, QPS consumption reports to the Ozone Secretariat and total QPS use as estimated from the survey, cross referenced with, and supplemented by DoEE data on sales.

It is unlikely that there are uses of greater than 0.1 tonnes/year in aggregate not identified by the survey in view of the range of data sources used, the diversity of fumigation business surveyed and the range of survey responses received from a broad cross section of methyl bromide fumigation service providers,

As shown in Table 1, 80% to 94% of the quantity of methyl bromide sold for years 2013 – 2016 are accounted for by the survey. The gap between quantities sold and that accounted for is due to a number of companies failing to respond and/or claiming that it was either not possible or too difficult obtain data that was up to four years old.

Despite a number of approaches, one major fumigation company that fumigates for import and export quarantine purposes failed to respond to the survey. Another significant fumigator of grains and cotton was unable to provide an accurate record of use.

Where possible, DoEE sales data from the database on methyl bromide sales to individual service providers, was used to estimate the use for individual categories of treatment by companies which failed to respond to the survey. In many instances, it is possible to determine the end use category where companies have an obvious single use for the methyl bromide (*e.g.* fumigation of export logs, hay, grain or import of perishables). Companies that did not respond to the survey accounted for 13% of methyl bromide purchases in 2016.

2015 was notable for the fact that methyl bromide supply was severely restricted due, in particular, to a fire in an overseas production facility. This led to a number of Australian companies stockpiling methyl bromide when it returned to the market.

Table 1. Total methyl bromide (metric tonnes) estimated from current survey and total Australian Methyl bromide use reported to the Ozone Secretariat (DoEE data, 2016).

Methyl bromide use (tonnes)	2013	2014	2015	2016	Total 2013 - 2016
Survey total	634.352	553.845	735.775	693.233	2617.205
DoEE methyl bromide sales data (1)	644.58	586.27	864.273	745.8	2840.923
Reported QPS consumption (Article 7)(2)	618.352	488.541	864.276	708.51	2679.679
% survey compared with sales data	98%	94%	85%	93%	92%

(1) DoEE methyl bromide sales data is the amount of methyl bromide reported as sold by importers to domestic fumigators for quarantine and pre-shipment applications and may not represent the actual amount of methyl bromide applied during fumigations. The survey requested actual use quantities.

(2) Reported QPS use is based on quarterly reports of expected use by treatment providers and may not reflect actual use.

3.2 Industry structure

There have been a number of changes to the methyl bromide treatment provider group since the previous survey by Banks (2012), with what appears to be a continued consolidation of treatment providers:

- Forty five companies identified in the 2012 survey no longer exist or trade in methyl bromide; only four of these were reported as using more than 1 tonne of methyl bromide in 2012
- Twenty nine new companies have been identified as using methyl bromide in 2016; four of these are reported as using more than 1 tonne of methyl bromide.
- One company has taken over a number of fumigation companies and established a fumigation service in all states, with methyl bromide or other control measures as appropriate.
- Fourteen companies were identified with an annual use of methyl bromide for QPS purposes in 2016 exceeding 10 tonnes. Two of these companies conducted treatments on exclusively on export logs, four on export grains and cottonseed and one was involved in fumigations of export hay, one company has a 60% - 40% split between logs and hay and six had fumigation business conducting treatments on a range of commodities for import and export.
- In contrast, most of the fumigation service providers used less than 3 tonnes of methyl bromide in total in 2016.

4.0 Methyl Bromide Use

4.1 Major use categories

The annual use of methyl bromide for QPS purposes for the period 2013-2016 is set out by tonnage in Tables 2a and b. The survey of methyl bromide service providers, supplemented with estimates of use from sales data held in a DoEE database provides the basis for these figures.
Major use categories (> 5 tonnes use in 2016) were:

- export cereal grains
- export cottonseed
- export hay
- export timber (logs with bark)
- export pulses
- fresh fruit and vegetables (export)
- fresh fruit and vegetables (interstate)
- furniture and personal effects (import)
- import disinfestation for insects/ticks/spiders
- solid wooden packaging material including to International Standard Phytosanitary Measure (ISPM15).

More than 640 tonnes of methyl bromide were used on these ten major categories in 2016, accounting for approximately 94% of total identified 2016 use. Of particular note is the increase in the export of logs as importing countries impose mandatory treatment on logs with bark. The situation with debarked logs and sawn timber is not as clear, with debarked logs and sawn timber usually requiring pre-export inspection for freedom from pests. Forest and Wood Products Australia reported in March 2017 that softwood log exports for 2016 were 3,619,100m^3, a 22% increase over 2015 exports. China, the most significant importer, permits treatment with sulfuryl fluoride or heat treatment in lieu of methyl bromide. The methyl bromide treatment rate varies from 80 to 120 g/m^3 at temperature above 15^oC or at 5-15^oC respectively. Two companies involved in the treatment of logs have trialled sulfuryl fluoride but have not continued to use it because of increased cost and retention time.

Of the 170,000 AIMS directions for quarantine treatment, identifiable uses of more than 1 tonne include the following categories of import:

- Equipment, parts and containers, other than for snail/insect treatments
- Flowers, bulbs and plants
- Fresh fruits and vegetables
- Steel and scrap
- Wood and timber

The common reason for treatment of imported equipment, steel and scrap other than for snail or insect control is for the presence of wood as pallets or packing
.

Table 2a. Estimated QPS methyl bromide use (metric tonnes) for various commodities (specified uses, > 50 kg per year for a fumigation provider) for 2013 – 2016 as determined by survey and sales data.

Treated commodity/material/situation	**Class**	**Usage (tonnes)**			
		2013	**2014**	**2015**	**2016**
Boats	Domestic	0.000	0.000	0.000	0.000
Branched broomrape	Domestic	0.000	0.000	0.000	0.000
Buildings, not grain, feed/flour mills	Domestic	0.000	0.000	0.000	0.000
Fresh fruit and vegetables	Domestic	3.279	4.942	6.332	7.300
Mills (grain, feed and flour)	Domestic	0.000	0.000	0.000	0.000
Total Domestic		***3.279***	***4.942***	***6.332***	***7.300***
Dried fruit	Import	0.000	0.012	0.000	0.000
Equipment/parts/components	Import	3.521	3.505	8.158	2.067
Flours and meals	Import	3.300	4.782	4.900	3.600
Flowers, bulbs and plants	Import	0.904	0.800	1.500	2.606
Fresh fruit and vegetables	Import	2.119	2.342	2.560	3.970
Furniture and personal effects	Import	12.111	13.193	16.982	9.019
Steel and steel scrap	Import	3.170	3.400	9.080	1.370
Tyres	Import	2.770	0.510	0.150	0.100
Wood and timber	Import	1.110	0.811	1.515	3.939
Wood Packaging	Import	2.054	2.020	7.620	1.458
Other uses (> 50kg a year) **(Table 2b)**	Import	70.987	69.331	106.550	45.413
Total Import		***102.046***	***100.706***	***159.015***	***73.542***
Cereal grains (including Rice)	Export	265.680	176.130	215.180	213.810
Cottonseed/cotton	Export	52.385	20.930	24.040	43.085
Empty grain ships and containers	Export	0.000	0.000	0.000	0.000
Fresh fruit and vegetables	Export	3.467	2.904	4.084	5.680
Hay	Export	57.286	70.880	72.398	43.644
Tobacco	Export	0.000	0.000	0.000	0.000
Wood and timber	Export	125.700	122.570	166.400	205.145
Wood Packaging, inc. ISPM 15	Export	2.450	4.670	5.810	5.950
Other uses (>50kg a year) **(Table 2b)**	Export	22.050	50.100	82.510	95.070
Total misc. minor uses (<50kg a year)		0.009	0.015	0.003	0.007
Undefined uses (use not recorded)		0.000	0.000	0.000	0.000
Total Export		***529.027***	***448.199***	***570.425***	***612.391***
Total annual MB usage (tonnes)		**634.352**	**553.847**	**735.772**	**693.233**

Table 2b. Estimated QPS methyl bromide use (metric tonnes) for various commodities (other uses, > 50 kg per year for a fumigation provider) for 2013 – 2016 as determined by survey and sales data.

