The NRA review of

PARATHION-METHYL
Interim Report

Volume I

March 1999

Existing Chemicals Review Program

National Registration Authority
for Agricultural and Veterinary Chemicals

Canberra
Australia
FOREWORD

The National Registration Authority for Agricultural and Veterinary Chemicals (NRA) is an independent statutory authority with responsibility for the regulation of agricultural and veterinary chemicals.

The NRA’s Existing Chemicals Review Program (ECRP) systematically examines agricultural and veterinary chemicals registered in the past to determine whether they continue to meet current standards for registration. Chemicals for review are chosen according to pre-determined, publicly available selection criteria. Public participation is a key aspect of this program.

In undertaking reviews, the NRA works in close cooperation with advisory agencies including the Department of Health and Aged Care (Chemicals and Non-Prescription Drug Branch), Environment Australia (Risk Assessment and Policy Section), National Occupational Health and Safety Council (Chemical Assessment Division) and State Departments of Agriculture.

The NRA has a policy of encouraging openness and transparency in its activities and community involvement in decision-making. The publication of evaluation documents for all ECRP reviews is a part of that process.

The NRA also makes these reports available to the regulatory agencies of other countries as part of bilateral agreements or as part of the OECD ad hoc exchange program. Under this program it is proposed that countries receiving these reports will not utilise them for registration purposes unless they are also provided with the raw data from the relevant applicant.

This report covers the review of parathion-methyl that has been conducted by the NRA and its advisory agencies. The review’s findings are based on information collected from a variety of sources, including data packages and information submitted by registrants, information submitted by members of the public, questionnaires sent to key user/industry groups and government organisations, and literature searches.

The information and technical data required by the NRA to review the safety of both new and existing chemical products must be derived according to accepted scientific principles, as must the methods of assessment undertaken. Details of required data are outlined in various NRA publications.

The full review report on parathion-methyl, containing assessments completed by the NRA and its advisory agencies, is also available. It can be viewed free of charge in the NRA Library, on the NRA web site http://www.affa.gov.au/nra/welcome.html or obtained by completing the order form in the back of this book.

Other publications explaining the NRA’s requirements for registration can also be purchased or obtained by contacting the NRA. Among these are: Ag Requirements Series; and the Vet Requirements Series.
## ABBREVIATIONS AND ACRONYMS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>µg</td>
<td>microgram</td>
</tr>
<tr>
<td>ACPH</td>
<td>Advisory Committee on Pesticides and Health</td>
</tr>
<tr>
<td>ADI</td>
<td>Acceptable Daily Intake (for humans)</td>
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<tr>
<td>ACGIH</td>
<td>American Conference of Governmental Industrial Hygienists</td>
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<tr>
<td>ai</td>
<td>active ingredient</td>
</tr>
<tr>
<td>BEI</td>
<td>Biological exposure index</td>
</tr>
<tr>
<td>ChE</td>
<td>cholinesterase</td>
</tr>
<tr>
<td>DT₅₀</td>
<td>time required for 50% of a chemical to degrade</td>
</tr>
<tr>
<td>EC</td>
<td>emulsifiable concentrate</td>
</tr>
<tr>
<td>EC₅₀</td>
<td>concentration at which 50% of the test population are affected</td>
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<tr>
<td>ECRP</td>
<td>Existing Chemicals Review Program</td>
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<tr>
<td>EEC</td>
<td>estimated environmental concentration</td>
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<tr>
<td>GAP</td>
<td>Good Agricultural Practice</td>
</tr>
<tr>
<td>GLP</td>
<td>Good Laboratory Practice</td>
</tr>
<tr>
<td>h</td>
<td>hour</td>
</tr>
<tr>
<td>ha</td>
<td>hectare</td>
</tr>
<tr>
<td>in vitro</td>
<td>outside the living body and in an artificial environment</td>
</tr>
<tr>
<td>in vivo</td>
<td>inside the living body of a plant or animal</td>
</tr>
<tr>
<td>IPM</td>
<td>Integrated Pest Management</td>
</tr>
<tr>
<td>IV</td>
<td>Intravenous</td>
</tr>
<tr>
<td>kg</td>
<td>kilogram</td>
</tr>
<tr>
<td>L</td>
<td>Litre</td>
</tr>
<tr>
<td>LC₅₀</td>
<td>concentration that kills 50% of the test population of organisms</td>
</tr>
<tr>
<td>LD₅₀</td>
<td>dosage of chemical that kills 50% of the test population of organisms</td>
</tr>
<tr>
<td>LOEL</td>
<td>Lowest Observable Effect Level</td>
</tr>
<tr>
<td>LV</td>
<td>Low volume</td>
</tr>
<tr>
<td>ME</td>
<td>microencapsulated</td>
</tr>
<tr>
<td>mg</td>
<td>Milligram</td>
</tr>
<tr>
<td>mg/kg</td>
<td>Milligram/kg bodyweight/day</td>
</tr>
<tr>
<td>bw/day</td>
<td>bodyweight/day</td>
</tr>
<tr>
<td>MOE</td>
<td>margin of exposure</td>
</tr>
<tr>
<td>MRL</td>
<td>maximum residue limit</td>
</tr>
<tr>
<td>NDPSC</td>
<td>National Drugs and Poisons Schedule Committee</td>
</tr>
<tr>
<td>NHMR</td>
<td>National Health and Medical Research Council</td>
</tr>
<tr>
<td>NOEL</td>
<td>No Observed Effect Level</td>
</tr>
<tr>
<td>NOHS</td>
<td>National Occupational Health and Safety Commission</td>
</tr>
<tr>
<td>OP</td>
<td>organophosphate</td>
</tr>
<tr>
<td>PNP</td>
<td>p-nitrophenol</td>
</tr>
<tr>
<td>POEM</td>
<td>Predicted Operator Exposure Model</td>
</tr>
<tr>
<td>ppb</td>
<td>parts per billion</td>
</tr>
<tr>
<td>PPE</td>
<td>personal protective equipment</td>
</tr>
<tr>
<td>ppm</td>
<td>parts per million</td>
</tr>
<tr>
<td>RBC</td>
<td>Red blood cells/erythrocyte</td>
</tr>
<tr>
<td>SUSDP</td>
<td>Standard for the Uniform Scheduling of Drugs and Poisons</td>
</tr>
<tr>
<td>TGAC</td>
<td>technical grade active constituent</td>
</tr>
<tr>
<td>ULV</td>
<td>Ultra Low Volume</td>
</tr>
<tr>
<td>USEPA</td>
<td>US Environment Protection Agency</td>
</tr>
<tr>
<td>WHP</td>
<td>withholding period</td>
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EXECUTIVE SUMMARY

Introduction

The NRA released the draft parathion-methyl review report for public comment in July 1998. The draft review report was placed on the NRA Website and printed copies were available on request. The draft report incorporated a new approach to public consultation where the emphasis was on identifying concerns and data gaps flowing from the review of parathion-methyl. The public comments phase lasted two months.

A significant response from the public was received and all responses received have been considered by the NRA. A summary describing the main issues raised during the public comments phase and the NRA response to those issues is at Attachment 1.

As foreshadowed in the draft report, the NRA now proposes to implement a series of interim regulatory measures to mitigate potential occupational exposure and environmental risks, and to fill the data gaps that have been identified.

Certain Interim Review Recommendations require the development of additional data. Where appropriate these data will be eligible for data protection in accordance with Part 3 of the Agvet Code. Those submitting data must provide appropriate protocols/study designs for generating the data by 31 December 1999.

The following summaries are intended to provide the reader with a brief background to the review findings and are repeated from the draft report released previously for public comment.

Uses of parathion-methyl

Uses of parathion-methyl in pome and stone fruit, citrus and cotton were highlighted in the efficacy assessment. The importance of these uses was also confirmed by State authorities at various stages during the review. Among the often quoted reasons for the importance of parathion-methyl in these uses is the particular suitability of parathion-methyl to integrated pest management (IPM) and resistance management programs.

Toxicology and Public Health

Assessment of available toxicological data revealed that parathion-methyl is extensively absorbed after oral ingestion, metabolised and excreted by mammals. In studies with laboratory rats, long-term exposure to a low concentration of parathion-methyl in the diet was associated with peripheral nerve damage. Short-term exposure to high concentrations caused symptoms consistent with the classical clinical signs associated with organophosphate poisoning. The occurrence and severity of these clinical signs (excessive salivation, pinpoint pupils, urination, defecation, depression, prostration, convulsions and respiratory failure) were directly related to the amount consumed.
Parathion-methyl does not interact with genetic material, and long-term cancer studies in animals provided no evidence that parathion-methyl would be likely to cause cancer in humans. Similarly, parathion-methyl exposure had no adverse effects on reproduction or development of the fetus in experimental animals.

Thus, the main concern arising from the review was the potential of parathion-methyl to cause peripheral nerve damage in laboratory animals following long-term dietary exposure. This endpoint was the one used to set public health standards.

In Australia, parathion-methyl is not registered for use in or around the home or garden. The most likely route of exposure to parathion-methyl for the public is therefore via residues in food, arising from agricultural use. The Australian Market Basket Survey estimates the daily intake of a range of pesticides based on average food consumption. In the 1994 survey, the highest average intake of parathion-methyl in the groups studied was in infants aged 9 months, and was estimated at 18.6% of the Acceptable Daily Intake (ADI), while the lowest exposure was seen in girls aged 12, with an intake of 5% of the ADI. The ADI is derived from toxicological data obtained from studies of life-time dietary administration of the chemical to laboratory animals. An appropriate safety factor is applied to account for the extrapolation to humans.

**Occupational Health and Safety**

The occupational health and safety assessment was conducted using measured worker exposure studies, published literature and predictive exposure modelling to estimate the risk to workers currently using parathion-methyl. However, in view of the toxicological assessment indicating that long term dietary exposure to parathion-methyl caused nerve damage, there was concern that the margins of exposure (MOE) estimated from currently available information are inadequate for most categories of worker involved in routine uses of parathion-methyl. While the most likely source of occupational exposure to parathion-methyl is via the dermal route, no appropriate dermal toxicity study was available to set toxicity end points applicable to limited seasonal use. Therefore, a three-month study in rats, which examines the dermal toxicity of parathion-methyl has been requested from the sponsors.

Based on the limited information currently available, the health risk to workers during routine ground spraying (airblast, electrostatic and boom spraying) of parathion-methyl products in all crops is unacceptable, irrespective of the use of closed mixing/loading, closed cabs and protective clothing (where applicable). According to the OHS assessment report, the health risk to workers was less with aerial application, although it was still considered not acceptable in some circumstances. Increased worker controls and training were proposed for continued aerial spraying, pending submission and assessment of worker exposure data. The proposed measures include upgraded training, engineering controls, and a requirement that human flaggers are protected by engineering controls such as cabs.

**Environmental Impact**

The main concerns arising from the environmental assessment are that parathion-methyl is hazardous to sensitive aquatic invertebrates and bees. Application practices that can result in direct overspray or spray drift have a potential for significantly
impacting on bees, and by implication other native terrestrial insects, as well as sensitive aquatic fauna, and therefore need to be addressed.

The environmental assessment findings for parathion-methyl were more favourable for ground application than for aerial application. With ground application, the potential for off-target movement of the chemical was found to be limited for certain crops when using certain types of ground-based application equipment. The environmental assessment concluded that, subject to restrictions regarding the rate and frequency of use and with the inclusion of appropriate environmental warnings, parathion-methyl could continue to be used in certain situations. Applications by ground-based application equipment in certain vegetables and pome fruit under IPM have been identified as situations where use could continue.

