Part A: SUMMARY

1. NOMINATING PARTY: AUSTRALIA

2. NAME AS PER NAMING CONVENTION (Section 3.5.2 of this Handbook)

AUS02 CUN18 Soil Strawberry Runners

3. BRIEF DESCRIPTIVE TITLE OF NOMINATION:

Re-application by the strawberry runner industry of Victoria, Australia, for critical use exemption in 2018 from the phase-out of methyl bromide (MB).

4. SOIL SITUATION OR STRUCTURE, COMMODITY OR OBJECT TREATED:

Soil fumigation for the production of strawberry runners in Victoria, Australia.

5. QUANTITY OF METHYL BROMIDE REQUESTED IN EACH YEAR OF NOMINATION:

2018 – 29.76 tonnes

6. SUMMARY OF ANY SIGNIFICANT CHANGES SINCE SUBMISSION OF PREVIOUS NOMINATIONS:

This nomination is for 29.76 tonnes of MB for soil disinfestation in the Victorian Strawberry Runner Industry (see Appendix I) at Toolangi in 2018. Soils in the industry are uniquely high in organic matter (5-10%) and clay content (>50%), and fumigation occurs under cold (5-10°C), wet conditions. These conditions favour the retention of registered alternative fumigants in soil, (including chloropicrin (Pic), 1,3-dichloropropene (1,3-D) and metham sodium (MITC)), and have contributed to regular incidences of phytotoxicity in strawberry runner crops (up to 40% plant losses) when using these fumigants [AUS02 CUN16, A19]. Recent research also shows that alternative fumigants do not provide the same level of control of pathogens as MB/Pic, particularly at greater soil depths (30-40 cm depth). Therefore, current alternative fumigants are not technically feasible for use by the runner industry.

The industry has adopted soil-less systems as an alternative to soil fumigation for production of the early generations of runners, which are known as the Nucleus and Foundation generations in the Victorian Strawberry Runner Certification Scheme (hereafter termed the multiplication Scheme). Production by soil-less systems is not technically or economically feasible for growing later generations of runners in the multiplication Scheme, known as Mother and Certified generations (see Part C & E for details). These involve larger number of runners, up to 1 million for Mother and 60 million for the Certified generations.

There are five significant developments since submission of AUS02 CUN17:

1. ***Diseases caused by Macrophomina and Fusarium spp. have continued to spread and are serious threats to the strawberry fruit industry where MB has been phased out.***

   Macrophomina phaseolina and *Fusarium oxysporum* f.sp. *fragariae* are soil-borne pathogens of strawberry that cause wilt diseases and plant deaths. Prior to 2006, these pathogens were well controlled in the strawberry fruit industry by MB/Pic-fumigation. By 2014, serious disease outbreaks caused by *Macrophomina* and *Fusarium* spp. occurred in the strawberry fruit industry in southern Victoria and on the Sunshine Coast in Queensland [AUS02 CUN17 A22, A23]. In Western Australia, the incidence of Fusarium wilt in strawberries has steadily increased since the phase-out of MB (https://www.agric.wa.gov.au/strawberries/crown-and-root-rot-diseases-strawberries). Similar outbreaks of crown rots caused by *Macrocphomina* and *Fusarium* spp. have occurred in strawberries in other regions of the world where MB has been phased-out (e.g. Avilés et al., 2008; Zveibil et al., 2012; Koike et al., 2013).

   Three independent laboratories (Victorian Department of Environment and Primary Industries, Queensland Department Agriculture, Fisheries and Forestry, and Victorian Strawberry Industry Certification Authority) confirmed disease outbreaks caused by *M. phaseolina* and *F. oxysporum* in strawberries in southern Victoria in 2014. Surveys conducted by the Victorian fruit industry showed that the diseases occurred on 20% of strawberry properties and caused plants losses of 15-30% on these sites. Infected sites have increased in 2015, with *M. phaseolina* now confirmed in strawberries on fruit farms just 15 km from the Toolangi Plant Protection District (where Certified strawberry runners are grown).

   In response to the outbreaks, the Victorian strawberry fruit industry approached Commonwealth and State governments to ascertain the process for applying for an emergency-use permit for MB to manage the problem. However, industry decided not to apply for emergency-use, based mostly on the fact they could still access clean planting material grown in MB/Pic-treated soil from the Victorian runner industry, and newly proposed research to find improved treatments for *M. phaseolina* for the fruit industry. Note that although *M. phaseolina* is primarily transmitted in soil, infected runners may also transmit the pathogen, and the use of clean runners is considered best practice in managing the disease (Koike et al., 2013).