Treated commodity/material/situation	**Class**	**Use (tonnes)**			
		2013	**2014**	**2015**	**2016**
Almonds/other Nuts	Export	0.130	0.060	0.400	0.640
Coffee and Cocoa Beans	Export	0	0	0	0
Dried fruit	Export	0	0	0	0
Dry Foodstuffs	Export	0	0	0	0
Flours, meals, stockfeed/hop pellets	Export	0.680	3.050	0.550	0.560
Furniture and personal effects	Export	0	0	0	0
Grapeseed	Export	0	0	0	0
Hides and Skins	Export	0	0	0	0
Malt	Export	0	0	0	0
Pulses	Export	21.26	46.88	81.54	93.98
Walnuts	Export	0	0	0	0
Seeds	Export		0.120	0.400	0.480
Total		**22.07**	**50.11**	**82.89**	**95.66**
Artefacts	Import	0.131	0.109	0.10608	0.042
Bamboo/Bamboo products	Import	0.104	0.144	0.09648	0.109
Disinfestation /insects/ticks/spiders	Import	17.195	15.619	14.68656	13.771
Disinfestation/snails	Import	3.076	1.532	1.35552	0.941
Dried Fruit	Import	0.000	0.000	0.00384	0.001
Dry Foodstuffs	Import	0.083	0.066	0.06816	0.152
Equipment/Parts/Components	Import	3.654	3.651	8.36544	1.769
Flours/Meals	Import	0.011	0.014	0.00432	0.011
Flowers/Bulbs/Plants	Import	0.022	0.027	0.01824	0.036
Fresh Fruit/Vegetables	Import	0.116	0.094	0.10056	0.086
Furniture/Personal effects	Import	12.114	13.196	16.9896	9.026
Hand tools	Import	0.177	0.174	0.65616	0.290
Hides/Skins	Import	0.029	0.029	0.00528	0.001
Steel/Steel scrap/Steel components	Import	1.137	1.053	5.16672	0.447
Stock-feed	Import	0.000	0.000	0.12672	0.000
Tyres	Import	2.769	0.508	0.1272	0.101
Uncategorised	Import	27.780	30.627	50.27376	16.827
Vehicles/Trailers/Caravans/Boats	Import	0.191	0.144	0.14208	0.093
Wood Packaging	Import	2.289	2.207	8.19456	1.624
Wood/Timber	Import	0.111	0.137	0.06288	0.084
Total		**70.987**	**69.331**	**106.55**	**45.413**

4.2 Post entry Quarantine methyl bromide use

Imported goods are required to meet both Customs and Quarantine requirements and are not permitted entry to Australia until they comply. The DAWR AIMS data base records quarantinable entries and the treatment directions they are given providing a reliable information source to support the survey and DoEE sales database in regard to methyl bromide treatment of imports.

Table 3 provides a summary of the estimated use on imports derived from the AIMS database and the standard dosage rates specified by AQIS for the various fumigation situations and import commodities. The standard dosage rates for import commodities can be obtained for a particular country of origin, commodity and pest risk from the DAWR managed Biosecurity Import Conditions (BICON) database (DAWR b. 2017).

The data is presented in Table 3 in the same format as the Survey Form to allow comparison with previous survey data. Compared to previous surveys, it has been possible to disaggregate the AIMS data to enable a better understanding of treatment trends. The survey data was collected independently of the AIMS data.

Disinfestation for insects, snails and spiders represents a significant portion of import quarantine methyl bromide use, with particularly concerns in regard to ants and Giant African Snail (GAS) (*Lissachatina fulica*), with fumigation rates of 80 g/m^3 and 128 g/m^3 respectively; analysis of the AIMS shows that in total, there is ten times more methyl bromide used for insects, snails and spiders than GAS.

Artefacts and antiques are generally treated for wood pests at 32-48 g/m^3. Hand tools are directed for treatment because they have wooden handles. Steel/ steel scrap and equipment and parts are usually directed for treatment because of wooden pallets or packaging which is not ISPM15 compliant. Tyres receive treatment because stored and shipped in the open, they are frequent carriers of mosquito larvae and eggs.

The dosage rates and derived methyl bromide use from the AIMS database relate to treatments under standard conditions at 21ºC and above. Table 3 presents minimum methyl bromide use figures and true use may be somewhat greater. The fumigator is required to make an adjustment of +8 g/m^3 to the dosage for each 5ºC that the fumigation minimum temperature falls below 21ºC down to a minimum of 11ºC (quarantine fumigations with methyl bromide are not permitted below this temperature).

If an adjustment of 8 g/m^3 for a 5^{o}C drop in temperature was made to every import fumigation it would add about 40 tonnes to the total estimate methyl bromide use on imports over the four year period covered by this survey (170,000 20-foot equivalent (TEU) containers treated in 2013 – 2016, with an additional 0.24kg methyl bromide per container).

Table 3. Minimum methyl bromide use on imports for Quarantine purposes estimated from AIMS database with application at specified dosage rates - no allowance for additional methyl bromide to compensate for low fumigation temperatures.

Import Category	2013	2014	2015	2016	Total T_MB_Used
Artefacts/Antiques	0.131	0.109	0.106	0.042	0.388
Bamboo/Bamboo products	0.104	0.144	0.096	0.109	0.453
Disinfest /insects/ticks/spiders	17.195	15.619	14.687	13.771	61.272
Disinfestation/snails	3.076	1.532	1.356	0.941	6.904
Dried Fruit			0.004	0.001	0.005
Dry Foodstuffs	0.083	0.070	0.076	0.160	0.388
Equipment/Parts/Components	3.521	3.505	8.158	1.747	16.931
Flours/Meals	0.011	0.014	0.004	0.011	0.041
Flowers/Bulbs/Plants	0.022	0.027	0.018	0.036	0.104
Fresh Fruit/Vegetables	0.116	0.094	0.101	0.088	0.398
Furniture/Personal effects	12.111	13.193	16.982	9.019	51.305
Hand tools	0.192	0.184	0.660	0.298	1.335
Hides/Skins	0.029	0.037	0.005	0.001	0.073
Steel/Steel scrap/Steel items	3.165	3.403	9.084	1.366	17.018
Stock-feed/Pet-food			0.127		0.127
Tyres	2.769	0.508	0.154	0.101	3.532
Uncategorised	26.046	28.559	47.087	16.069	117.761
Vehicles/Trailers/Caravans/Boats	0.246	0.166	0.152	0.101	0.665
Wood Packaging	2.054	2.020	7.620	1.458	13.152
Wood/Timber	0.115	0.146	0.073	0.095	0.429
Total	**70.987**	**69.331**	**106.550**	**45.413**	**292.281**

4.3 Relative quantities used for Pre-shipment, import Quarantine and export Quarantine.

The terms 'Quarantine' and 'Pre-shipment' (QPS) in relation to methyl bromide fumigations and other treatments are described in Decisions VI/11, VII/5 and XI/12 of the Montreal Protocol. In the discussions below, these definitions are interpreted for the Australian context as:

- Quarantine treatment of imports – treatments carried out as instructed by the National Plant Protection Organisation (NPPO for Australia, DAWR) or environmental or health authorities against risk of importing pests of quarantine concern.

- Quarantine treatment of exports – treatments carried out as required by an importing country NPPO to guard against risk of importing exotic pests or diseases.

- Pre-shipment of exports – treatments within 21 days of export to meet official phytosanitary requirements of the importing country or established official Australian export regulations to control risk of presence of excessive numbers of non-quarantine pests associated with the export commodity.
- Domestic treatment – treatment to control pests or disease of quarantine concern in or on commodities moving in interstate or intrastate trade.

The survey did not ask methyl bromide users in Australia to differentiate between Pre-shipment, export Quarantine and import Quarantine. The decision on which category of QPS a particular use falls into was made on the basis of its known reason for methyl bromide use. Import Quarantine use is well defined and there is no category equivalent to Pre-shipment for imports.

4.3.1 Imports

Australia, as many other countries, has a detailed published list of exotic pests and diseases that are of quarantine concern (*e.g*. see PaDIL 2017). Treatments against risk of importation and establishment of these pests are specified by DAWR in the BICON database (bicon.agriculture.gov.au) which houses the Australian Governments database of import conditions for more than 20,000 plants, animals, minerals and biological products. These may include methyl bromide treatment where appropriate to manage this risk.

The best estimate for import Quarantine use of methyl bromide usage was derived from the AIMS database (Table 3).

4.3.2 Exports (Quarantine and pre-shipment)

The distinction between export Quarantine treatments and Pre-shipment treatments is problematic and accurate data on which treatments fall into these two categories is not available. This survey uses the same basis for determination as used in previous surveys; in the first instance because they appear adequate and secondly, to enable continuity of reporting and evaluation. Accordingly the following considerations were taken, in drawing a distinction between a Pre-shipment and an export Quarantine treatment.

Information on importing country requirements for treatment of particular imports, including whether phytosanitary certificates are required and quarantine requirements, if any is set out in the DAWR MICoR website (MICoR 2017a). If this indicated that there was a specific pest or disease of quarantine concern and that it was to be controlled with methyl bromide, it was classified here as a Quarantine fumigation. Additionally all timber and wood treatments, including ISPM15 treatments, were classified as Quarantine, as they were against wood and forest pests of quarantine concern.

Methyl bromide may also be used as a phytosanitary treatment. Some Australian exports have Australian exports regulations and protocols that set standards for freedom from insect pests. The *Export Control Act 1982*, the *Export Control (Plants and Plant Products) Order 2011* and the *Export Control (Prescribed Goods—General) Order 2005* provide the legal framework when plant and plant products are prepared or processed for export (DAWR c. 2017). The Act specifies that goods are 'prescribed' or 'non-prescribed', with prescribed goods subject to specific standards and requirements relating to quality and inspection in a registered establishment under the Export Control Orders. Methyl bromide fumigations may be used to meet phytosanitary requirements associated with these standards. Where quarantine pests are not involved, this was classified here as Pre-shipment.

Prescribed export goods (DAWR 2017c) that sometimes require methyl bromide fumigation include prescribed grains, hay and straw, fresh fruit and vegetables. Most hay exports are fumigated for phytosanitary purposes and because they receive a reduced level of inspection when treated.

Typically, an importing country will require a phytosanitary certificate for the commodities inspected by DAWR.