Identifying spray drift and possible overspray from aerial application of parathion-methyl as hazardous to sensitive fauna in aquatic ecosystems, the environmental assessment proposed that a series of exposure-mitigating measures be implemented, including the use of suitable buffers. Without such measures, aerial application of parathion-methyl is considered likely to cause significant impacts on sensitive aquatic organisms. Reports of bee deaths were seen as a clear indication that unacceptable spray drift can occur during aerial application. The environmental assessment noted, however, that a ban on parathion-methyl at this stage may only generate additional environmental concerns through increased use of equally environmental damaging pesticides in crops where it is now applied aerially. Accordingly, it was of the view that aerial application of parathion-methyl should be phased out as less toxic chemicals become available. In the meantime it is proposed that aerial application of parathion-methyl require the use of buffers and other suitable measures to limit the environmental exposure.

Residue Limits

The assessment of residues was based primarily on overseas data. However, sufficient data was available to set a series of temporary MRLs and two full MRLs (which were set at or about the limit of analytical quantitation), subject to a requirement that Australian confirmatory trial data be produced. Most MRLs were therefore declared temporary and effective until 31 December 2000, subject to the submission of confirmatory Australian trial data for evaluation.

Interim regime of use for parathion-methyl

On the basis of the available data and theoretical modeling the OHS and environment assessments highlighted significant concerns relating to its pre-existing use pattern for parathion-methyl. The draft report also highlighted that for some use patterns and agricultural practices, there were insufficient Australian data on which to enable regulatory decisions to be made with any reasonable degree of confidence. Public comments obtained on the draft review report indicated general support for the NRA’s proposed regulatory approach to filling the identified data gaps and implementing risk mitigation measures.
The NRA now proposes to implement a series of interim regulatory measures to mitigate risks, particularly in relation to occupational exposure and environmental impact and to fill the data gaps that have been identified.

**Interim restrictions and data requirements**

In order to mitigate potential risks to workers and the environment while data is generated, an interim use regime with the following elements will apply for parathion-methyl:

- certain labeling and other restrictions (as outlined in section 7.3) would apply;
- registrants would carry the primary responsibility of ensuring that users are aware of and complying with these restrictions;
- during the period required to generate the outstanding data, parathion-methyl is recommended to be available for use only by persons having appropriate training in the use of chemicals;
- product labels would be strengthened to include appropriate environmental and occupational exposure warnings to reduce potential exposure;
- aerial application requires the use of suitable spray drift minimisation strategies such as large droplet placement technology and other measures to limit environmental exposure;
- data requirements outlined in Table 7.1 should be provided within the set timelines.

At the end of the period required to generate the necessary data, (3 years from the date of gazettal of interim recommendations) the NRA will re-examine the use of parathion-methyl, assessing both the data provided to fill the identified data gaps and the effectiveness of the proposed changes in use practices in mitigating risk.

Any consideration of the continued use of parathion-methyl will include the provision of the required data and successful implementation of the restricted use regime. It is emphasised that even with the provision of the data, the long term use of parathion-methyl may not be sustainable, if assessment of the data confirms unacceptable occupational health environmental or other risks. In addition, the effectiveness of implementing the changes proposed in Section 7 in reducing these risks will also be a significant factor in decisions regarding any long-term use of parathion-methyl.

**PLEASE NOTE:**
Further details of the proposed interim use regime are presented in Section 7 of this report.
1. INTRODUCTION

The National Registration Authority for Agricultural and Veterinary Chemicals (NRA) has reviewed the active ingredient parathion-methyl, all products containing parathion-methyl and associated labels.

The purpose of this document is to provide a summary of the data evaluated and of the regulatory decisions reached, as a result of the review of parathion-methyl.

1.1 Regulatory Information

Initiating a review

The NRA has statutory powers to reconsider the approval of active constituents, the registration of chemical products or the approval of labels for containers at any time. The basis for a reconsideration is whether the NRA is satisfied that the requirements prescribed by the Agricultural and Veterinary Chemicals Code (scheduled to the Agricultural and Veterinary Chemicals Act 1994) for continued approval are being met. These requirements are that the use of an active constituent or product, in accordance with the recommendations for its use:

- would not be an undue hazard to the safety of people exposed to it during its handling or people using anything containing its residues;

- would not be likely to have an effect that is harmful to human beings;

- would not be likely to have an unintended effect that is harmful to animals, plants or things or to the environment; and

- would not unduly prejudice trade or commerce between Australia and places outside Australia.

Obligations to submit data and other information on chemicals under review

On initiating a review, the NRA has to notify relevant approval holders and registrants of the matters it intends to reconsider and its reasons for doing so, and to invite them to make written submissions on those matters. These parties are also requested to submit all existing information and data (regardless of its age or confidentiality) on the chemical under review. The NRA also notifies the community of the review through national and local newspapers, inviting them to make submissions.

In addition to inviting public submissions, the NRA may consult with persons, organisations or government agencies with relevant knowledge or interests for the purposes of obtaining information or advice relating to the review.

Once a review is under way, the NRA may request additional information from approval holders and registrants. If such a request is denied, the NRA may suspend or cancel the relevant approval or registration.
Outcomes of reviews

There are three possible outcomes to an ECRP review:

1. The NRA is satisfied that the chemical under review continues to meet the prescribed requirements for the initial approval or registration and confirms the approval or registration.

2. The NRA is satisfied that the conditions to which the approval or registration is currently subject can be varied in such a way that the requirements for continued approval or registration will be complied with and varies the conditions of approval or registration.

3. The NRA is not satisfied that the conditions continue to be met and suspends or cancels the approval or registration.

The NRA must notify the approval holders, registrants and the community of the outcomes of these reviews.

1.2 Data Protection

To grant protection to providers of certain information relating to agricultural and veterinary chemicals, the NRA introduced a program of data protection. The objectives of this program are:

- to provide an incentive for the development of products and data applicable to Australian or local conditions;
- to encourage the availability of overseas products and data; and
- to provide reciprocal protection for Australian products and data under overseas’ data protection systems.

In general, the NRA designates information as ‘protected registration information’ for a ‘protection period’ of two to seven years if the information:

- is requested by the NRA for the purposes of reviewing a product;
- is relevant to the scope of the review; and
- relates to the interaction between the product and the environment of living organisms or naturally occurring populations in ecosystems, including human beings.

If the NRA proposes to use the same information to determine whether to register, or continue registration, of another chemical product, the NRA must not use the information until the parties come to an agreement as to terms for compensation, unless the protection period has expired or the NRA is satisfied that it is in the public interest to use the information.
1.3 Reasons for the Parathion-methyl Review

Parathion-methyl was selected for review by the NRA Board after scoring highly against the agreed selection criteria for public health, occupational health and safety, and environment. In summary, the concerns over the chemical were:

- its very high toxicity to bees;
- its association with worker poisonings overseas, during end use and upon re-entry;
- high worker exposure scenarios; and
- high potential acute and chronic toxicity risk.

Whilst the selection process ranked parathion-methyl highly due to certain issues, the review was not confined only to those issues, but covered all aspects of the conditions of registration and approval of parathion-methyl.

1.4 Consultation Activities

In response to the widely publicised call for submissions on the review of parathion and parathion-methyl, the NRA received 24 public submissions.

In the sections that follow, most of the public comments have been summarised and organised into similar categories where possible. Where two or more submissions raised the same or closely related points, they have been consolidated for the ease of presentation.

Introduction

Consistent with its policy of consultation with all parties interested in the reviews process, the NRA published notices in the Australian rural and metropolitan press calling for written submissions. This resulted in some 24 submissions on the reviews of parathion and parathion-methyl, from members of the public, and from environmental, government and commodity organisations. The majority of these submissions dealt with all five ECRP first cycle chemicals, several submissions dealt primarily with parathion and parathion-methyl.

One submission dealt specifically with the use of parathion-methyl in Tasmanian apple and pear Industry. The public submissions expressed views ranging from strong support to the continuation of all existing use patterns, to total banning of the use of both parathion and parathion-methyl. Grower groups and commodity organisations generally supported the retention of the existing uses arguing that the parathions play a central role in the pest management strategies as front-line chemicals or as niche chemicals that strengthen chemical resistance management programs.
While all views expressed as a result of public consultation were considered in the review these remain the views of the authors of the public submissions and not those of the NRA. The identities of the sources of public submissions have been kept confidential. The numbers enclosed in parentheses in the text are NRA reference numbers which enable the NRA to identify the respective sources if necessary. The primary purpose of this section is to highlight the range of views resulting from public consultation. Where practical, the wording used by the respondent has been preserved. In most cases, respondents made statements and presented views without supporting documentation. Therefore, no supporting references will be noted unless they were supplied with the original submission.

For the ease of presentation, concerns/views on parathion-methyl have been categorised as follows. Concerns identifying toxicity and environmental risks, including target and non-target damage, are presented under ‘Risk identification’, while comments on any measures designed to mitigate risk factors associated with the use of chemical such as farmer training and use-reduction programs etc., are presented under ‘Risk mitigation’. Comments/views on the role of the chemical in integrated pest management (IPM) and resistance management programs, are presented under ‘Agronomic issues’; and any comments from State regulatory authorities and general comments on the chemical, are reported under ‘Regulatory and general matters’. Most views expressed in public submissions have been presented in summary form and when views expressed in several submissions are similar or related, these have been consolidated.

**Risk identification**

Two respondents raised concerns regarding the toxicity of organophosphates in general [17] and parathion in particular [2]. One respondent also raised concerns regarding the persistence of some organophosphates [2]. These concerns are considered elsewhere in the report under toxicology and environmental assessment sections, respectively.

Some respondents raised concerns about parathion-methyl use-related bee kills while one of these respondents expressed views regarding the toxicity of the microencapsulated form of parathion-methyl to honeybees.

It was stated that the loss or damage to managed or feral hives from chemicals sprays, such as parathion, would be significant given that the estimated value of crops grown in Australia requiring pollination was in the order of 1.2 billion dollars. This respondent also reported that aerial application of chemicals as compared to ground application, leads to greater loses of bees. Effects of pollination on fruit quality was also discussed by this respondent [5].

Another respondent raised general concerns about the total load of chemicals in the environment and stated that the use of parathion is also contributing to this problem [7]. Issues of damage to non-target organisms and the environment is considered in the environmental assessment section of the parathion report.
Greenpeace Australia in their submission attaching two detailed reports relating to human and environmental effects of chlorinated chemicals and specifically organophosphorus pesticides, stated that all ECRP 1st cycle chemicals*1 are widely used in Australia and are found in the Australian environment [17]. Greenpeace Australia further stated that there is increasing evidence that these chemicals pose an undue hazard to the environment and the human population due to their hormone disruptive and reproductive effects. Aspects of human and environmental toxicology of parathions are considered in detail under environmental assessment and toxicological assessment sections of this report.

Some respondents were of the view that all organophosphate pesticides should be severely restricted or banned from use due to toxicity and environmental concerns and actions on a number of organophosphates had been undertaken by several overseas regulatory agencies [2,7,17]. One respondent provided an account of possible misuse of parathion leading to exposure during spray operations in an orchard [25].

Drawing from experience with spraying parathion, one respondent observed that at time of application, beneficial insects were also affected, however this respondent also stated that these insect numbers quickly recovered [22].