   Currently, MB/Pic is the only fumigant proven to eradicate *Macrophomina* in infected strawberry debris in soil in Australia (Hutton et al., 2013). Therefore, the continued critical-use of MB in the Victorian strawberry runner industry is now considered more important than ever, until new treatments are developed that can control *M. phaseolina* and *F. oxysporum* to equivalent levels as MB/Pic. This is especially the case given that *Macrophomina* outbreaks in strawberry fruit industry are so close to the strawberry runner industry, and the potential for this pathogen to be carried in soil.

2. Study tour of the South African strawberry nursery industries completed.

Representatives of the Toolangi Certified Strawberry Runner Growers Co-operative (TCSRGC) and Victorian Strawberry Industry Certification Authority (VSICA) visited South Africa in February 2015 to study the production of strawberry runner tips and plug transplants in soil-less media, and to identify technologies to be investigated for the economical production of tips and plugs in the Victorian multiplication Scheme. The tour members also observed control of weeds and soil-borne diseases in strawberry fruit crops grown in soil treated with alternatives to MB. They visited the four main nurseries in the country (at Brits, Ceres and George) and six fruit cropping enterprises (at Brits, Stellenbosch, George and Hankey).

There was considerable variation in the systems for production of runner tips and plug transplants in soil-less media. Variables included the type of vertical support structures and gutters used for growing mother plants for the production of tips in semi-hydroponic systems; the distance between rows of hanging runners/stolons and between mother plants in gutters; the type and size of protective netting; the composition of soil-less mix and size of pots for plug production; the methods of growing the plug plants; and the general nursery management practices.

The cost of production of plug plants was generally 1.4 times more expensive than that for bare rooted runners. The production of plug plants for fruit production was not prohibitively expensive because of the relatively cheap costs of labour (A$11/day i.e. less than A$1.50/hr) and infrastructure etc.

None of the technologies used for the production of tips and plug plants in soil-less systems in South Africa is immediately transferable for the economic production of plug transplants in Australia. However, the findings of the visit have been useful in designing experiments to further investigate the feasibility and economics of production of plug plants under environmental conditions and costs of labour, capital and infrastructure in Victoria (see Part C 8g).

The tour group observed considerable weed and disease problems in all the fruit crops inspected (e.g. Phytophthora and black root rots), and growers suggested that the problems were far greater since MB was withdrawn from use in South Africa.

3. The weed Raphanus raphanistrum (wild radish), which is controlled by MB/Pic, has tested positive for the green petal phytoplasma of strawberry.

Candidatus Phytoplasma australiense causes green petal and lethal yellow diseases of strawberry in Australia and New Zealand, and infected plants fail to flower and produce fruit. The insect vector of the phytoplasma is not known. The Victorian Strawberry Runner Certification Scheme has set threshold levels for green petal disease that meet Certification standards (maximum of 5% of infection per crop), based on inspection for symptoms. However, infection can remain symptomless until after runners are harvested and planted in fruit fields. Green petal disease is being found more regularly in runners at Toolangi than in the past, and this is causing concern in the runner and fruit industries.

Victorian government scientists have initiated a project on the epidemiology and control of green petal disease, including a survey to identify alternative hosts (weeds,

cover crops and native plants). In this survey, the weed *Raphanus raphanistrum* (wild radish) sampled from Toolangi tested positive to the phytoplasma using molecular methods. This is the first time this weed species has been implicated as a potential alternative host of *Ca.* Phytoplasma australiense.

The identification of *Ca.* Phytoplasma australiense in *R. raphansitrum* at Toolangi highlights the importance of weed management in the runner industry, not only for high yields, but also for disease management. *Ca.* Phytoplasma australiense is not soil-borne, but soil fumigation with MB/Pic is highly effective at killing *R. raphanistrum*. This case provides an example of why equivalent weed control with alternative fumigants to MB/Pic is essential for production of strawberry runners. Current research has identified promising herbicide and fumigant combinations that can control weeds to equivalent levels as MB/Pic, but these products are not yet registered and available to runner growers for use (see Part C).