Cottonseed and cereal grains are major export commodities that can fall into either category, Quarantine or Pre-shipment. Methyl bromide treatments of cottonseed shipments to USA pose a challenge as they require methyl bromide use at a rate of 112 g/m^3 or 80 g/m^3 against a strain of *Fusarium* fungus (MICoR 2017b). The rate to be used is determined by the USA at the time of export and appears to be a function of the size of the USA cotton crop (R. Qaisrani. 2017 personal communication), while other destinations such as China only require a phytosanitary certificate indicating that "consignments are free from pests, soil, weed seeds and extraneous material" and the certificate is endorsed to say that two quarantine pests Khapra beetle (*Trogoderma granarium*) and Cotton boll weevil (*Anthonomus grandis*) are not known to occur in Australia. Survey respondents were not asked for the destination of cottonseed shipments, however data extracted from DAWR EXDOC shows the major destination for cotton/cottonseed over the survey period as India (202,910 t), followed by Bangladesh (197,000t), Pakistan (38,14 t), Malaysia (27,479t), USA (3,008t), and China (1610t). On this basis, for the purposes of this study, it was assumed that 56% of cottonseed methyl bromide usage was Quarantine, while the remainder was Pre-shipment.

Cereal grains pose a similar difficulty in categorisation with some countries (*e.g.* India) requiring mandatory fumigation and others, inspection for absence of weeds and pests. Methyl bromide is, therefore, frequently used as a precautionary phytosanitary treatment to ensure the commodity passes inspection. For the purposes of this survey cereal grains include barley, corn, maize, oats, sorghum and wheat. India, Pakistan and Bangladesh all require treatment before export and account for 41% of all cereal exports over the survey period. Reported methyl bromide use has been allocated to Quarantine or Pre-shipment on this basis.

4.3.3 Domestic interstate and intrastate movements

A small quantity of methyl bromide has been used for domestic control of quarantine pests within Australia as specified by state authorities such as Quarantine WA. These include or recently included:

- control of risk of *Trogoderma variable* entering Western Australia from the eastern states
- control of risk of insect and other pests entering Barrow Island from mainland Australia
- control of risk of Western Flower Thrips and Pea Weevil entering Tasmania from other states
- control of risk of Queensland Fruit Fly entering fruitfly free areas from areas where it commonly occurs
- control and eradication of European House Borer in Western Australia
- control of drywood termites in the Maryborough area in Queensland
- control of risk of importing Sirex wood wasp into Western Australia from South Australia.

Methyl bromide is used for these interstate and intrastate quarantine applications. Based on responses received and previous information, it appears that its use for this purpose is increasing; (2013 2.3MT), (2014 4.9MT), (2015 6.3MT) and (2016 7.3MT).

On the basis of the above discussion, classification of the main QPS uses by volume of methyl bromide are set out in Table 4. The estimated breakdown of total Australian QPS methyl bromide use for the survey period 2013 to 2016, derived from the classifications in Table 4 and import treatment data from the AIMS database is set out in Table 5.

Table 4. Classification of methyl bromide treatments on exports as Quarantine or Pre-shipment, as used in this study.

Methyl bromide application	Class of use
Export grains	41% Quarantine 59% Pre-shipment
Export pulses	Pre-shipment
Export hay and straw	Pre-shipment
Export wood and timber, including logs	Quarantine
Export wood packing, including for ISPM15	Quarantine
Export cottonseed	56% Quarantine, 44% Pre-shipment
Export fresh fruit and vegetables	Quarantine

Table 5. Class of use of Australian QPS methyl bromide use (tonnes) for 2013– 2016, estimated from survey results and data from the AIMS database.

Class of use	2013	2014	2015	2016	Data source
Export Quarantine	266.4 45(%)	165.68 38%	256.33 42%	322.855 50(%)	This study. Table 2a and 2b
Import Quarantine	70.987 12%	69.331 16%	106.55 15%	45.41 7%	AIMS database interpretation. Table 3
Pre-shipment	258.297 43%	199.17 46%	268.518 43%	282.734 43%	This study. Table 2a and 2b
Total	**595.684**	**434.181**	**631.39**	**650.999**	

4.4 Trends in methyl bromide use for Pre-shipment and Quarantine use.

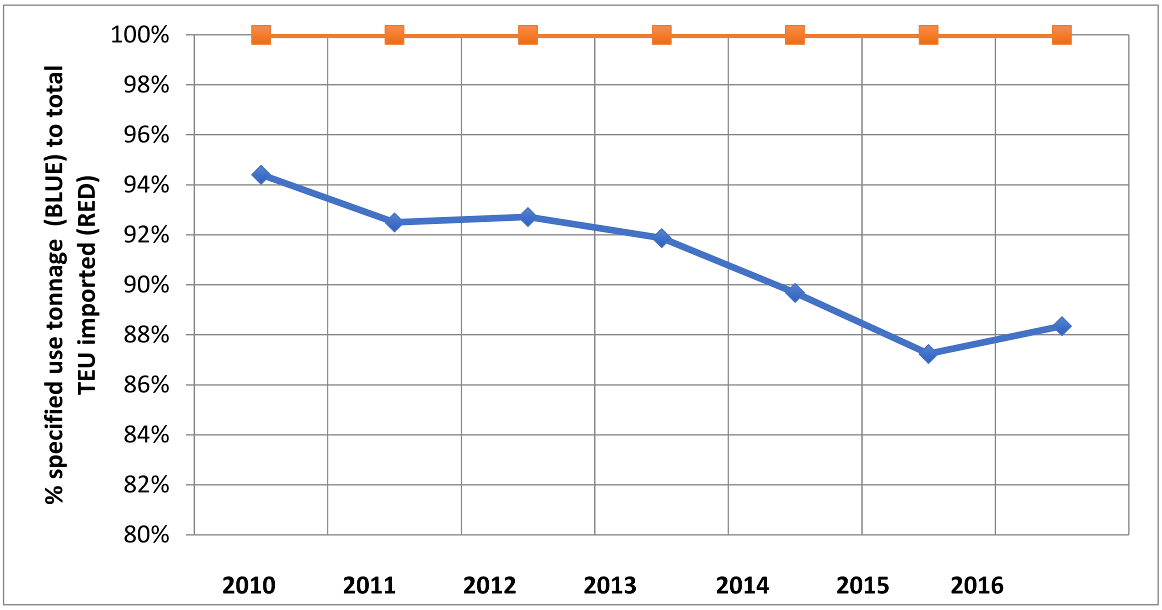
The data set derived from the DAWR AIMS database (Table 3) is inconclusive in showing any significant trend over time; 71t in 2013 increasing to 106.5t in 2015 and dropping to 45t in 2016. The overall trend could be considered as flat if you take into consideration the figures of 45.5t in 2009 and 50.4t in 2012 (Banks 2012).

4.4.1 Methyl bromide use as a percentage of trade

Methyl bromide for specified usage for the period 2010 to 2106 was compared to Australian trade figures represented by container movements (TEU) through ports. TEU (twenty foot equivalent container units) are the basis on which the methyl bromide use estimates are calculated from AIMS and EXDOC data (Tables 2a and 2b). As such a direct correlation can be made with trade volumes measured as TEU movements and set out in Figure 1. For each year, container numbers are shown as 100% (in red) and methyl bromide use is shown as tonnes used in relation to TEU numbers (in blue). The figures show that methyl bromide use as a percentage of trade has decreased by approximately 6% over the period; a theoretical saving of 42t in 2016.

Figure 1

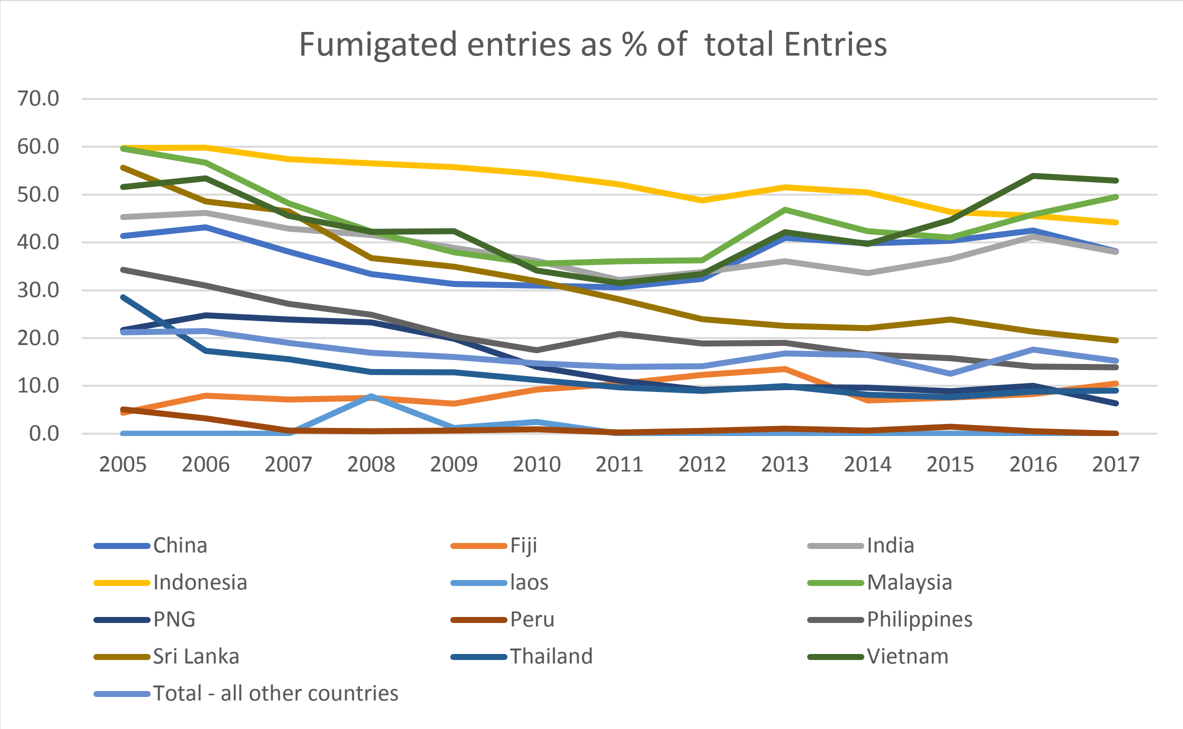
Percentage changes of methyl bromide - 'specified use' for each year in relation to total TEU volumes imported in the same year. Data from http://www.portaustralia.com.au Data for 2016 TEU are estimates.