**Risk mitigation**

**Farm Chemical User Training/Monitoring Programs**

Several respondents stated that as a response to concerns of risk to human health, occupational health and environment, programs have been undertaken to create grower awareness about the misuse of chemicals. In the Goulburn Valley region of Northern Victoria, numerous surveys have been directed at measuring the impact of pesticide use in relation to blood cholinesterase levels in orchard workers who apply pesticides, and pesticide residue present on fruit at time of harvest, with particular reference to parathion [1,15]. In addition to biological monitoring, training for farm workers is actively supported and promoted by many commodity organisations and State authorities [8,11,15].

Northern Victoria Fruit Growers Association (NVFA) in their submission pointed out that they have prepared specific guidelines for use of parathion and parathion-methyl and stated that a majority of growers and their employees are trained in the safe use of farm chemicals. This submission further stated that no grower has raised concerns with NVFA about poisoning with parathion and despite research and investments in to use of biological control methods and/or safer chemicals, none have resulted in the option of eliminating the use of parathion sprays completely [15]. The OH&S section of the report will examine *inter alia*, known/ reported incidents of parathion-methyl poisoning while the efficacy aspects are considered in the Section 4 of the parathion-methyl report.

Several commodity organisations in their submissions have stated that they have developed or support, guidelines on the safe use of chemicals and judging from information received from some of the States regulatory authorities, farmer and chemical user training in safe use of chemicals is conducted and widely supported in

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* ECRP First Cycle Chemicals include: atrazine, endosulfan, mevinphos, parathion and parathion methyl.
several states [8,9,11,15,19,21]. NSW Farmers Association submission [11] stated that in assessing a chemical implicated with health concerns, it was important to first examine the way a certain chemical is stored, handled and applied including the attitudes of those handling the chemical. NSW Farmers Association submission also stated that the most effective way to reduce the health risk posed by agricultural chemicals is to increase the skills of those in contact with chemicals. These submissions also noted that the health and safety issues of most agricultural chemicals have been the focus of successful educational programs, confirming the trend in most states where parathion-methyl is used [9,11,12,15,18,21].

Under the new Victorian Agricultural Chemicals Act passed in 1994 and subsequent legislation in 1995 all Schedule 7 chemicals will only be able to be purchased and used by people who have received recognised training. Victorian Farmers Federation submission has identified the Farm Chemicals Users Course (FCUC) as being the benchmark [6]. Northern Victorian Fruit Growers Association have also stated that about 90% of their members have completed the FCUC, which included specially designed versions of the course to meet the demands of growers with reading or language difficulties [15]. FCUC in the Goulburn Valley region has been tailored to meet the guidelines for use of parathion and parathion-methyl [15], established following the Victorian Chemical Working Party review of parathion. Over 6,000 chemical users within the state of South Australia have completed the FCUC since its inception three years ago [21] and 5,000 users within the state of NSW have also attended a similar course (Farm Chemical Training Course, is conducted by some 160 trained professionals) [11].

Northern Victorian Fruit Growers Association have pointed out that many growers now utilise the services of their local chemical resellers to store chemicals to reduce the quantities of chemicals stored on farm over the spray season [15]. This submission also quoted comparative costs of traditional spray programs and parathion based - IPM programs to show the cost advantages of the latter [15]. Comparative costing of spray programs with and without the use of parathions is considered in the trade section of this report.

According to Northern Victorian Fruit Growers Association submission, programs of point-of-harvest residue testing by the Institute of Horticultural Development (IHD) and Agriculture Victoria, during two consecutive seasons in 1994-1995 on pears showed residue levels below the Australian MRL. Chemical residue and MRL related issues of parathion-methyl usage are considered in the Residues section of this report [15].

**Chemical use reduction**

Another respondent expressed concern that if parathion ethyl was removed and control of mealy bug using Parathion methyl was poor, the farmers in the area will be forced to use prothiophos and azinphos methyl, and lead to increased use of chemicals for mite control etc., in the long term. The submission stated further that the use of ‘softer’ chemical options (having identified parathions as belonging in this category,) in conjunction with IPM, offers the strongest possibilities for reducing the total use of chemicals [15].
Agronomic issues

Integrated pest management (IPM) practices are widespread in the pear-growing industry. According to the submission from the Environmental Monitoring Services in Shepparton, more than 90% of pear growers use at least some of the IPM practices [1].

According to this submission, current IPM programs in the Goulburn Valley are dependent on the selective use of non-residual broad spectrum insecticides to achieve overall reductions in pesticide usage. These chemicals tend to give adequate control of annual key pests while concurrently allowing natural enemies to feed on sporadic and secondary pests such as two-spotted mite, mealybug, scale and aphids. Submissions from grower organisations argued that parathion was essential for IPM programs in the Goulburn Valley [1,6,15]. Both the SA and NSW Farmers Federations’ submissions also confirmed the place of parathions in IPM programs in their respective State [11,21]. IPM Programs using parathion are characterised by:

- an overall reduction in the quantity and frequency of pesticide usage;
- less pesticide residues on fruit;
- a reduction in risk of development in pest resistance to pesticides

Several respondents from commodity and grower organisations pointed out the prominent role played by parathions in the control of codling moth and light brown apple moth (the two key pests) the target of most IPM programs. The control of these two pests is vital to the viability of apple and pear industries [1,15, 19]. These pests are traditionally controlled by parathion or gusathion. A second group of pests: two-spotted mite, mealybug, scale and aphid are normally controlled by natural enemies such as predatory mites and parasitic wasps. In intensely sprayed orchards, where gusathion was used, the occurrence of the natural predators was unpredictable or low. These submissions argued that the success of IPM programs and economic viability of pome and stone fruit production in their respective regions will depend on the availability and use of parathions [1,3,15,19,22]. The Victorian Farmers Federation stated that parathion methyl is used by many growers in the horticultural industries of Victoria. Where it is considered by vegetable growers as a vital alternative chemical in controlling Plutella, and within fruit crops essential for implementation of IPM strategies [6]. The Northern Victorian Fruitgrowers Association also indicated the need for using parathion in order to control pest populations that may exist following the implementation of IPM programs. Such programs involve the use of new chemical/biological methods such as pheromones, bacteria sprays and growth regulators.

Four respondents discussed parathion methyl use within the cotton industry in controlling resistant *Helicoverpa armigera* when used in combination with pyrethroids and endosulfan. Where the prime purpose is as a ‘cleanup’ spray to flush out resistant *Helicoverpa armigera* larvae following previous spray failures. Respondents indicated that the cotton use was minor [16,18,23,24]. However NSW Agriculture indicated that the use of parathion methyl had increased during the 1994-95 season probably due to particular problems associated with alternative chemicals such as methomyl and thiodicarb (resistance), chlorfluazuron (product withdrawal) and profenofos (odour problems) [16].
Making the general observation about resistance management strategy, WA Fruit Growers Association submission stated that the use of several chemicals in rotation enables minimisation of the risk of developing resistance in pest species to one particular type of chemical [13]. Several respondents contended that it is important for a range of chemical products (reserve chemicals) to be available to combat pest resistance and outbreaks in their respective industries [3,4, 8,9,13, 15 & 20,24].

Several respondents indicated that parathions are cost-effective chemicals [11,15,18,19,24]. NVFA submissions also stated that parathion methyl was not a suitable chemical alternative to parathion ethyl in some orchard use situations as the level of pest control and fruit quality resulting from the use of parathion is not achievable using comparable quantities of parathion methyl [15]. Some of the economic aspects of parathion usage are dealt with in the trade section of this report.

**Regulatory and general matters**

The submission from Tasmanian DPIF, while not dealing directly with parathion, pointed out the many controls of use and application of chemicals and risk management options available under the new and existing legislation in that State [10].

Greenpeace Australia stated that many overseas countries have acted to curb the release of these substances (including parathions) into the environment and through the ECRP, Australia now has an opportunity to do the same [17].

Tasmanian Farmers and Graziers Association in their submission stated that the total volume of use of parathions is low and suitable alternatives exist for each of the uses in relation to the use pattern in Tasmania. This submission further stated that parathions are of significant value as reserve insecticides for managing pesticide resistance and also for controlling outbreaks of new insects which happen to be introduced into that State [9]. A similar view was expressed by the Australian Vegetable and Potato Growers Federation whose submission stated that the value of parathion is based on its strategic importance in managing pest resistance problems [19].

WA Fruit Growers Association stated that parathion methyl is used in WA only sparingly and mainly for the control of San Jose Scale [13]. NSW Agriculture similarly stated that the only significant use of parathion methyl is in cotton and that parathion is not registered in that State [16]. QDPI submission stated that there are relatively few registrations of parathion and parathion-methyl in that State and that there are alternatives available for the most of those registered uses [14]. Apple and Pear Growers Association of South Australia have stated that parathion is important in IPM programs and that it is used in the control of mealybug [3].

Queensland Graingrowers have acknowledged the role parathion plays in IPM and resistance management strategies in that State and stated that parathions occupy ‘important niches’ in the overall insect management strategies [18]. Riverland Horticultural Council of South Australia submission advised that parathion is used widely in the citrus industry for the control of Red scale and mealybug [4]. South Burnett Heliothis Management Committee submission stated that during 1994/95
season, significant resistance was detected to the usual control agents of Heliothis (methomyl, endosulfan and pyrethroids) requiring the increased use of thiodicarb. This submission further stated that parathion methyl would give grain legume growers a last resort alternative should control using thiodicarb fail. For this reason it was stated that parathion methyl should be retained until new generation heliothis pesticides eg. spinosad are registered for use in grain legumes [20]. Similarly the Queensland Fruit and Vegetable Growers stated that the registration of parathion methyl and other chemicals should not be withdrawn or altered unless affected industries have access to suitable and effective alternatives [8].

The Cotton Research and Development Corporation (CRDC) in combination with The Cooperative Research Centre for Sustainable Cotton Production (CRC) stated that the introduction of transgenic cotton plants (Bt Cotton) and other new technology could be expected to reduce pesticide usage in cotton, although an envisaged smaller area of conventionally grown cotton would still require use of currently approved chemicals. Additionally the CRDC and CRC stated that parathion methyl was primarily used as a late season spray in controlling resistant Heliothis larvae. In which case most applications are only undertaken by aerial applicators, and with cotton chipping normally completed by this stage (ie. after January) the risk of worker exposure to parathion methyl when used late in the growing season is minimised [24].

The issue of ‘minor use’ was raised by two respondents, stating that several small industries exist in which the overall use of a particular chemical does not warrant product registration, but where the use of such products is crucial to the economic survival of these industries and the withdrawal of product registrations could therefore significantly impact upon the survival of these ‘minor use’ industries [8,10].

Responses from growers

In general, growers argued strongly for the retention of parathion-methyl, especially in certain areas of horticulture due to their wide spectrum of activity, compatibility with IPM, and its usefulness as a clean-up spray in cotton when used in conjunction with other chemical control measures.

Growers are aware of several alternatives to parathion-methyl in most of their uses. Although there are other chemicals that can be used, none can match the broad spectrum of activity, rapid knockdown and comparable IPM compatibility with parathions. Because of this, growers state that the withdrawal of parathion-methyl would have a serious impact on the efficiency of production of many crops.

Users generally acknowledge the high toxicity of parathion-methyl and apply these chemicals during cooler parts of the day when protective clothing is more comfortable to wear and conditions are conducive to reduce spray drift. Several growers have stated they are not aware of any adverse incidents involving parathion products, when used according to label instructions and point out that the levels of training in the handling of chemicals have risen substantially in recent times.
Responses from the community

Comments from the community focused on the high acute toxicity of parathion-methyl and the potential risks this poses to users and the environment. They claim parathion-methyl are among the most toxic and potentially hazardous insecticides used in the horticultural sector.