4. The second year of a three-year research program on MB alternatives is completed.

In December 2013, the federal government's Research and Development Corporation, Horticulture Australia Limited (HAL, now Horticulture Innovation Australia), confirmed co-funding for a new 3-year research program on MB alternatives for strawberry runners [AUS02 CUN16 A20]. This complemented funding already provided by the runner industry, which allowed the research program to commence in 2013. The Victorian Strawberry Industry Certification Authority (VSICA) is conducting the program, and has employed a full-time research leader (Dr Scott Mattner) to implement it, with input from Dr Frank Greenhalgh, Mr Mirko Milinkovic, Dr Peter Merriman, and Ms Corina Horstra.

The program requires the use of MB/Pic for soil disinfestation for comparative research purposes (i.e. as a positive control). As such, the allocation of MB to VSICA previously used for soil disinfestation in the production of Foundation stock is now used for research purposes, and is not a contingency use.

The aims of the research program are to '(1) develop new systems from combinations of existing and new chemistries (especially application of Pic or 1,3-D combined with MITC, and herbicides), and (2) examine the technical and economic feasibility of soil-less systems for production of runners that avoid the need for soil fumigation'.

Key progress from the second year of trials (2014/15) included:

- Co-application of alternative fumigants (PicPlus® and TF-80®) with the herbicides isoxaben and phenmedipham, increased weed control and runner yields in replicated trials to levels equivalent to MB/Pic (see Part C). TF-80®, isoxaben, and phenmedipham are not yet registered for use in the strawberry industry in Australia, and not available for use by runner growers.
- TF-80® (1,3-D/Pic, 20:80) showed great promise in trials in reducing the risk of phytotoxicity occurring in strawberry runners grown in soils at Toolangi because of its low concentration of 1,3-D. Residues of 1,3-D dissipated at least 42 days earlier in plots treated with TF-80® than in plots treated with Telone C-35® (1,3-D/Pic 65:35) (TC-35®). Plant-back times (the time required between fumigation and planting) determined in trials conducted in Spring were much shorter for TF-80® (2.4 weeks) than TC-35® (6.2 weeks).

TF-80® is not yet registered for use in Australia, and not available for use by runner growers.

Remaining research challenges include:

- All fumigant alternatives were significantly less effective for pathogen control, particularly at greater (30-40 cm) soil depths, compared with MB/Pic (see Part C for details). This means that there are no alternative fumigants currently available that are technically feasible for producing Certified runners. High levels of pathogen control are essential for production of Certified runners to meet phytosanitary standards, and to manage the risk of litigation against the runner industry (see AUS02 CUN16; AUS02 CUN17). To address this issue, new research established in 2015/16 is investigating deeper injection of alternative fumigants, the use of barrier films (VIF and TIF), and co-application of alternative fumigants with MITC generators and biofumigants (see Part C for details).
- Partial budget analysis shows that soil-less systems (production in bins of substrate) are not economically feasible for runner production in Australia, compared with bare-rooted runners produced in MB/Pic-treated soils (see Part E for details). In addition, trials in 2014/15 showed that the fruit yields from plug plants produced in hydroponic systems are highly inconsistent, and therefore not technically feasible for adoption by the fruit or runner industries. The development of methods to increase tip yields in soil-less systems for production of plug plants is considered important for reducing the relative costs of production [A27]. The development of conditioning treatments to improve the consistency of fruit fruit yields from plug plants is also essential. To address these issues, current research established in 2015/16 is investigating: (1) the use of micro-propagated mother plants for tip production, (2) different hydroponics designs for tip production, (3) higher planting densities for tip production, and (4) artificial chill treatments on tips and plugs and their effects on fruit yields.

Despite recent progress and targeted new research to address the remaining challenges, there is no guarantee that the research program will develop technically or economically viable alternatives, or generate sufficient data to support registration of new alternatives, by its scheduled completion date in 2016. Therefore, planning is underway with key stakeholders to continue the research program beyond 2016.

5. New fumigant alternatives imported into Australia.

The alternative fumigants propylene oxide (98%) and propylene oxide / chloropicrin (67:33) are being imported into Australia for trials in the strawberry runner industry in 2016/17. Research in the IR-4 program in the USA has shown that these fumigants can control soil-borne fungal and nematode pathogens of strawberry, and weeds (Norton, 2007). It is hypothesised that these fumigants may be effective alternatives to MB in the runner industry at Toolangi, due to their low boiling point and high vapour pressure, which makes them more suitable for application in clay soil types.

Changes in the status of key alternatives and emission reduction strategies are summarised below, and further elaborated on in the main document.