4.4.2 Australian Fumigation Accreditation Scheme

The Australian Fumigation Accreditation Scheme (AFAS), established in Indonesia in 2005, seeks to enable overseas exporters to conduct their own fumigations in a rigorous and effective manner to meet Australia's quarantine requirements (D. Cox 2008). Through country to country agreements and appropriate auditing it removes the need for mandatory on-shore fumigations of various imports into Australia that have a risk of carrying quarantine (regulated) pests; some continue to be treated post-entry under DAWR regulations. What is possible under this scheme is illustrated by the reduction in the need for treatment since 2005 of imports from Indonesia (by 15.5%), and the Philippines, (by 19%) - see Figure 2. This compares with imports from all other countries which have seen little improvement and remained static at around 6%. In considering these figures it must be noted that the AFAS is focussed on countries with significant imports of commodities of quarantine concern. These results together with the long term flat line trend in use of methyl bromide for import quarantine use (Table 5) suggest that the AFAS scheme has prevented an increase in import quarantine treatments due to increases associated with higher volumes of trade occurring overseas.

Figure 2: Fumigated container import movements as a percentage of total container imports for each participating AFAS country 2005 - 2017



Data courtesy of DAWR, 2017

4.5 Changes in methyl bromide use since 2000

This survey closely follows the methodology used in surveys conducted since 2000 (Porter 2001, Banks 2005, Banks 2010, Banks 2012) providing a 16-year record of changes in use of methyl bromide on specific categories of QPS methyl bromide treatment.

The years 2000, 2005, 2008 and 2012 have been used here as a guide to changes and are set out in Tables 6a and 6b.

Some changes in export use, are associated with seasonal growing conditions, not changes in usage or adoption of alternatives. Variation in high volume uses on cottonseed and cereals probably reflect these seasonal influences. Other changes reflect changing trade patterns, for example increased log exports to China:

- Recent increase in use on export grains with increased exports to India (2013 – 10,612t to 2016 – 929,529t), Bangladesh (2013 – 552,500t to 2016 – 154,593t) and Malaysia (2013 – 1,273t to 2016 – 2,341,557t), all requiring methyl bromide treatment. The use of methyl bromide on these commodities may reduce in future as DAWR has recently negotiated a reduction in treatment rate for Pakistan to match that of India (72 g/m^3 down to 32 g/m^3), (R Qaisrani, Personal communication). This change has not applied to the current survey period.
- The use of methyl bromide for rice (domestic use) has been phased out in favour of phosphine by one company.
- There is a steady increase in use on fresh fruits and vegetables for export and interstate trade, from 5.7t in 2012 to 13t in 2016.
- A decrease in use on export hay from a peak of 84t in 2012 to 43.6t in 2016.
- Increasing use on pulses to meet import requirements and rising trade volumes to India, Pakistan and Bangladesh.

- Use on wood and timber continues to increase over previous years, reflecting continued development of the trade in export logs, mainly to China.
- There appears to be a steady decline in usage on export wood packing, including for ISPM 15, down from 11t in 2010 to 6t in 2012. This may result from increasing adoption of heat treatment in place of methyl bromide to meet ISPM 15 requirements.
- A move to increase grain sales to India may result in increased methyl bromide use in 2017 (P. Clamp, personal communication).

Table 6a. Comparison of methyl bromide used for QPS treatment of commodities and situations for 2016 (specified uses) and representative years from previous surveys, covering the years 2000 to 2016.

Treated commodity/material/situation	**Class**	**Use (tonnes)**				
		Porter (2001)	**Banks (2008)**	**Banks (2010)**	**Banks (2012)**	**Present study**
		2000	2005	2009	2012	2016
Boats	Domestic		0.670	0.150	0.030	
Branched broomrape	Domestic		3.200			
Buildings, excluding grain, feed/flour mills	Domestic	4.800				
Cereal grains (including Rice)	Export	49.080	72.650	86.160	173.416	213.810
Cottonseed/cotton	Export	85.360	9.140	0.110	71.500	43.085
Dried fruit	Import		1.00	0.570		
Empty grain ships and containers	Export	5.480	4.600	0.500	4.811	
Equipment/parts/components	Import	6.810	1.620	1.740	1.274	2.067
Flours and meals	Import		1.240		0.042	3.600
Flowers, bulbs and plants	Import	8.140	0.750	2.470	1.541	2.606
Fresh fruit and vegetables	Export	13.340	8.180	10.600	5.701	5.680
Fresh fruit and vegetables	Import			0.810	0.421	3.970
Fresh fruit and vegetables	Domestic					7.300
Furniture and personal effects	Import	21.220	1.350	0.790	7.101	9.019
Hay	Export	131.110	72.880	25.040	84.423	43.644
Mills (grain, feed and flour)	Domestic	2.680			0.600	
Steel and steel scrap	Import		0.840	0.310	1.210	1.370
Tobacco	Export	1.380		0.040		
Tyres	Import		2.960	1.670	10.477	0.100
Wood and timber	Export	13.310	48.040	11.520	136.607	205.145
Wood and timber	Import			2.620	6.558	3.939
Wood Packaging	Import			1.940	9.397	1.458
Wood Packaging, including for ISPM 15	Export	36.720	58.950	15.490	6.324	5.950
Other uses (> 50kg a year)	Import					45.413
Other uses (>50kg a year) **	Export	14.111	7.883	14.525	30.000	95.070
Total miscellaneous minor uses (each <50kg a year)			4.802	10.120	0.296	0.007
Undefined uses (use not recorded)		9.730	30.500	83.280	3.292	
Total annual methyl bromide use (tonnes)		**403.3**	**331.3**	**270.5**	**555.1**	**693.23**

*** Category - 'Other uses >50kg' not split into import/export until this survey (2013 – 2016)*

Table 6b. Comparison of methyl bromide used for QPS treatment of commodities and situations for 2016 (other uses) and representative years from previous surveys, covering the years 2000 to 2016.

Treated commodity/material/situation	Class		Use (tonnes)			
		2000	2005	2009	2012	2016
Almonds	Export				1.579	0.060
Coffee and Cocoa Beans	Export				0.001	0.000
Cotton		1.520	0.480		0.059	
Dried fruit	Export	0	0		0.455	0.000
Dry Foodstuffs	Export	0	0		0.025	0.000
Flours, meals, stock-feed/hop pellets	Export	0	0		2.156	0.550
Furniture and personal effects	Export	0	0		0.423	0.000
Grapeseed	Export	0	0		0	0.000
Hides and Skins	Export	0	0		0.038	0.000
Malt	Export	0	0		0.003	0.000
Pulses	Export	12.591	6.743	14.525	24.641	93.98
Walnuts	Export	0	0	0	0.228	0.000
Seeds	Export	0	0	0	0	0.480
Total		**14.111**	**7.223**	**14.525**	**29.608**	**95.070**
Artefacts/Antiques	Import				0.064	0.042
Bamboo/Bamboo products	Import				0.119	0.109
Disinfestation /insects/ticks/spiders	Import				0.069	13.771
Disinfestation/snails	Import				0.088	0.941
Dried Fruit	Import				0	0.001
Dry Foodstuffs	Import				0.050	0.160
Equipment parts and components**	Import					1.769
Flours/Meals	Import				0	0.011
Flowers/Bulbs/Plants	Import				0	0.036
Fresh Fruit/Vegetables	Import				0	0.086
Hand tools**	Import				0	0.290
Hides/Skins	Import				0	0.001
Steel/Steel scrap/Steel components**	Import					7.803
Stock-feed/Pet food	Import				0.005	0.000
Tyres **	Import					1.01
Uncategorised	Import				0	16.069
Vehicles/Trailers/Caravans/Boats**	Import				0	0.093
Wood packaging	Import					1.624
Wood/Timber	Import				0	0.084
Total					**0.**395	**45.313**

*Categories marked ** not separately identified in previous surveys*

5 Opportunities for reduction in methyl bromide use

5.1 Background

Methyl bromide is used as a quarantine treatment because it has a reputation for effectiveness against a wide range of quarantine and other pests, has a low material cost compared to other treatments, is relatively rapid in use and is widely approved for quarantine purposes by regulatory authorities. There are a number of areas that can be addressed to reduce Australia's consumption of methyl bromide that stands at 640t and 94% of total use, for the ten major uses in 2016 (Table 1).