Parathion-methyl survey

The NRA also surveyed various groups involved as advisers, users and registrants of parathion-methyl to gather information on use, performance, changed agricultural practices, adverse effects and trade and residues. The results form part of the efficacy and trade reports which appear in section 3 of this summary.

1.5 Chemical and Product Details

History of registration

Parathion-methyl was developed in the late 1940s. Parathion-methyl was first registered in Australia for control of various insect pests in cotton, pome and stone fruit, vegetable crops, tomatoes, beans, potatoes, tobacco and clover seed crops. Some of the main insect pests are the light brown apple moth, codling moth, longtailed mealybug and oriental fruit moth in pome and stone fruit.

In 1990–91, clearance was granted for the TGAC parathion-methyl and it was classified as Schedule 7 in the Standard for the Uniform Scheduling of Drugs and Poisons (SUSDP). A microencapsulated formulation was approved in the late seventies. This form of parathion-methyl was placed in Schedule 6 of the SUSDP primarily because of its lower acute toxicity.

In Australia, there are currently two TGAC approvals and five product registrations for parathion methyl.

Use pattern

Parathion-methyl is a non-systemic insecticide and acaricide with contact, stomach, and some respiratory action. It is used to control chewing and sucking insects, and mites in a wide range of crops as listed below:

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<th>Citrus</th>
<th>Stone Fruit</th>
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<td>Beans**</td>
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<tr>
<td>Egg Fruit**</td>
<td>Potatoes**</td>
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<tr>
<td>Apples*</td>
<td>Tobacco</td>
</tr>
<tr>
<td>Pears*</td>
<td>Grapesvines</td>
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<tr>
<td>Vegetable Crops**</td>
<td>Cotton</td>
</tr>
<tr>
<td>Clover Seed Crops</td>
<td>Cruciferous Forage Crops</td>
</tr>
<tr>
<td>Peas**</td>
<td>Tomatoes**</td>
</tr>
<tr>
<td>Carrots**</td>
<td>Capsicums**</td>
</tr>
<tr>
<td>Pome Fruit*</td>
<td></td>
</tr>
</tbody>
</table>
Application methods

Traditional application in orchards is by orchard air blasters using high volume equipment. However, many orchardists are now using low volume or electrostatic ultra low volume equipment to apply orchard sprays. Aerial spraying is normal practice on cotton crops, and sometimes on tomatoes and brassica forage crops. Applications to vegetable crops is normally by horizontal boom spray, although taller crops may be sprayed using vertical boom sprays.

Current application are done mainly by low volume or electrostatic ultra low volume equipment to apply orchard sprays, whereas original rates of use (and MRL determinations) were based on high volume application methods.

Formulation

Parathion-methyl technical grade active constituent is not manufactured in Australia. Some products are imported fully-formulated and others are formulated in Australia using the imported active constituent.

Packaging

Parathion-methyl is marketed in 20L or 200L containers.

1.6. Overseas Regulatory Status

Parathion-methyl is registered in the following countries for uses largely similar to those in Australia:

<table>
<thead>
<tr>
<th>Countries</th>
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<tbody>
<tr>
<td>Netherlands</td>
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<td>USA</td>
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<td>Greece</td>
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<td>Spain</td>
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</tbody>
</table>

Parathion-methyl is no longer registered in several European countries including UK and Denmark. It is either banned or severely restricted in a number of countries including Japan and Finland.
2. CHEMISTRY ASSESSMENT

2.1 Chemical identity

Common Name: Parathion-methyl

Structural Formula:

![Structural formula of Parathion-methyl]

Purity: 95% minimum parathion-methyl.

Microcontaminants: The impurity for O,O,O,O-tetramethyl thiodiphosphate (methyl analogue of sulfotep) is 1.5% maximum. It is considered that other compounds of toxicological significance (N-nitrosamines, halogenated dibenzo-p-dioxins or halogenated dibenzofurans and PCBs) are not expected in parathion-methyl TGAC due to the raw materials and synthetic chemistry route used.

Empirical formula: \(C_8H_{10}NO_5PS\)

Molecular weight: 263.21

2.2 Chemistry Aspects

The chemistry aspects (manufacturing process, quality control procedures, batch analysis results and analytical methods) of parathion-methyl continue to meet current standards.
3. AGRICULTURAL ASSESSMENT

3.1 Efficacy

Information contained in the performance questionnaires from all sectors of the rural industry surveyed in relation to this chemical indicated that it was still efficacious for many of the purposes claimed. In fact, in orchard IPM situations, some growers advised that they had actually reduced their rates and frequency of use but were achieving the same level of control as when they had first used the chemical. This phenomenon could be attributable to a number of factors including use of more efficient application equipment (low volume application equipment, electrostatic sprayers as opposed to high volume boom sprayers) and better timing of sprays based on pest monitoring to achieve maximum effect on pest populations. It was also noted that label rates were in some cases being converted to rates per hectare for the purposes of using low volume equipment.

Registrants indicated that they did not have any information on any reduction in efficacy and had not received any complaints from growers in relation to failure to control nominated pests using this chemical.

The Victorian Department of Agriculture has consistently supported claims made by the growers concerning the efficacy of this material especially in Integrated Pest Management programs in pome and stone fruit production.

However, the Queensland Department of Primary Industries (QDPI) advised that resistance to parathion-methyl is a major technical difficulty associated with use of this chemical in that State. Green Peach Aphid (Myzus persicae) is one of the main aphid species which attacks tomatoes, capsicum, eggfruit and curcubits and resistance to parathion-methyl in this species has been recognized in Australia since 1978 and was demonstrated in North Queensland in 1989.

There is some information in the literature which suggests that parathion-methyl may be phytotoxic to pears (including russetting of pears) and some apple varieties, and one of the respondents to the performance questionnaires indicated that this phenomenon could be associated with spraying when there is high humidity or very dry conditions. However, it is commented that most of the respondents advised that they had been using the chemical for more than five years without encountering any major difficulties.

The Queensland Department of Primary Industries reported that excessive use of this chemical can cause reddening of cotton and yield decline, while there was potential for phytotoxicity to sorghum where drift occurs from adjacent cotton.

Some phytotoxicity was also reported in Nashi and Josephine pears by the Institute of Horticulture Development, Knoxfield.
Use Patterns

An examination of performance questionnaires for parathion-methyl completed by growers, commodity organizations, State Departments of Agriculture and registrants indicates that the inclusion of this chemical in Integrated Pest Management (IPM) programs for pears is one of the most significant developments in its use since it was first introduced. Growers, supported by the Northern Victoria Fruit Growers Association, advise that these programs have reduced chemical usage by up to 60% in the Goulburn Valley in Victoria which produces 87% of Australia’s pears. This use is seen as important by the Victorian Department of Agriculture. The NSW Farmers Federation in their original submission to the review also indicated that parathion-methyl is a key chemical in IPM programs for stone fruit.

Major pests which are targets for IPM programs are Light Brown Apple Moth, Codling Moth, Longtailed Mealybug and Oriental Fruit Moth.

However, there appears to be a lack of clarity regarding the relative importance of parathion-methyl and parathion (parathion-ethyl) in relation to these programs. Some growers appear to use the chemicals interchangeably, while others believe that parathion is more suitable than parathion-methyl and vice versa. Some concerns have also been expressed regarding the suitability of the microencapsulated form of parathion-methyl as a substitute for the EC forms of parathion in IPM programs. There is anecdotal evidence which suggests that the microencapsulated form may have a longer residual life than the EC formulations and therefore it may have an enhanced effect on predator populations. This could reduce its usefulness in IPM programs.

In IPM programs, parathion sprays (either parathion or parathion-methyl) are only used when crop monitoring for pests indicates that pest numbers have reached a level which cannot be controlled by predators. Parathion is then applied as a knock down spray to re-establish the pest/predator balance. In this way, the number of parathion sprays has been considerably reduced, often by more than 50%.

From the performance questionnaires returned it has been ascertained that parathion is used for this purpose because it does not have the level of adverse effects on predators of other chemicals and has a comparatively short residual activity. The other main alternative, azinphos-methyl is known to be a causative factor in build up of mites in (mite flare) because of its effect on two spotted mite fecundity, while other organophosphate chemicals are also disruptive to IPM programs.

Mite flare problems with the use of azinphos-methyl were observed in pears in the Goulburn valley region of Victoria. Mite flare problem with the use of azinphos-methyl has not been observed in apples, however.

It is commented that parathion-methyl is recommended at a significantly higher rate than that for parathion to control the same pests. This has implications for the relative costs associated with the two chemicals, since the concentrates are similarly priced.

Another significant development is that many orchardists are now using low volume (in some cases electrostatic ultra low volume) equipment to apply parathion-methyl,
whereas original rates of use in orchard crops (and possibly, MRL determinations) were based on high volume application methods.

The main difficulty posed by this development stems from the fact that there are no directions on the label in relation to the amount of water which should be used in high volume applications to the various crops specified on the labels. In relation to pome and stone fruit orchards, most estimates of spray volume fall between 1500-3000 L/ha. Thus, amounts of chemical between 300-1500 g ai/ha could be applied during a high volume application (minimum rate of 40 mL/100 L; maximum rate of 100 mL/100 L). Growers are then taking these rates and applying them in a markedly reduced volume of water. Volumes of water applied during low volume application vary between 180-500 L/ha. Where electrostatic sprayers are used, volumes between 50-80 L/ha are applied.

In a high volume operation, there is a loss of chemical because of run-off (up to 50% according to some estimates). In a low volume spraying operation, the reduction in run-off (almost to non-existence in some cases), and better efficiency of equipment mean that there is a better rate of deposition of spray onto the target. It is therefore apparent that rates of use could be examined both from a standardization point of view and with a view to reducing the amount of chemical applied per hectare.

This could be achieved by reducing the rates of application of current products. Alternatively, in consultation with the registrant chemical companies, it may be possible to produce formulations of parathion-methyl which could be used at lower rates of use or which contain a lower concentration of parathion-methyl.

Growers who were surveyed indicate that in the IPM programs, sprays are only applied as a result of orchard monitoring, often by professional crop monitoring services, for pest pressure. In fact, there is evidence to suggest that even growers who do not plan to use a full IPM program apply sprays in response to pest monitoring. They further indicate that when sprays are applied, they are applied according to the current label directions.

Another use of parathion-methyl which has been highlighted by NSW Agriculture is its place in resistance management strategies in cotton. NSW Agriculture considers this chemical essential for control of resistant *Helicoverpa armigera* in cotton, but acknowledges that there are alternatives for cotton aphids. It is recommended by NSW Agriculture in mixtures with other heliothicides for this purpose. It is considered that this chemical will continue to be required in cotton in spite of the introduction of transgenic cottons since there will still be a need in some situations in the non-transgenic refuge crops. It is also under consideration, in its microencapsulated form, for inclusion in spray programs for codling moth control in that State.

The Queensland Department of Primary Industries advised that although approval for use of this chemical for control of heliothis in navy beans was sought and obtained for the 95/96 season, the efficacy of the chemical and thus its further usefulness is questioned. As in NSW, it is commonly used in tank mixes in cotton for aphid control because it is considered to be cheap and effective, however more effective alternative chemicals (eg dimethoate, pirimicarb) are available. At higher rates
growers use it as a ‘flushing agent’ for entrenched *Helicoverpa*. QDPI advises that its effectiveness against *Helicoverpa* is limited in that State. There is some use of parathion-methyl in tomatoes to control aphids and green vegetable bug, but alternative chemicals are available and the industry is developing IPM strategies.

The South Australian Department of Agriculture advised that this chemical was considered essential for citrus production in South Australia. South Australian Research & Development Institute (SARDI) also advised that parathion-methyl is the only insecticide registered in two minor use situations: clover seed moth in strawberry and white clover seed crops and Etiella moth in Lucerne seed crops. It is also the only chemical used (off-label use) to control Lucerne seed wasps in seed Lucerne crops.

It is important to note that this chemical is regularly applied by air in broad acre crops such as cotton and in some cases in crops such as tomatoes and brassica forage crops.

### 3.2 Trade

#### Introduction

The information available on the potential effects of the withdrawal of parathion-methyl, or modification of its availability, on the export of agricultural commodities has been examined and an estimate made of the impact on Australian trade with other countries. It is emphasised that this report focuses only on the export market and does not draw any conclusions on the impact of regulatory activity in relation to parathion-methyl on the domestic market. Because the domestic market is, in most cases, larger than the export market, the effects will be greater in that sector.

**Parathion-methyl and parathion**

The registered uses and use patterns are very similar in comparison with the ethyl ester of this chemical, parathion. However, the methyl ester is slightly less acutely toxic, but requires a higher use rate, than the ethyl ester. There is also some suggestion that it is not as effective in integrated pest management (IPM) programs. Nevertheless, evidence supplied during the review suggests that these chemicals have been used interchangeably by producers with only comparatively minor inconvenience in terms of pest control strategies.

**Formulation Innovation**

A significant innovation in the registration of parathion-methyl has been the approval of a microencapsulated form of this chemical. This reformulation has enabled the rescheduling of that particular product from S7 to S6 primarily because of the lower acute toxicity of this formulation.

**Export Crops**

Parathion-methyl, like parathion, is registered for use on the two most valuable Australian horticultural export crops and two other major horticultural export crops. These are citrus (oranges), apples, grapes/sultanas and pears. The total contribution of
these export crops to Australian trade is of the order of $300 million. It should also be noted that wine exports totalled some $603 million in 1996-97.

In addition, it is registered for use in cotton which is now firmly established as Australia’s fourth largest rural export worth about $1 billion this year.

Information examined indicates that there may be some use of parathion-methyl on citrus in South Australia, but the use on pears is very significant. Most of Australia’s export apples are sourced from Tasmania, although the South Australian industry is experiencing growth. It would appear that use of parathion-methyl is not critical to the export apple industry.

**MRL Discrepancies with Trading Partners**

There is some incompatibility between Australian MRLs and those of some trading partners. In particular, the Codex listing for ‘fruits’ has been deleted and there are no individual MRLs for the individual fruit commodities of concern. Apart from the loss of export production of pears, any trade difficulties are likely to arise from these incompatibilities.

**Use of parathion-methyl in Pear Production**

By far the greatest proportion of Australia’s export pear crop (87%) is produced in the Goulburn Valley of Northern Victoria. Advice from the Northern Victoria Fruitgrowers Association, which represents the Goulburn Valley pear growers, is that this chemical, and the related chemical parathion, are an integral and very important part of IPM programs which have been adopted by more than 90% of growers in the region. They consider that other chemicals cannot be used in IPM programs because either they adversely effect beneficial insect populations or they create other pest problems.

However, it is very difficult to estimate the separate effects of parathion and parathion-methyl on the export trade in pears since it is apparent that some growers use them interchangeably. It is apparent that the industry could function, perhaps not as effectively, with only one of the parathions, but if they lost both chemicals, the estimated cost of the loss to the export pear industry would be over $2 million.

**Use of parathion-methyl in Cotton Production**

NSW Agriculture advised that parathion-methyl is an essential use product in the cotton industry where it is used mainly as a mixing partner for the synthetic pyrethroids and endosulfan where resistant *Helicoverpa armigera* are present. However, there are other mixing partners (profenofos, Bt and thiodicarb) which can be used in this situation. According to the QDPI, the importance of parathion-methyl for cotton is considered less in Queensland, due to the existence of alternatives.
3.3 Residues

Introduction

An extensive overseas (mainly US) residue package was provided to support the residue review of parathion-methyl. A limited number of Australian residue trial reports were provided.

Current labels

The current labels generally do not specify the maximum number of applications or, on occasion, the interval between applications. There is also a lack of label directions relating high and low volume use rates.

Plant metabolism

In proposed metabolic pathways in cotton, lettuce, and potatoes, parathion-methyl changed to monodesmethyl-parathion-methyl (in cotton, paraoxon-methyl also formed) which then formed p-nitrophenol. Direct conversion to the nitrophenol and formation of a nitrophenol glucopyranoside conjugate were also possible. Foliar treatment of potatoes and cotton with parathion-methyl resulted in minor translocation of the active with the residue present in seeds and tubers being much less than in treated parts.

Animal metabolism

The metabolic pathways found in goats and poultry were similar with the majority of metabolites found being common to both species. Formation of conjugates occurred in both species. There were no signs of residue accumulation in goat or hen tissues and offal tended to be the site of highest residues. Metabolism of parathion-methyl was rapid and extensive in both species.

Residue definition

The current Australian residue definition for parathion-methyl is “parathion-methyl”. Analytical methods can adequately measure that compound. Residue and metabolism data evaluated indicated the present residue definition was appropriate. These data also showed there was no need to include the paraoxon-methyl metabolite in the definition. The residue definition is consistent with that used by the Codex Alimentarius.

Residue trials

Australian residue data from apple, pear, brussels sprouts, cauliflower, cotton, and sweet corn trials were presented. The data included residue results from EC and microencapsulated formulation treatments. Overall there was insufficient Australian data presented to confirm the current MRLs. Where possible the overseas data presented were used to support establishment of temporary Australian MRLs.
The current entries in the MRL Standard for fruits and for vegetables are general entries, namely “fruits 1 mg/kg” and “vegetables 1 mg/kg”. Such broad entries are unsatisfactory and it has been recommended that they be deleted and replaced with MRLs for various fruit and vegetable groups or individual entries. This allowed establishment of temporary MRLs for stone fruit, pome fruit, citrus, grapes, brassica vegetables, carrots, celery, fruiting vegetables (cucurbits and vegetables other than cucurbits), legume vegetables, and pulses. Because overseas residue trials conducted at exaggerated rates compared to the Australian situation showed that residues in sweet corn and potatoes should not be of consequence, MRLs at the limit of quantitation were recommended for those two commodities.

The residue data presented allowed the recommendation that the current MRL entry for cottonseed oil (crude) could be deleted and the cottonseed MRL was established as a temporary value. A temporary cottonseed fodder MRL was recommended and the recommendation made that there be a label prohibition on the grazing of parathion-methyl treated cotton crops in the absence of data on the levels actually present.

Based on overseas data, temporary MRLs were recommended for the animal feeds, clover, clover hay or fodder, cruciferous forage crops, and legume animal feeds. No animal transfer studies were presented and the livestock metabolism studies were not sufficient on their own to recommend retention of the present animal commodity MRLs. As a result, a temporary status was recommended for the current edible offal [mammalian], meat [mammalian], and milks MRLs.

**Residue stability**

Residue data indicate that with EC formulations, the majority of the residue frequently depleted within the first seven days after the final application. Limited micro-encapsulated formulation data indicate that residues may be more stable in the environment than was the case with EC formulations.

**Fat solubility**

Parathion-methyl has a log $P_{ow} = 3$. This indicates some lipid solubility and residue and processing studies showed concentration in processed oil commodities could occur on occasion. Parathion-methyl was metabolised by animals and should not accumulate in fat. Therefore, although oil soluble, parathion-methyl is not expected to be a fat accumulator in animals when low or intermittent exposure occurs.

**Conclusions**

The residue data package presented did not contain sufficient Australian residue data to confirm the present MRLs. Consequently temporary Australian MRLs have been recommended with their retention dependent on the presentation of satisfactory Australian residue data or where appropriate, argument.

Because MRL entries for broad food categories are no longer desirable, the present MRL entries for fruits and vegetables have been deleted and replaced by temporary MRLs for those fruits and vegetables which were identified as requiring parathion-
methyl treatments. The data presented indicated there was no clear need for the present cottonseed oil (crude) MRL and its deletion has been recommended.

The residue definition of parathion-methyl remains unchanged as the parent parathion-methyl.

The current 14 day WHP before harvesting for human consumption and grazing and cutting for stock food remain unchanged and should be used to replace the 7 day withholding period found in one of the registered product labels and a grazing restraint for cotton should be included on the label.

There are no objections, from a residues point of view, to the continued registration of products containing parathion-methyl if additional confirmatory studies for the T MRLs recommended are completed and evaluated.

The following amendments to the MRL Standard are recommended.

Table 1

<table>
<thead>
<tr>
<th>Compound</th>
<th>Food</th>
<th>MRL (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Parathion-methyl</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delete:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO 0691</td>
<td>Cotton seed</td>
<td>1</td>
</tr>
<tr>
<td>OC 0691</td>
<td>Cotton seed oil, crude</td>
<td>0.05</td>
</tr>
<tr>
<td>MO 0105</td>
<td>Edible offal (mammalian)</td>
<td>*0.05</td>
</tr>
<tr>
<td></td>
<td>Fruits</td>
<td>1</td>
</tr>
<tr>
<td>MM 0095</td>
<td>Meat (mammalian)</td>
<td>*0.05</td>
</tr>
<tr>
<td>ML 0106</td>
<td>Milks</td>
<td>*0.05</td>
</tr>
<tr>
<td></td>
<td>Vegetables</td>
<td>1</td>
</tr>
<tr>
<td><strong>Add</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VB 0040</td>
<td>Brassica vegetables</td>
<td>T0.1</td>
</tr>
<tr>
<td>VR 0577</td>
<td>Carrot</td>
<td>T0.5</td>
</tr>
<tr>
<td>VS 0624</td>
<td>Celery</td>
<td>T3</td>
</tr>
<tr>
<td>SO 0691</td>
<td>Cottonseed</td>
<td>T1</td>
</tr>
<tr>
<td>FC 0001</td>
<td>Citrus fruit</td>
<td>T1</td>
</tr>
<tr>
<td>MO 0105</td>
<td>Edible offal (mammalian)</td>
<td>T*0.05</td>
</tr>
<tr>
<td>VC 0045</td>
<td>Fruiting vegetable, Cucurbits</td>
<td>T1</td>
</tr>
<tr>
<td>VO 0050</td>
<td>Fruiting vegetable, other the</td>
<td>T0.2</td>
</tr>
<tr>
<td></td>
<td>Cucurbits (except sweet corn)</td>
<td></td>
</tr>
<tr>
<td>FB 0269</td>
<td>Grapes</td>
<td>T0.5</td>
</tr>
<tr>
<td>VP 0060</td>
<td>Legume vegetables</td>
<td>T0.5</td>
</tr>
<tr>
<td>MM 0095</td>
<td>Meat (mammalian)</td>
<td>T*0.05</td>
</tr>
<tr>
<td>ML 0106</td>
<td>Milks</td>
<td>T*0.05</td>
</tr>
<tr>
<td>FP 0009</td>
<td>Pome fruits</td>
<td>T0.5</td>
</tr>
<tr>
<td>VR 0589</td>
<td>Potato</td>
<td>*0.05</td>
</tr>
<tr>
<td>VD 0070</td>
<td>Pulses</td>
<td>T0.2</td>
</tr>
<tr>
<td>FS 0012</td>
<td>Stone fruits</td>
<td>T0.2</td>
</tr>
<tr>
<td>VO 0447</td>
<td>Sweet corn</td>
<td>*0.1</td>
</tr>
</tbody>
</table>
The following commodities would require confirmatory Australian residue data to confirm MRLs:

- Brassica vegetables (cabbages, cauliflower, and Brussels sprouts or broccoli)
- Carrot
- Celery
- Cottonseed
- Citrus fruit (orange and lemons)
- Edible offal (mammalian) (cattle, pigs, and sheep)
- Fruiting vegetables, Cucurbits (cucumber or gherkin, pumpkin or squash, and a Melon)
- Fruiting vegetables other than Cucurbits (except sweet corn) (tomato, peppers, mushroom, and one other vegetable in the group)
- Grapes
- Legume vegetables (peas, beans, and one other vegetable of the group)
- Meat [mammalian] (cattle, pigs, and sheep)
- Milks (cattle, and sheep or goats)
- Pome fruits (apple and pear)
- Pulses (lupin (dry) or soya bean (dry) and two other vegetables of the group)
- Stone fruits (peaches, cherries, and one other fruit from the group)
- Clover (seed, hay, and fodder)
- Cruciferous forage crops (three of rape, kale, swedes, and turnips)
- Legume animal feeds (three of the group, e.g. bean fodder, clover, vetch).