Regulated use, a mandatory requirement of an importing country to control a pest or disease of concern, can only be changed by negotiation with the importing country which will require evidence of growing area freedom from the pest or disease of concern, or evidence of the effectiveness of an alternative treatment or control method. Export quarantine treatments have to be agreed bilaterally with the importing country and the commodity may also be covered by international standards (e.g. ISPM 15). Never-the-less this is possible and the DAWR and various industry bodies expend considerable energy in negotiating such entry arrangements. An example of this approach is that Pakistan has recently agreed to reduce its methyl bromide dosage requirement for grains (72 g/m^3 to 32 g/m^3), (R Qaisrani, personal communication).

Pre-shipment treatments account for approximately 45% of all methyl bromide use. Such pre-shipment application is used to enable commodities to meet general phytosanitary standards. For example, in the case of Malaysia, consignments of wheat require inspection and certification that they are 'free from pests, soil, weed seeds and extraneous material' (Micor 2017c). While there is no specific requirement to treat with methyl bromide or any other fumigant or process, the problem for exporters is that failure to meet these standards on inspection, at the point of loading, can incur significant costs and delays as shipments failing inspection are typically required to be retreated and re-inspected. This makes treatment with methyl bromide a cost effective insurance. One answer or at least partial remedy to this issue is to improve supply chain hygiene wherever possible through education and good practice. This is particularly applicable to cereal commodities and for fruit and vegetable exports, discussed below. Another is to pre-treat with a suitable alternative fumigant or process. These alternatives generally take longer and are not feasible if they have to be carried out in a shipping container, as containers themselves are only made available in the 24 hours before shipment.

On the import side, DAWR has in place a 'Sea Container Hygiene System' (DAWR d 2017) that is designed as an industry regulated, in country system (supported by training and offshore audits) to manage cleanliness of empty containers that are to be exported. These containers are often contaminated with soil, seeds, insects and spiders through standing on unsealed, often neglected areas. Methyl bromide use for container disinfestation has declined from 20t in 2013 to 14.5T in 2016.

5.2 Alternatives to methyl bromide

5.2.1 Summary

Table 7 provides a summary of registered alternatives for major Australian QPS uses, a) where immediately available and, b) alternatives that have significant potential but are not registered or approved.

Table 7. Major methyl bromide QPS usages by volume, >6 tonnes per year in 2016, with alternatives.

Fumigated commodity	Class of treatment	Existing and near market alternative treatments	Treatments acceptable to Importing country	Estimated usage in 2016 (tonnes, Table 2)
Fresh fruit and vegetables (including interstate)	E, Q	Various, see text		13
Wood Packaging, including for ISPM 15	E, Q	HT, SF, dialectic heating	Most countries - HT, dialectic heating	6
Wood and timber	I, E, Q	PH, HT, SF, EDN	India – MB, HT Malaysia – MB, HT, EDN China MB, SF, PH NZ – MB, HT, PH, chemical treatment	205
Furniture and personal effects	I, Q	HT, SF,		9
Wood Packaging	I, Q	HT, EDN		9
Cottonseed	E, P/Q	Phosphine for P, none approved for Q	India – MB Pakistan - MB USA - MB	43
Hay (including cereal straw)	E, P	PH, CO_2, SF	Japan, Korea, Malaysia – insect freedom only	43
Cereal grains (including rice and pulses)	E, P	PH, SF, CA, grain management	India – grains/peas – MB Pakistan – grains –MB Pakistan - peas – MB, PH, HT	173

E = Export, I = Import, Q = Quarantine, P = Pre-shipment,
CA = Controlled atmosphere, CO_2 = Carbon dioxide, HT = Heat treatment, PH = Phosphine,
EDN = Ethanedinitrile, SF = sulfuryl fluoride

Most of the major uses of QPS methyl bromide by volume, summarised in Table 7, have approved, effective alternatives for some, or all, of the commodities they comprise. These alternatives include:

Fumigants

- Sulfuryl fluoride
- Phosphine
- Ethanedinitrile (EDN)

Controlled atmospheres

- Low Oxygen
- Heat Treatment
- Cold Treatment

5.2.2 Sulfuryl fluoride

Sulfuryl fluoride, (SO_2F_2) is an easily condensed gas that is widely used for structural fumigations and to control termites. After a period of increasing use as a methyl bromide replacement in Australia, use has declined since 2012. In 2011/12 cereal grain producers had a significant problem with phosphine resistance and consequently used sulfuryl fluoride to eliminate resistant strains. The program was successful. Reduced grain harvests from 2013 to 2016 made resistant pests easier to control, so, with phosphine 25% cheaper than sulfuryl fluoride they have reverted to phosphine (M. Stein, Personal communication). Phosphine itself had replaced the use of methyl bromide in bunker and other temporary grain storage structures. Note that sulfuryl fluoride has a high Global Warming Potential of around 5000 (Andersen *et al.* 2009) but is otherwise suited to a wide range of quarantine applications including furniture and personal effects, where the poor effectiveness of sulfuryl fluoride against egg stages of pests at maximum permitted dosages is judged not to present an excessive quarantine risk.

Sulfuryl fluoride is a registered treatment for cereal grains that can be used in a way that it gives similar treatment times to methyl bromide fumigation, including airing times, thus providing a technical replacement for methyl bromide in most of these situations. It is currently in limited use in Australia at point of export as a methyl bromide replacement (*e.g*. Morton Seed and Grain installations, WA).

Sulfuryl fluoride has potential to replace methyl bromide for fumigations of logs, hay, cotton and wood packaging. Where sulfuryl fluoride is a DAWR approved treatment for particular commodities, (particularly to control insect pests of timber), the DAWR accepts certification from offshore sulfuryl fluoride treatment providers in all countries. Significantly, however, DAWR does not yet approve its use for quarantine treatments conducted in Australia. This may change as Australia is a member of the International Plant Protection Convention (IPPC) and in May 2017 the Commission approved sulfuryl fluoride as a treatment for wood packaging (ISPM15) and as a treatment for insects and nematodes ((ISPM 28, annexe' 22 and 23 respectively. (IPPC 2017)).

China, the major log importer, has specific requirements for imported timber, with all logs with bark to be treated using a treatment method approved by the China Inspection and Quarantine authorities (CIQ). These treatments include methyl bromide and sulfuryl fluoride. Log shipments to China from USA can be treated with sulfuryl fluoride prior to shipment (> 10°C 80g/m^3 for 20 hrs) (Jeffers *et al*. 2012). The Australian distributor undertook a successful export trial in 2015, fumigating approximately 2000 containers of logs destined for China, with sulfuryl fluoride.

Hay importers (*e.g*. Japan, South Korea) require phytosanitary certification of consignments. The treatments that are to be used to achieve pest-free status at inspection are not specified. Methyl bromide is generally used for these fumigations because it is an accepted treatment (Hay Export Procedure 2000, (DAWR e. 2017)), together with CO_2, phosphine and sulfuryl fluoride, and it is a rapid process (24hrs versus several days for CO_2 and phosphine). Fumigation of export hay with sulfuryl fluoride, an alternative, rapid fumigant, is permitted but is not recognised under the Hay Export Procedure and treated consignments are subject to more exhaustive sampling than methyl bromide, CO_2 or phosphine treatments, to determine if they are pest free as appropriate to phytosanitary certification. Only those conducted using methyl bromide, phosphine or CO_2 receive the benefit of a reduced inspection rate (DAWR e. 2017). This is considered to be an impediment to a greater uptake for hay fumigations.

Sulfuryl fluoride is potentially a good alternative fumigant to methyl bromide for cottonseed, with lower reaction and sorption problems than methyl bromide, but is not currently registered in Australia for application to oilseeds (application for registration is under consideration).

One treatment provider has reported that sulfuryl fluoride is being used instead of methyl bromide for export almond and pre-shipment hay fumigations (S. Ball, Personal communication).

5.2.3 Phosphine

Phosphine or hydrogen phosphide (PH_3) is a low molecular weight, low boiling point compound that diffuses rapidly and penetrates deeply into materials, such as large bulks of grain or tightly packed materials. The gas is produced from formulations of metallic phosphides (usually aluminium or magnesium phosphide) that contain additional materials for regulating release of the gas.

Phosphine provides an alternative to methyl bromide for Pre-shipment treatments of cotton. Major cottonseed export markets *e.g*. China (MICoR 2017d) and Saudi Arabia (MICoR 2017e) require that the "consignments are to be free from pests, soil, weed seeds and extraneous material" but do not specify use of a particular treatment method to achieve this. Typically, a phytosanitary certificate is required. Cottonseed exports to the USA are required to be fumigated with methyl bromide at a rate of 112 g/m^3 or 80 g/m^3 against a strain of *Fusarium* fungus (MICoR 2017b). The rate to be used is determined by the USA at the time of export. Insect pests present are controlled at the same time. There are no currently recognised alternatives to methyl bromide. Graincorp Brisbane is the only establishment that can carry out the fumigations at the higher rate.

Wood and timber (logs) are well known potential vectors of a variety of insects, other invertebrate pests and fungi that are of quarantine concern to importing countries. Importers of Australian timber typically require phytosanitary certification indicating that consignments are free of quarantine and other pests. Phosphine can be used for log fumigations but the required fumigation exposure period is considerably greater than for methyl bromides (3-4 days compared to 24hrs). The cost and logistics of holding logs in containers for these extended periods render phosphine fumigation unviable (R. Ramlose, personal communication). New Zealand has got around this problem by fumigating bulk logs shipments with phosphine, a complex process requiring on board supervision and fumigant top up but acceptable to China. Application by direct generation of phosphine gas at 200ppm for 10 days, was shown to be an effective replacement for methyl bromide in the fumigation of sawn timber for surface infestations of hitchhiking *Arhopalus* beetles, with possible much wider potential for phosphine use against surface pests of forest produce. Monitoring of fumigant dispersion through the timber stacks, and within plastic wrapped timber packets, showed phosphine to be a far more active disperser than methyl bromide. (Glassey KL. *et al.* 2005).

Phosphine fumigation has been considered unsuitable for fresh produce fumigation because of associated quality damage to the commodity. This damage has now been recognised as caused by ammonia, an impurity, in the fumigant then used. Low temperature phosphine fumigation of export fruit from Chile is in now use as a quarantine treatment on a variety of fruits (Horn *et al.*, 2005). Fruits including apples, grapes, kiwis and berries, pears, nectarines and peaches are treated directly in the cooling chambers where the fruit is stored at -1.5 to 2^{o}C after the selection process. Other fruits like avocados and citrus fruits are preferably treated between 6 and 8^{o}C. While cold chambers need some modification there is no technical reason why this process could not be used in Australia.

5.2.4 Ethanedinitrile (EDN)

Ethanedinitrile (EDN), is a non-ozone depleting gas at standard temperature and pressure. It has a smaller molecular size than methyl bromide, giving it a high rate of diffusion and penetrability making it ideal for fumigation of wet or dry timber (McConville K. 2016). Research shows that is effective against a range of fungi and timber pests including pinewood nematode (B. xylophilus) and pine sawyers (M.alternatus), both timber pests of significant quarantine concern (Park et al. 2014). EDN has the potential to replace the broad spectrum of uses currently covered by methyl bromide.

In 2014 Draslovka Services, the previous manufacturer for the Linde group, took over sole responsibility for development and registration of EDN in Australia and has been working with a number of governments, including New Zealand, where they have in place a long-term study with Plant and Food Research, on registration for post-harvest use, notably timber. This research is co-funded by 'Stakeholders in Methyl Bromide Reduction' (STIMBR) and Draslovka Services and is addressing both chemical registration and phytosanitary efficacy. Registration for use is anticipated in early 2018. Draslovka Services are currently negotiating with China and India for approval for EDN use on timber and with the IPPC for acceptability for ISPM15 treatments. Malaysia has approved EDN for timber treatments at an application rate of 100g/m^3 and registration is underway in Russia and South Korea (K McConville, personal communication). EDN is currently registered for use in Australia at a maximum application rate of 50g/m^3, a rate that as a result of more recent research, is now deemed to be insufficient, consequently Draslovka Services intend seeking a review of the APVMA label approval based on that New Zealand research. Discussions are also taking place with DAWR regarding acceptance of EDN for quarantine purposes and subject to approval EDN has the potential for a significant reduction in methyl bromide use.

Because EDN utilises similar fumigation techniques, it could be considered as a drop in replacement for methyl bromide on timber and logs. EDN and sulfuryl fluoride have the potential between them, to replace the 210t of methyl bromide (30% of consumption) used on logs and timber in 2016.

5.2.5 Low Oxygen

Controlled Atmosphere Treatment involves the lowering of oxygen within a sealed enclosure to a percentage low enough to kill all stages of the insect life-cycle: adults, larvae, pupae and eggs. Either nitrogen or CO_2 are introduced into the chamber to displace the oxygen. Compared to CO_2 nitrogen the have the advantages of less complexity, lower maintenance and cost and being more environmentally friendly. The process is not suitable for fresh fruits and vegetables but is entirely suitable for cereal grains, nuts, and inert materials such as museum specimens and antiques that may be damaged by exposure to chemicals or heat. The treatment process takes 3 – 14 days and must be carefully monitored. Monitoring and control of the chambers can be carried out onsite or from a central offsite location and a number of companies have been established overseas to carry out this process.

One such company is EcO_2 Solutions who have a Controlled Atmosphere and Heat Treatment facility in Binh Duong, Vietnam, where products are placed in one of five airtight chambers or silos. Nitrogen is introduced to reduce the oxygen level to the required level. Oxygen levels and temperatures are controlled from a central facility (EcO_2 2017). Another such company is Van Van Amerongen specialising in CA technology and operating in over 50 countries with its ZerOx® controlled atmosphere technology. The ZerOx® system can be attached to any hermetically sealed space, e.g. a storage room, container, silo, tent or bag and filters out the oxygen to below 0.5%, inside the sealed chambers, using an N2 generator/oxygen (O2) scrubber (ZerOx®).

There are no environmental or technical barriers to uptake of this technology in Australia. Cost and logistic delays may be the major issue.

5.2.6 Heat treatment

The current version of ISPM 15 (IPPC 2017) encourages the use of heat treatment (conventional steam heating, kiln-drying, heat-enabled chemical pressure impregnation and dielectric heating) as an alternative to methyl bromide. Heat treatment systems have a higher infrastructure cost than methyl bromide due to the requirement for a chamber and heating and continuous monitoring system. Such systems have been shown to be cost effective and practical in many locations (MBTOC 2014) and heat treatment is widely used internationally on solid wood packing materials, with many countries using this process exclusively to meet ISPM 15. There is a question regarding the global warming potential of CO_2 arising from some heat sources such as timber offcuts, petroleum products and electricity produced utilising fossil fuels, however, modern natural gas plants emit 50-60% less CO_2 than an equivalent coal fired plant (although leakage rates also need to be taken into consideration), (Union of Concerned Scientists 2017) and electricity derived from renewable sources offers a clean and non-polluting alternative.

Methyl bromide is still being used in Australia for ISPM15 but with increasing adoption of heat treatment using electrical or gas heating. Heat treatment to a similar level to that required by ISPM15 appears a feasible alternative to methyl bromide where imported wood packaging is on its own or is associated with heat stable materials capable of withstanding temperatures up to 65˚C without unacceptable damage or degradation. The DAWR approves heat treatment and kiln drying for timber products (DAWR g. 2017).

Heat treatment is especially suited to treatment of commodities with a low thermal mass and high conductivity. Vehicles, caravans, boats and shipping containers can be brought to the required temperature of 60-65°C in 10 minutes by circulation of heated air. This procedure is commonly carried out in New Zealand for quarantine purposes, using a diesel powered heat source, (*e.g.* Biovapor Heat Treatment System, Genera 2017). The system provides a rapid treatment, taking approximately 20 to 30 minutes from start to finish and can be performed in fixed or mobile chambers. The Biovapour system is not suited to commodities with high thermal mass, good insulating properties or high water content, making it unsuitable for logs. (M Self, personal communication).

Joule heating, a process utilising a direct electric current to heat logs, is currently under development in New Zealand. The treatment is seen as non-polluting and sustainable but has yet to be scaled up for commercial use (STIMBR 2017).

Vapour heat treatment and hot water dipping offer acceptable alternatives to methyl bromide for some fruits and vegetables for example Indian mangos (DAWR h. 2017). However, it needs to be noted that all these import and export conditions for fruits and vegetables require negotiation on a case by case basis.

5.2.7 Cold Treatment

Cold treatment involves holding commodities at temperatures between 3°C and 0°C for 14 or more days and is an effective treatment against a range of pests other than cold climate insects. Freezing to minus 18°C is an effective method of killing many insects and can be used against wood borers, and *dermestid* beetles in museum specimens and antiques (Canadian Conservation Institute). The major limitations to cold treatments are the infrastructure costs, the long exposure time and unsuitability for tropical and some temperate fruits due to quality issues. Subject to state agency acceptance, cold treatment is useful for interstate quarantine of fruits and vegetables, particularly control of fruit fly. There is international interest in cold treatment as phytosanitary measure and a 'Phytosanitary Temperature Treatments Expert Group' has been formed under the auspices of the IPPC to bring a multi-disciplinary approach to temperature related problems of global significance through scientific analysis and review (IPPC 2013).

5.2.8 Irradiation

Irradiation has gained increasing acceptance as a phytosanitary treatment in recent years, and the application of irradiation to control arthropods in fresh commodities, stored products and ornamentals has grown. Irradiation has several major advantages over other post-harvest treatments and whereas development and approval of heat, cold and fumigation treatments involves generating data for each fruit- pest combination, irradiation treatments are developed for a pest species irrespective of commodity. It is the ideal technology for developing "generic" treatments (IAEA 2002). In Australia Irradiation is now an acceptable treatment for fruit fly and a range of other crops including tropical fruits (bread fruit, carambola, custard apple, longan, lychee, mango, mangosteen, papaya and rambutan) (Leach 2012)

5.2.9 Other treatments

Carbonyl sulfide offers an alternative to both methyl bromide and phosphine as a grain fumigant. Unlike sulfuryl fluoride it appears to be suitable for a range of foods, models suggest that fumigation exposure times for carbonyl sulfide will be a compromise between those of methyl bromide (typically 24h) and phosphine (7-10d) to achieve a very high kill of all pest developmental stages (Wright E J. 2003). Ethyl formate and ethyl formate/CO_2 mixtures, propylene oxide are likely to present technically effective alternatives to methyl bromide for some use categories.