Supply of residue data from all the commodities listed and establishment of equal MRLs for them with comparable use patterns would allow establishment of the relevant group MRL. Otherwise MRLs for individual commodities could be set on the basis of the commodity residue data provided.

Where additional residue data are required, the residue trials should be conducted according to appropriate NRA requirements at maximum label rates and take account of the use of EC and or microencapsulaton type formulations. The trials also need to address the use of g/L and g/ha rates, low and high volume applications and the effect of multiple applications on residue values.
4. TOXICOLOGICAL ASSESSMENT

The extensive toxicological database for parathion-methyl consists primarily of toxicity tests conducted using animals, with some experiments using human volunteers, and a number of reports of human exposure by accidental, occupational or deliberate means.

In interpreting the data, it should be noted that toxicity tests generally use doses that are high relative to likely human exposures. The use of high doses increases the likelihood that potentially significant toxic effects will be identified. Toxicity tests should also indicate dose levels at which the specific toxic effects are unlikely to occur. Such dose levels as the No-Observable-Effect-Level (NOEL) are used to develop acceptable limits for dietary or other intakes at which no adverse health effects in humans would be expected.

4.1 Public health aspects

Toxicology

Parathion-methyl is an organophosphate pesticide that has been in use in Australia and other countries for over 40 years. Parathion-methyl exhibits high acute toxicity. Like a number of other pesticides, parathion-methyl is an anti-cholinesterase compound, and this accounts for the insecticidal activity as well as the human hazard associated with exposure. Regardless of whether parathion-methyl is taken orally, applied to the skin, or breathed in, the effects of poisoning are similar. Signs of parathion-methyl poisoning are typical of those seen with other organophosphorous insecticides, and in mammals include: increased swallowing, excessive saliva, rapid breathing, pinpoint pupils, loss of coordination, excitement, twitching and rapid contractions of the neck and jowl muscles, coarse generalised body tremors, secretion of tears, urination, defeation, depression, prostration, convulsions, respiratory failure, and death. The severity of signs increases with the amount of exposure, and the onset of severe signs (including death) is swift in experimental animals and humans. There is an effective antidotal treatment for the acute effects of parathion-methyl poisoning.

Parathion-methyl is extensively absorbed, metabolised and excreted by humans and other mammals. In studies in laboratory rats, long term exposure to a low concentration of parathion-methyl in the diet was associated with some damage to peripheral nerves; high concentrations caused the acute symptoms listed above. Parathion-methyl does not interact with genetic material, and long term cancer studies in animals provided no clear evidence that parathion-methyl would be likely to cause cancers in humans. Parathion-methyl exposure had no adverse effects on reproduction or development of the fetus in experimental animals.
Conclusion

In Australia, parathion-methyl is not registered for use in or around the home or garden. The most likely exposure to parathion-methyl for the public is via residues in food. There is a wide range of registered uses for parathion-methyl, and it is recommended that the potential for public exposure be reduced as much as possible, whilst allowing continued use where this is essential for agricultural purposes.

4.2 Metabolism and Toxicokinetics

Parathion-methyl is reasonably fat-soluble and is readily absorbed by all routes of exposure, however the toxicity resulting from an exposure episode varies considerably with the dose and exposure route. The toxicity of parathion-methyl is directly related to the inhibition of cholinesterases by the initial metabolite of parathion-methyl, methyl-paraoxon, formed mainly in the liver, but also in other tissues. The liver functions as the major controller of the circulating level of parathion-methyl and methyl-paraoxon. In oral exposures, essentially all of the dose of parathion-methyl is bound to blood proteins and passes through the liver. The liver activates the parathion-methyl to methyl-paraoxon, and then proceeds to rapidly break it down, hence much of the parathion-methyl may be detoxified within the liver. However a large dose of parathion-methyl may overwhelm the detoxification abilities of the liver and allow parathion-methyl or methyl-paraoxon to leave the liver and enter the general blood circulation. There is considerable genetically-determined variation in activation and detoxification abilities between individual animals and humans. Animal studies have found that when parathion-methyl is breathed in, applied to the skin, injected intravenously or intraperitoneally, given as a single dose orally or fed in the diet at high dose, then signs of poisoning may appear. Studies in rats, hens and goats indicate that parathion-methyl which enters the general circulation can be widely distributed throughout the body but will generally be excreted very rapidly in the urine and faeces, with low concentrations of residues remaining in tissues such as fat, brain and liver.

Parathion-methyl is readily absorbed and metabolised after exposure to the skin. However, based on findings with the similar pesticide, parathion-ethyl, the absorption through the skin is likely to be highly variable. There are expected to be species, gender and individual differences in the amount of the applied dose that is absorbed. Additional factors that will vary the absorption include: application site, temperature, the presence of solvent in the formulation, skin integrity and occlusion of the application site by clothing.

4.3 Acute studies

There is a substantial literature, both published and unpublished, on the lethal dose toxicity of parathion-methyl, and the acute toxicity varies with species, age and gender. The oral LD50 values in rats are in the range 2.9-62 mg/kg bw, with females less sensitive than males.
Clinical signs following parathion-methyl exposure by all major routes of administration are typical of cholinesterase inhibition and included increased swallowing, excessive saliva, rapid breathing, twitching of the ears, pinpoint pupils, tail lashing, loss of coordination, excitement, twitching and rapid contractions of the neck and jowl muscles, coarse generalised body tremors, secretion of tears, urination, defecation, depression, prostration, epileptoid tremors, convulsions, respiratory failure, and death. In rats, signs of poisoning commenced typically within 0.5 h of treatment and deaths occurred within 24 hours. Signs of toxicity were evident up to 5 days post-dose. In an acute neurotoxicity study in rats, there was significant ChE inhibition at oral doses above 0.025 mg/kg bw (NOEL), and histopathology revealed dose-related degenerative lesions of myelin in the central nervous system with a NOEL of 7.5 mg/kg bw.

When tested on rabbits, parathion-methyl was not an eye irritant nor a skin sensitiser, but was a slight skin irritant. A microencapsulated form of parathion-methyl was of low acute oral and negligible dermal toxicity in rats. This product has minimal dermal irritation potential in rabbits, and is not an eye irritant in rabbits nor a skin sensitiser in guinea pigs.

4.4 Short-term repeat-dose studies

In a 4-week mouse dietary study where the doses ranged from 3.75-60 mg/kg bw/day, deaths occurred at the highest doses and signs of poisoning including weight loss were seen at all doses except 3.75 mg/kg bw/day. Two 3-week studies investigated the daily unoccluded dermal application of parathion-methyl at doses up to 250 mg/kg bw for 6 h in rabbits. Clinical signs of poisoning and cholinesterase inhibition were seen at the high doses, and the NOELs for the two studies were 5 and 10 mg/kg bw/day respectively.

4.5 Subchronic studies

In 3 dietary studies in mice at parathion-methyl doses up to 15 mg/kg/day, bodyweight decreases determined a NOEL of 6.1 mg/kg bw/day in one 3-month study, and no NOEL could be set in a 2-month study due to low survival and ChE inhibition at the lowest dose tested. In a second 2-month study, no animals survived doses higher than 15 mg/kg bw/day. There was some liver toxicity at 15 mg/kg bw/day and the NOEL for ChE inhibition was 0.9 mg/kg bw/day. A 3-month dietary study in rats at doses up to 7 mg/kg bw/day caused signs of toxicity including tremors, kidney effects and weight loss at the high doses. The NOEL for ChE inhibition and clinical chemistry effects was 0.2 mg/kg bw/day. Stomach irritation and bodyweight loss were seen in rodent studies at high dietary doses only. In 3 dietary studies of three months duration in dogs at doses up to 3 mg/kg bw/day, there were no consistent treatment-related clinical signs. Plasma, brain and erythrocyte ChE inhibition were seen at 3.0 mg/kg bw/day, and the lowest NOEL for ChE inhibition was 0.13 mg/kg bw/day.
4.6 Chronic studies

Long-term dietary studies were performed in mice, rats and dogs. The 2-year mouse study recorded bodyweight increases at 9.2 mg/kg bw/day, mild clinical signs and ChE inhibition at 1.6 mg/kg bw/day, and increases in cholesterol and serum protein levels at all doses including 0.2 mg/kg bw/day. There were no treatment-related tumour findings.

In a 1-year rat dietary study, body weight was decreased at 2.2 mg/kg bw/day. The NOEL for ChE inhibition was 0.1 mg/kg bw/day. Gross and microscopic examination of the eye and optic nerve revealed no evidence of demyelination or other treatment-related ocular toxicity in the high-dose group at 12 months. However, there was evidence of neuronal degeneration in the sciatic nerve of animals at 0.1 mg/kg bw/day, with an occasional occurrence in animals at 0.02 mg/kg bw/day (NOEL). In another dietary study carried out over 2 years with the same strain of rats, the same NOEL (0.02 mg/kg bw/day) was established based on a dose-related increase in the incidence and time to onset of altered gait. Clinical signs of cholinomimetic toxicity and decreased body weight were seen at 2.2 mg/kg bw/day, and there was a dose-related increase in urinary bladder epithelium hyperplasia. The NOEL for ChE inhibition was 0.2 mg/kg bw/day.

In a 2-year rat dietary study, clinical signs were seen at 3.1 mg/kg bw/day, and ChE inhibition and clinical chemistry effects were seen at 0.78 mg/kg bw/day. Benign thyroid tumours were seen in males only at the highest dose of 3.1 mg/kg bw/day. The overall NOEL was 0.1 mg/kg bw/day.

In a 12-month dog dietary study, at doses up to 0.3 mg/kg bw/day, there were no clinical signs, mortalities or body weight changes. There were clinical chemistry changes at 0.1 and 0.3 mg/kg bw/day, while ChE was inhibited in erythrocytes at even the lowest dose of 0.03 mg/kg bw/day. The NOEL for plasma ChE inhibition was 0.03 mg/kg bw/day, and for brain ChE inhibition, 0.1 mg/kg bw/day.

4.7 Reproduction studies

Two studies suggest that parathion-methyl does not impair reproductive performance of rats. In a two-generation study in rats at dietary concentrations up to 1.68 mg/kg bw/day, there was parental body weight loss above 0.5 mg/kg bw/day (NOEL) but no adverse findings for reproductive effects at the highest dose tested. In a three-generation reproduction study using rats fed on parathion-methyl up to 5 mg/kg bw/day, parental body weight loss was observed with a NOEL of 1.0 mg/kg bw/day. The NOEL for reproductive effects was set at 0.2 mg/kg bw/day because of reduced pup survival at the next higher dose tested (1.0 mg/kg bw/day).
4.8 Developmental studies

In a series of studies, parathion-methyl administered intraperitoneally, intravenously or orally to rats or rabbits revealed no evidence for teratogenicity, even at maternotoxic doses.

4.9 Genotoxicity studies

The genotoxicity of parathion-methyl has been extensively investigated in a wide range of *in vitro* and *in vivo* systems. There were positive results in many *in vitro* assays, but equivocal results in *in vivo* studies. There is no unequivocal evidence, particularly from recent work, that parathion-methyl is a genotoxin.

4.10. Special studies

Several studies investigated the acute neurotoxicity of parathion-methyl and its potential to cause organophosphate induced delayed neuropathy (OPIDN). A neurotoxicity study in chickens using TOCP as a positive control found parathion-methyl did not cause the presence of neural degenerative changes associated with OPIDN. An early published neurotoxicity study in chickens found that parathion-methyl did not cause the paralysis typical of agents inducing OPIDN. In a 13-week dietary study in rats, at doses up to 3 mg/kg bw/day, there were no treatment-related deaths, significant clinical signs or ophthalmological findings. A functional observation battery revealed some transient treatment-related neurobehavioural changes. The lowest NOEL was 0.02 mg/kg bw/day (males) and 0.03 mg/kg bw/day (females) for inhibition of erythrocyte ChE activity.

4.11. Effects in humans

Parathion-methyl is highly acutely toxic to man and animals. Human poisonings as a consequence of exposure to parathion-methyl have occurred through accidental, occupational and deliberate exposure by all routes. The course of acute parathion-methyl intoxication in man is identical to the acute toxicity seen in laboratory animal studies and is mediated by cholinesterase inhibition. Symptoms range from “flu like” chest tightness and fever in mild cases, through to respiratory paralysis and death at high doses. There exists an effective antidotal regime for parathion-methyl intoxication. Animal studies indicate that there may be a minimal risk that acute high dose exposure or long-term exposure to low doses of parathion-methyl may lead to delayed neuropathy in humans, but there is no evidence of long term sequelae for immunotoxic, reproductive or developmental effects or for cancer induction in humans.
4.12. Conclusions for public health standards

Poisons scheduling

Parathion-methyl is currently in Schedule 7 except when included in Schedule 6 of the Standard for the Scheduling of Drugs and Poisons (SUSDP). Aqueous preparations containing 25 per cent or less of microencapsulated parathion-methyl are in Schedule 6 of the SUSDP. There are provisions for appropriate safety directions on the product label aimed at limiting exposure, and first aid instructions in the event of poisoning.

No Observed Effect Level/Acceptable Daily Intake

The current acceptable daily intake (ADI) is 0.0002 mg/kg bw/day. This ADI was derived from a NOEL of 0.02 mg/kg bw/day, based on neurotoxicological effects seen in a 12- and 24-month feeding study in rats and applying a 100-fold safety factor.
5. OCCUPATIONAL HEALTH AND SAFETY ASSESSMENT

5.1 Existing regulatory controls for occupational health and safety

**Hazardous substances**

Parathion-methyl is listed in the National Occupational Health and Safety Commission (NOHSC) List of Designated Hazardous Substances with the following risk and safety phrases:

- R24 Toxic in contact with skin.
- R28 Very toxic if swallowed.
- S28 After contact with skin wash immediately with plenty of ...(to be specified by manufacturer).
- S36/37 Wear suitable protective clothing and suitable gloves
- S45 In case of accident or if you feel unwell, seek medical advice immediately (show label where possible).

All parathion-methyl products registered in Australia are determined to be hazardous substances. Hazardous substances come under the controls for workers specified in NOHSC Control of Workplace Hazardous Substances.

**Atmospheric monitoring**

There is a NOHSC Exposure Standard for parathion-methyl of 0.2 mg/m³ Time-Weighted-Average (TWA) with an ‘sk’ skin notation, indicating that absorption through the skin may be a significant source of exposure.

**5.2 Toxicity relevant to occupational exposure**

In experimental animals, parathion-methyl is of high acute toxicity by the oral, dermal and inhalation routes. The lowest rat acute dermal LD₅₀ for parathion-methyl is 44 mg/kg. It is a slight skin and eye irritant and has low skin sensitising potential. Parathion-methyl emulsifiable concentrate (EC) formulations have high acute oral toxicity, moderate dermal toxicity and are slight skin and eye irritants, but not skin sensitisers. Microencapsulated (ME) parathion-methyl (240 g/L) has low acute toxicity and is non-irritant and non-sensitising.

Animal studies do not reveal a species difference in sensitivity to parathion-methyl. Acute toxicity studies demonstrated a sensitivity according to gender, with males being more sensitive than females.

Parathion-methyl is associated with acute neuropathies caused by inhibition of ChE. In addition, in a number of animal studies it induced dose-related peripheral neuropathy at doses below those which caused ChE depression. The no-observable-effect-level (NOEL) established for peripheral neuropathy was 0.02 mg/kg/d, derived...
from a 1 year rat study. From an occupational health and safety perspective, neuropathy is considered to be the significant health effect produced by exposure to parathion-methyl.

The human lethal dose for parathion-methyl is unknown. It was noted that acute poisoning victims, presumably exposed to parathion-methyl on a single occasion, demonstrated persistent muscle weakness and altered electromyography changes indicating impaired nerve conduction. These symptoms were associated with severe depression of plasma and RBC ChE.

In a range of studies, human volunteers tolerated doses of parathion-methyl up to 0.3 mg/kg/d for 30 days without clinical signs.

Paraoxon-methyl is the major degradation product of parathion-methyl. It is of similar acute toxicity to the parent compound.

No experimental data was available on the penetration of parathion-methyl across human or animal skin. In the absence of data, a 10% default value is assumed in the risk assessment for EC and ME formulations of parathion-methyl. This default is based on skin absorption data available for the closely related chemical, parathion.

5.3 Reported health effects of parathion-methyl

In Australia, there are no incident reporting systems for pesticide poisoning. There have been a number of documented cases of illness/poisoning following organophosphate pesticide exposures. It is not known how many of these are related to parathion-methyl exposure.

Several overseas reports exist of illness/poisoning in agricultural workers occupationally exposed to parathion-methyl. Some reports indicate that in the case of acute dermal exposure, symptoms increased in severity during the first few days following exposure and lasted several days. Some cases of behavioural changes have been reported following multiple exposures to pesticides, including parathion-methyl.

In a US study, 3 of the 238 illness reports among 10,000 agricultural workers were related to the use of parathion-methyl alone. One of these was accidental, one following safety violations and one due to adverse weather conditions.

A study conducted in Nicaragua involved 1960 workers from an estimated 15,000 exposed population working on farms and airfields. More airfield workers (eg. plane washers, mixer/loaders, mechanics) than farm workers (eg, tractor sprayers and general field workers) demonstrated depressed ChE levels. Workers wearing personal protective equipment (PPE) were less likely to have depressed ChE levels. Of the 129 organophosphate related reports, 96 were associated with the use of parathion-methyl alone or in combination with other pesticides.

Studies on human volunteers indicated that following repeated exposure to parathion-methyl, there can be a decrease in blood ChE activity without clinical manifestations.
5.4 Use pattern for parathion-methyl in Australia

Handling prior to end use

Parathion-methyl and some end use products are imported while other products are formulated in Australia. Formulators may be exposed to parathion-methyl and products by the dermal and inhalation routes. Formulation workers require protective equipment where efficient engineering controls are not in place.

Transport and storage workers and retailers only handle the packaged active ingredient and/or products. They could potentially be exposed to parathion-methyl if packaging were breached.

Liquid parathion-methyl products are available in containers varying from 1 L - 200 L. ME parathion-methyl is available in 5 L jerry cans.

Handling by end users

The EC formulations of parathion-methyl can be applied in Australia to the following crops: cotton, citrus, stone and pome fruit, vines, vegetables, cruciferous forage crops, tobacco and clover seed crops. The ME product is only approved for use in Australia on citrus, vines and pome fruit. Information on the Australian use pattern of parathion-methyl derives from product labels, performance questionnaires obtained through the National Registration Authority for Agricultural and Veterinary Chemicals (NRA) Existing Chemicals Review Program and the NRA reviews. It is used to estimate worker exposure under Australian conditions and is summarised in the Tables 1 and 2 for the EC and ME products, respectively.
Table 1. End use parameters used to estimate worker exposure and risk to liquid formulations of parathion-methyl

<table>
<thead>
<tr>
<th>Crop</th>
<th>Application method</th>
<th>Maximum application rate (kg ai/ha)</th>
<th>Maximum work rate (ha/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>cotton</td>
<td>boom spraying</td>
<td>1.4</td>
<td>600 (120)*</td>
</tr>
<tr>
<td>cotton</td>
<td>aerial spraying</td>
<td>1.4</td>
<td>3000</td>
</tr>
<tr>
<td>citrus</td>
<td>airblast spraying</td>
<td>7.5</td>
<td>15</td>
</tr>
<tr>
<td>stone fruit, pome fruit</td>
<td>airblast spraying</td>
<td>1.5</td>
<td>21(9)*</td>
</tr>
<tr>
<td>Vines, vegetables</td>
<td>airblast spraying</td>
<td>0.325</td>
<td>27</td>
</tr>
<tr>
<td>Cruciferous forage crops, vegetables</td>
<td>boom spraying</td>
<td>0.26</td>
<td>50 (4)*</td>
</tr>
<tr>
<td>Cruciferous forage crops, tobacco</td>
<td>aerial spraying</td>
<td>0.065</td>
<td>900</td>
</tr>
<tr>
<td>clover seed crops</td>
<td>boom spraying</td>
<td>0.4</td>
<td>240 (120)*</td>
</tr>
</tbody>
</table>

* based on estimates received from grower groups

The maximum concentrations of the EC parathion-methyl formulations in working strength solutions is 0.05% in horticultural and field crops, 2.8% for boom spraying of cotton and 7% for aerial spraying of cotton.

Table 2. End use parameters used to estimate worker exposure and risk to ME formulations of parathion-methyl

<table>
<thead>
<tr>
<th>Crop</th>
<th>Application method</th>
<th>Maximum application rate (kg ai/ha)</th>
<th>Maximum work rate (ha/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pome fruit</td>
<td>Airblast spraying</td>
<td>0.9</td>
<td>21 (9)*</td>
</tr>
<tr>
<td>Citrus</td>
<td>Airblast spraying</td>
<td>4.5</td>
<td>15</td>
</tr>
<tr>
<td>vines</td>
<td>Airblast spraying</td>
<td>0.3</td>
<td>27</td>
</tr>
</tbody>
</table>

* based on estimates received from grower groups

The spray strength of the ME formulation in horticultural crops is 0.03% parathion-methyl.

Open pour or closed methods may be used for mixing/loading. Open or closed cabs may be used for spray application. In most ground spraying operations, it is anticipated that the same workers would mix/load and apply the chemical. In aerial operations, the mixing/loading and spraying would be conducted by different workers.

Workers may be exposed to parathion-methyl products when opening containers, preparing spray, cleaning up spills and maintaining equipment. Exposure to the diluted solution can occur during spray application and maintenance operations. Re-
entry workers, harvesters and workers handling harvested crops may be exposed to parathion-methyl and its degradation products, mainly paraoxon-methyl.