Propylene oxide has been approved as a disinfestant and sterilant for almonds and has the potential to replace methyl bromide directly for treatment of this and other similar commodities.

5.3 Barriers to adoption of alternatives

The main barriers to the adoption of alternatives to methyl bromide are proof of efficacy and safety, acceptance by importing and exporting agencies, lack of legislated or financial incentives, interference with logistics and cost.

Proving the efficacy and safety of an alternative is the first step in obtaining acceptance of any quarantine treatment and it can be a prolonged, difficult and costly process. Methyl bromide has been in use for so long that it is considered to be effective against a wide range of species which may or may not have undergone the rigorous efficacy testing that is now required for replacements. The accepted standard for biosecurity purposes is Probit-9, (100% mortality of 93,613 test organisms). Obtaining the required number of individual specimens can be extremely difficult as many are hard to breed in laboratory conditions. Additionally, there are literally thousands of insect species to be tested, unless agreement can be reached on a more limited number of representative species. The appropriateness of Probit-9 is now being questioned and alternative approaches offered which should facilitate efficacy testing (Haack. *et al*.2011 and Schortemeyer *et al*. 2011).

In Australia responsibility for approval for use of substance or technique as a biosecurity treatment rests with DAWR in terms of efficacy and with APVMA for registration for use. There is no single entity with responsibility for intra or interdepartmental coordination of the approval process, which can make it make it difficult for interested companies to navigate the overall approval process.

Approval of treatment does not mean automatic acceptance by trading partners and DAWR and export bodies may need to engage in trade negotiations to change accepted protocols or standards. Commodity, operational and premise' standards together with appropriate inspection and audit regimes may also need to be developed. A time saving measure would be to develop these, particularly the latter group, as part of and during a properly coordinated approval process.

The incentives for a company to seek registration of an alternate technology or treatment in Australia are purely commercial and may be limited by market size. Australia has no obligation under the Montreal Protocol to phase out the use of methyl bromide for quarantine and pre-shipment treatment. There are no legislated or government financed incentives to seek out or adopt already approved alternatives other than the $130 per tonne cost recovery levy on methyl bromide.

In the absence of specific regulation, the actual take up of approved methyl bromide alternatives is affected by competitive forces and technical constraints. If companies cannot compete on cost, whether material, operational or logistical, then uptake is unlikely. A major exporter of logs has indicated that the decision not to replace methyl bromide with sulfuryl fluoride is entirely based on the material cost (D. Canham, personal communication). Interestingly, the sole importer of sulfuryl fluoride has difficulty in matching the cost of methyl bromide due to the downward price pressure placed on the latter though competition by multiple importers (M. Stein, Personal communication).

Phosphine has not replaced methyl bromide for a number of possible applications due to the longer exposure time that is required; 7 days compared to 12 -24 hours for methyl bromide. As an example, containers for hay are in most instances, only available with a three day turnaround from the time the containers arrive. Filling, fumigating and venting with phosphine is not possible within this time frame (T. Guidera, personal communication). Holding containers for the required time would result in significant additional demurrage costs.

It is noted that regulation in the form of emission standards for consumer or workforce protection is resulting in increased interest in alternatives and recapture in Australia and other countries, such as New Zealand where mandatory recapture or destruction of methyl bromide will be required by October 2020 (Ministry for Primary Industries - New Zealand, 2017).

6 Recapture technologies for methyl bromide

6.1 Background

Recapture of methyl bromide provides a means of restricting emissions of the ozone-depleting substance to the atmosphere after it has been used in a fumigation. Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer, including Australia, are urged under Decision VII/5(c) dealing with QPS uses to minimise emissions and use of methyl bromide through containment and recovery and recycling methodologies to the extent possible while XI/13(7) asks Parties to "encourage the use of methyl bromide recovery and recycling technology (where technically and economically feasible) until alternatives to methyl bromide for QPS uses are available".

Recapture technologies need to be able to remove fumigant concentrations of methyl bromide from the atmosphere remaining in a fumigation enclosure. Fumigant concentrations post treatment can vary from a maximum of about 120 g/m^3 down to about 10 g/m^3 at the end of treatment. Limits on the concentration discharged to the atmosphere may be specified as low as 5 ppm v/v or even less.

6.2 Available recapture technologies.

6.2.1 Recovery and reuse

Recovery and reuse of methyl bromide is, in theory, the easiest of all the recapture technologies to implement. Methyl bromide can be captured on activated carbon scrubbers, condensed and reused or simply pumped from one chamber to another at the end of the requisite contact period and topped up to the appropriate concentration for the next fumigation. The author has personal knowledge of such a plant in Shanghai, China, used for treatment of timber and plants, where fumigant use is said to be reduced by 30%.

Potentially, the sorbed methyl bromide can be released from the carbon for reuse or reclamation. The methyl bromide can be stripped from the carbon by heating with steam, hot gases, electrothermally (Yuanqing Li. *et al*. 2016) or by microbial degradation (Schafer H. *et al*. 2007, Miller l G. *et al*. 2003). In practice recapture and reuse has problems of taints carried from one commodity to the next and the cost of desorbing and concentration makes it difficult to match the comparatively low cost of commercially available methyl bromide. Registration requirements for methyl bromide do not allow captured methyl bromide to be reused in Australia due to admixture with other gases and contaminants (APVMA 2007).

6.2.2 Recovery and disposal

Activated carbon systems retain the captured methyl bromide unchanged. The carbon is subsequently disposed of by deep burial or incineration. The largest operator of recapture systems in Australia, Nordiko Quarantine Systems has developed a range of techniques for fumigant extraction and container venting that are adaptable to containers, chambers and tarped systems and claim to have systems in operation in over 20 countries (Nordiko 2017). They offer both recovery and disposal or recovery and destruction, however, the majority of users dispose of the carbon by deep burial (W. Grullemans, 2017 personal communication). Activated carbon can adsorb relatively large amounts of methyl bromide, the actual ratio varying from 1kg of methyl bromide per 10 – 20kg activated carbon, depending on the carbon quality (Leesch *et.al*. 2000) . Deep burial in a landfill site provides a highly active decomposition environment where the methyl bromide is decomposed through hydrolysis, reaction with organic materials containing active nucleophiles and possibly through bacterial action (MBTOC 2010, Oremland *et al*. 1994).

6.2.3 Recovery and destruction

There are no methyl bromide destruction technologies approved by the Montreal Protocol as at September 2017.

In recovery and destruction processes methyl bromide is extracted from the fumigation enclosure captured on activated charcoal or by liquid scrubbing and then broken down using potassium thiosulphate or electrochemically. These process' have the environmental advantage of reducing up to 96% of the captured methyl bromide to harmless substance. The company Value Recovery, extract air from the container over a carbon bed which traps the methyl bromide, the gas is subsequently drawn off over a liquid scrubber containing potassium thiosulfate breaking the methyl bromide down into potassium methyl thiosulfate and potassium bromide. Value Recovery claim that this process allows the carbon bed to be reused every 24 hours, saving the cost of carbon replacement (Value Recovery 2017).

Improvements have been recently reported in the process of debromination, using electrochemical techniques that could reduce the cost of treatment to US$5/kg a claimed one third of current alternatives (Yuanqing *et al*. 2016).

Biodegradation of methyl bromide using methyl bromide oxidising bacteria has been demonstrated in a closed system bioreactor at 100% efficiency (Miller l G. *et al*. 2003) but has yet to be brought to commercial scale.

Table 8 lists current and near commercial suppliers of methyl bromide recapture equipment. Activated carbon-based scrubbing systems use various reactivation, decomposition and disposal systems, as appropriate to local waste and hazardous substances regulations. These include thiosulphate washing or landfill disposal (Nordiko), heat regeneration and scrubbing of evolved methyl bromide in thiosulphate solution (Value Recovery) incineration or thermal destruction offsite with recovery of bromine (TIGG) and gas-liquid fumigant scrubbing by an undisclosed process (Genera). Genera have advised that its new scrubbing technology will be available in Australia within 12 months (R. Ramlose. personal communication).

A South Australian registered company, Scrubbing Fumigants Pty Ltd, is developing with the aid of a state government grant, a scrubber based recapture and destruction system for methyl bromide and sulfuryl fluoride. It is intended that system be commercially available in 2018.
The Insects Ltd system (Swords et al. 2012) is said to be able to decompose not only methyl bromide but also sulfuryl fluoride and phosphine. The active constituents of the liquid scrubbing system have not been disclosed and the system may no longer be available.

Mebrom Research & Development is in the final stages of developing a range of portable and or fixed commercial scale Gas Destruction Units (GDU) to destroy the fumigant gases methyl bromide, sulfuryl fluoride, and phosphine through a patented thermal decay and scrubbing process within which the fumigants are destroyed and converted into harmless salts that can be utilized in a myriad of commercial manufacture and industrial processes.

Trials have indicated that destruction rates of 99.99% are consistently achievable with process integrity and operator safety assured through sophisticated electronic control and monitoring systems. Machines with throughput capacities of 3,600, 5,000, 12,000 and 16,000 cubic metres per day are slated for production in the latter part of 2017.
The gas destruction system is supported by a range of ancillary equipment that permits fumigators to undertake fumigations and safely extract the fumigant from the fumigation enclosure without release of any fumigant to the atmosphere (K. Bartolo, personal communication).

Table 8. Commercial suppliers of methyl bromide recapture systems.

Scrubbing system	Company	Address	Reference or webpage
Activated carbon	Nordiko Quarantine Systems Pty Ltd	403 Pacific Highway, Artarmon, Sydney, NSW 2064 Australia	www.nordiko.com.au
Activated carbon	TIGG Corporation	1 Willow Ave, Oakdale, PA 15071, USA	www.tigg.com
Activated carbon	Value Recovery, Inc.	525 Route 73 North, suite 104, Marlton, NJ 08053, USA	www.valuerecovery.net
Liquid reactant	Insects Limited	16950 Westfield Park Road ,Westfield, IN 46074, USA	www.insectslimited.com
Liquid reactant	Genera	11 Maru Street, Mount Maunganui, NZ	www.genera.co.nz

<u>*6.3 Barriers to adoption of recapture technology*</u>

The barriers to adoption of recapture technology are cost, inconvenience, commercial competitive pressure and lack of incentives. Installation and use of recapture equipment by the Australian fumigation industry is currently seen as an additional cost to the price of a fumigation treatment with a consequential loss of business to companies that are not carrying the same cost burden. The largest Australian user of Nordiko systems, Newcastle Grain terminal has treated more than 1 million tonnes of grain since installing the system and claims it is cost effective solely because of the presence of an adjacent air separation plant (P. Clamp, personal communication).

Early recapture systems were inconvenient to use, requiring specialised chambers or containers; more recently, mobile treatment and venting systems and lightweight fittings for standard containers and sheeted enclosures have been developed that enable recapture to be undertaken anywhere. Never-the-less establishing the infrastructure to deal with, for example, 150 to 200 containers of logs per day, would involve considerable expense and, according to a number of respondents to the survey is impractical (T. Guidera, personal communication).

Disposal of activated charcoal post recapture remains an issue. Recapture can generate relatively large quantities and while methods exist for destruction or deactivation (see 6.2 above), as Banks (2010) noted, 'handling of waste products from recapture on carbon is at present difficult. Local health safety and hazardous waste regulations restrict the choice of how best to reactivate or dispose of the fumigant-laden carbon from activated carbon-based systems. Additionally, there are no 'approved destruction technologies' for methyl bromide in the sense of Decision XV/9 of the Montreal Protocol that would allow some 'credit' for quantities of methyl bromide destroyed.' This situation has not changed. While recovery and reclamation of the sorbed methyl bromide is, at present, uneconomic though technically feasible, it would not meet APVMA requirements concerning purity and could not be reused.

The costs of installation, hire and utilisation of recapture systems is substantial. The APVMA reported that some fumigators had calculated that the lease and filter costs for recapture systems for them, plus extra work hours to mount, monitor and operate recapture systems, could be in the order of $500,000 to $750,000 pa (as at September 2006) (APVMA 2007). Even if the costs were to be reduced through efficiencies of production scale or technology, fumigation companies will need to recover the costs through an increase in charges to the customer, placing them at a disadvantage to fumigators who are not carrying such costs.

The main driver for uptake of recapture systems is undoubtedly the imposition of air quality and worker safety standards, with no system known to have been commissioned specifically for ozone-layer protection (MBTOC 2014). These standards can be seen as driving both development and uptake of recapture technologies and could result in more competitive pricing. State air quality regulations have underpinned installation of recapture units at fresh produce markets in Sydney, Brisbane and Melbourne as well as at Perth airport. New Zealand's decision to require all methyl bromide emissions to be captured by 2020 is driving a rapid uptake of recapture systems and development and reconsideration of alternatives.

6.4 Potential quantities of methyl bromide available for recapture

Methyl bromide is intended to be applied in gas tight enclosures; the AQIS Methyl Bromide Fumigation Standard (2015) requires a retention of 30% or more of initial dosage, though top up is allowed if the level falls below the trend that would result in less than this value, and international standard ISPM 15 for fumigation of wood packaging material (IPPC 2017) requires a minimum retention of 50% of initial dosage at 24h. The actual retention rates of gas available for recapture will be affected by loss due to ambient air temperature and wind speed and the percentage of the applied gas that reacts with constituents of the commodity to produce non-volatile residues.

The proportion of the added methyl bromide that reacts with the fumigated commodity to produce bromide ion and other non-volatile constituents is dependent on the commodity and its state, particularly its temperature and moisture content and sets the upper limit on quantities of methyl bromide that are theoretically available for recapture.

The applied methyl bromide lost to atmosphere in absence of recapture measures for fumigation of commodities, including timber, was estimated by MBTOC (2007) to be about 82% (range 76 – 88%).

Commercial recapture systems all claim to capture at least 95% of methyl bromide present in the enclosure at the end of the fumigation exposure period. Considering these practical constraints, TEAP (2002) estimated that 70% of applied material could be recovered from structure, commodity and QPS fumigations. As already discussed, the actual figure can vary significantly from this.

Taking these factors into consideration and assuming an actual loss to atmosphere of 82% of the initial methyl bromide added to a fumigation, Australian QPS use of 651 tonnes of methyl bromide (QPS consumption for 2016, Table 5) in 2016 resulted in approximately 534 metric tonnes of emissions of methyl bromide. Assuming an estimate of 70% of applied methyl bromide can be recovered from QPS fumigations at a 95% efficiency, 433 tonnes of the Australian on-shore QPS use of 651 tonnes of methyl bromide could have been recaptured (Table 9). In total, there were a potential 1538 metric tonnes available for recapture and destruction over the survey period.

Table 9: Estimate of methyl bromide loss to atmosphere and potential for recapture from QPS use 2013 – 2016 - metric tonnes.

Year	2013	2014	2015	2016
Estimated use	596	434	631	651
Estimated loss	489	356	518	634
Potential for recapture	396	289	420	433

7 Suggestions for survey improvements

In considering ways in which this survey could be improved two issues stand out. The first is the length of time between surveys. While most respondents were able to provide data going back four years there were some complaints and if it were possible, shorter periods between surveys may enable greater engagement by users and increased accuracy.

The issue most frequently mentioned by users as a concern was the number of agencies which collect information on methyl bromide use; indeed, there is some confusion in user's minds as to which agency collects what information and its use. DAWR gathers its AIMS data as record of completion of treatment of imported goods under quarantine direction. That record, the record of fumigation, includes a description of the goods, dose rate and quantity applied. Although the initial quarantine direction is in an accessible database, the record of fumigation is scanned, but not entered. On the export side, a Notice of Intention to Export Prescribed Goods must be presented to and approved by an authorised officer, under the terms of the Export Control Act 1982. This notice provides information on goods descriptions, the place and date of departure and the destination, together with a statement of compliance with regulatory conditions. Entered into EXDOC it is possible at a later date, to extract commodities by tonnage, date and destination. Methyl bromide use can only be extrapolated from this data based on potential use for specific destinations.

DoEE requires users to maintain detailed records of every fumigation in addition to a summary record of use. In the main these records are intended to mimic record keeping requirements under other Commonwealth, state or territory laws, to prevent duplication. These records potentially capture all methyl bromide use, QPS and non QPS and include information on the date, commodity treated and total usage. Obtaining these records may assist in any future surveys. Individual state authorities may capture similar data.

Some element of coordination of this information across the agencies should enable more accurate and accessible data collection. Without undertaking a thorough investigation of costs, benefits and practicalities of the matter, it does seem possible that it would be feasible and that the cost of doing this could be borne by a levy (fee for service/ozone regulations) as discussed under barriers to uptake of alternatives (Part 5.4).

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APPENDIX A

Survey form

Summary of methyl bromide use by commodity or situation treated.

Treated commodity/material/situation	**Class**	2013	2014	2015	2016
		tonnes used			
Boats	Domestic				
Branched broomrape	Domestic				
Buildings	Domestic				
Cereal grains	Export				
Cottonseed	Export				
Dried fruit	Import				
Empty grain ships	Export				
Equipment	Import				
Flours and meals	Import				
Flowers, bulbs and plants	Import				
Fresh fruit and vegetables	Export				
Fresh fruit and vegetables	Import				
Furniture and personal effects	Import				
Hay	Export				
Mills	Domestic				
Steel and steel scrap	Import				
Tobacco	Export				
Tyres	Import				
Wood and timber	Export				
Wood and timber	Import				
Wood Packaging	Import				
Wood Packaging, including ISPM 15	Export				
Other uses (> 50kg a year)	Import				
Other uses (> 50kg a year	Export				
Total miscellaneous minor uses (each <50kg year)					
Undefined uses (use not recorded)					
TOTAL USAGE					