Workers may handle parathion-methyl repeatedly throughout the season(s). Parathion-methyl EC products may be applied 2-5 times per season in any given crop. Some vegetable growers may produce 2-3 crops per year. Each horticultural crop application of parathion-methyl in Australia is likely to take place over 1-2 days. Application of parathion-methyl in cotton may take place over a longer period, especially when conducted aerially over large areas. The application of the ME product can take place as required during the growing season at intervals of 2-4 weeks (depending on crop) with each application likely to take place over 1-2 days. Contract workers may be exposed more frequently and over longer periods.

The main route of occupational exposure to parathion-methyl products is expected to be via skin contamination. Inhalation exposure to parathion-methyl vapour is not expected to be significant because it has low vapour pressure. Inhalation of spray mist is possible.

5.5 Estimation of worker exposure

Estimations of worker exposure relied on measured field studies and a predictive model. Where appropriate, extrapolations were made from similar use patterns in the studies. Estimates of exposure (and risk) used the maximum application rates and work rates specified in Tables 1 and 2 and assumed that maximum PPE was worn (ie. gloves, overalls and waterproof clothing).

The application rates and work rates summarised in Tables 1 and 2 were used in the POEM estimates, together with the assumptions used to assess measured worker data (refer above for details).

Measured end use exposure

A number of worker studies of varying quality and applicability to the Australian use pattern were used in the assessment of exposure to parathion-methyl during end use. Only the Australian exposure study used parathion-methyl. It is summarised separately below. Due to the small number of studies available for parathion-methyl and considering the similarity between parathion and parathion-methyl, parathion exposure data was used as a surrogate for parathion-methyl. The studies used in the risk assessment included:

- airblast and electrostatic spraying of parathions in orchards - an Australian study, under local use conditions;
- airblast spraying of parathion in orchards - three studies conducted in the US;
- airblast application of a surrogate chemical (chemical similar to parathions) in orchards - one US study; and
- aerial and ground (boom) application of parathion in field crops - one US study.
**Exposure assessment of the Australian study during airblast spraying of parathions in orchards**

Only one Australian exposure study was available. In this study, worker exposure during mixing/loading and application (combined functions) was measured under typical working conditions, during airblast and electrostatic spraying of parathion and parathion-methyl in orchards.

Workers followed their usual practices with respect to spray techniques and use of PPE. However, exposures were adjusted to assume full PPE was worn as per the label and health risk to workers assessed on that basis. The results included exposures during spray application using open tractors and wearing full protective clothing and closed cabs wearing gloves and one layer of clothing. Penetration of parathion-methyl through gloves and each layer of protective clothing was taken as 10%. Since each worker in this study conducted mixing/loading and application, it is not possible to determine the influence of each function on overall exposure.

**Exposure assessment (all studies)**

Data from worker studies indicate the importance of engineering controls in reducing worker exposure. Exposure during mixing/loading was greater when using the open-pour method. Applicator exposure was greater when in open cabs and when cab windows were left open. Hand exposure was the main contributor to total skin exposure during both mixing/loading and application. All studies showed that exposure by the dermal route was greater than by the inhalation route.

Limited exposure data was available for aerial mixer/loaders and spray applicators using fixed wing aircraft.

Human flaggers involved in aerial spray operations may be contaminated with spray mist. Some information was available on bystander exposure and was used to assess the health risk to human flaggers.

**Predicted end use exposure**

The measured worker exposure data was supplemented by modelling where possible. The UK Predictive Operator Exposure Model (POEM) was used to estimate parathion-methyl exposure for the Australian use pattern in horticulture and field crops. Four application methods were chosen:

- airblast spray: ie. vehicle mounted (without cab) air assisted (V-500);
- vehicle mounted (without cab) air assisted (V-100);
- vehicle mounted (without cab) air assisted rotary discs (V-RDA-2);

and

- boom spray: ie. vehicle mounted (with cab) hydraulic nozzles (V-Nozzle).
POEM could not be used to estimate worker exposure during aerial spraying and electrostatic spraying.

**Re-entry exposure**

No Australian re-entry exposure data or field residue data were available. Overseas measured worker re-entry exposure data was available from the published literature. Overseas residue data was available for both EC and ME parathion-methyl in various crops, from spray application to 7 days post-application. Parathion-methyl and paraoxon-methyl residues were measured for up to 7 days and 4 days post-application, respectively, for both formulations.

**Assessment of health risk to workers**

In estimating health risk to workers from exposure data, an average body weight of 60 kg per worker and skin penetration of 10% for parathion-methyl, were used.

**Single exposure**

Parathion-methyl is associated with poisonings in individuals and workers, but the human lethal dose for parathion-methyl has not been established. For workers, the dermal route contributes most to overall exposure. Extrapolation from the rat dermal LD$_{50}$ for parathion-methyl of 44 mg/kg shows that this endpoint is equivalent to worker skin contamination with 2.64 g parathion-methyl or 5.28 mL of the undiluted EC product.

The acute toxic potential of the ME parathion-methyl product is lower than that of the EC products. The concentration of the chemical in the prepared spray is lower than in the EC formulations. In addition, the active ingredient is released gradually as the capsules dry out on skin and clothing. Therefore, the amount of ME product equivalent to the rat dermal LD$_{50}$ for parathion-methyl will be greater than for the EC product.

**Repeated exposure**

The animal oral NOEL of 0.02 mg/kg/d for peripheral neuropathy is selected for the occupational health and safety risk assessment.

For the EC formulations, the NOEL for peripheral neuropathy is equivalent to a daily dermal exposure of 12 mg of parathion-methyl, 0.024 mL of the concentrate, 24 mL of the most concentrated spray in horticultural and field crops (0.05% ai), 0.43 mL of the most concentrated boom spray in cotton (2.8% ai) and 0.17 mL of the most concentrated aerial spray in cotton (7% ai).

For the ME formulation, using the same assumptions as for the EC products, the NOEL (0.02 mg/kg/d) is equivalent to 12 mg of parathion-methyl, 0.05 mL of the concentrate and 40 mL of the most concentrated spray in horticultural crops (0.03% ai).
Assessment of risk was based on calculations of margins of exposure (MOE). MOE for Australian use patterns were calculated by comparing the NOEL with measured and/or predicted worker exposure. An MOE of 100 or more was considered acceptable for parathion-methyl.

**Assessment - ground application**

Worker health risk was assessed from measured exposure data, including the study conducted in Australian orchards and model data. A range of control measures were considered including maximum PPE, closed mixing systems and closed cabs.

**Stone and pome fruit**

The NRA identified the critical ground uses of parathion-methyl as being in stone and pome fruit. In the Australian field study, MOE generated for parathion-methyl were <1. This was found for high volume airblast and electrostatic spraying. The assessment incorporated protection factors for PPE and closed cabs. Biological exposure data showed that the ACGIH BEI for parathion was exceeded in three out of ten workers spraying parathion-methyl under normal practices. One of these workers used ME parathion-methyl.

**EC formulation** - POEM estimates, Australian worker exposure data and a surrogate US study gave unacceptable risk during combined mixing/loading and application. Modelled data indicates unacceptable MOE for application alone. Consequently, closed mixing/loading alone would not adequately reduce overall exposure.

**ME formulation** - ME parathion-methyl is not registered for use in stone fruit. MOE were similar to EC formulation estimates for pome fruit.

**Other crops**

The assessment of parathion-methyl use (EC and ME formulations) found an unacceptable level of risk during ground spraying in vegetables and cruciferous forage crops.

**Assessment - aerial application**

**Cotton**

The NRA identified aerial spraying of parathion-methyl in cotton as a critical use. ME parathion-methyl is not registered for aerial use. Limited worker exposure data indicate unacceptable risk. Insufficient data was available to determine the potential benefits of closed mixing/loading systems and good spray application practices.
**Other crops**

Further data would be required to assess whether aerial application of EC parathion-methyl products in vegetables and cruciferous forage crops is safe with closed mixing/loading systems and with good spray application practices.

**Hand-held uses and greenhouse uses of parathion-methyl**

These use patterns potentially cause high worker exposure. No data was available to assess these uses, therefore, they are not supported.

**Bystander exposure**

Limited data was available to assess bystander exposure. Available information indicates that human flagging during aerial application of parathion-methyl is not acceptable, unless workers have additional protection.

**Tank mixing with other chemicals**

The risk assessment indicates unacceptable risk where parathion-methyl is used alone. The additional risk to workers posed by tank mixing parathion-methyl products with other anticholinesterase products would be unacceptable. Therefore, data should be provided on the occupational health and safety effects of this practice.

**Re-entry assessment**

Foliar residue data was compared against foliar levels of parathion-methyl considered to be safe in the US. No safe level is proposed for paraoxon-methyl. MOE were calculated from measured re-entry exposure data.

**EC formulation**

Foliar thion residues were below the safe level 48 hours post-application. Insufficient oxon data was available to identify a safe re-entry period. Assessment of the limited actual re-entry exposure data showed that MOE were still unacceptable at 96 hours post application, the last time point measured.

Available data indicates that the current re-entry period of 2-5 days specified on EC parathion-methyl labels is inadequate.

**ME formulation**

Limited foliar residue data indicated that thion residues exceeded the safe level 7 days post-application. MOE calculated for re-entry workers were unacceptable up to 7 days after application.

Available foliar residue data and worker exposure data indicate that the re-entry period for ME parathion-methyl should be longer than for EC parathion-methyl.
5.6 Conclusions

The OHS risk assessment utilised measured worker exposure studies, published literature and predictive exposure modelling to estimate the risk to workers currently using parathion-methyl.

The risk assessment found that the health risk to workers during routine ground spraying (airblast, electrostatic and boom spraying) of parathion-methyl products in all crops was unacceptable, irrespective of the use of closed mixing/loading, closed cabs and protective clothing (where applicable). Where the appropriate authorities allow continued use of ground spraying of parathion-methyl, upgraded training plus restrictions on application rates, spray intervals, engineering controls, re-entry periods and tank mixing are required. Parathion-methyl labels should be amended to include clear instructions for low volume applications.

The OHS risk was not acceptable in all circumstances for aerial spraying, however, increased worker controls were recommended, pending submission and assessment of worker exposure data. The worker controls include upgraded training plus engineering controls and prohibition of human flagging unless flaggers are protected by engineering controls such as cabs. Existing guidance on safe flagging procedures requires upgrading.

The OHS risk assessment concluded that field workers were at risk when re-entering parathion-methyl treated areas. Re-entry restrictions currently on parathion-methyl product labels are inadequate. An interim re-entry period of 14 days is to be introduced, pending submission and assessment of suitable re-entry information.

No data was available to assess hand-held uses and greenhouse uses of parathion-methyl.

Parathion-methyl and the products under review are hazardous substances and are covered by regulations to control workplace hazardous substances.

The existing safety directions for micro-encapsulated parathion-methyl product(s) need to be upgraded to include the personal protective equipment requirements as assigned for the emulsifiable concentrate formulation.

Tank mixing with parathion-methyl is part of current practice. The OHS risk assessment indicated unacceptable risk when using parathion-methyl alone. The additional risk posed by tank mixing with other anticholinesterase products is unknown.
6. ENVIRONMENTAL ASSESSMENT

6.1 Introduction

In Australia parathion methyl (EC) is used in cotton, vegetable and orchard crops. It can be used in IPM programs in orchards. Application is normally by air for cotton as a mixture with other insecticides and it may also be aerially applied to vines and some vegetable crops. Ground based equipment is used for other crops.

The currently registered micro-encapsulated formulation, Penncap-M, is for pome fruit, citrus and grapevines, while another micro-encapsulated product for which data was available for assessment, is proposed for cotton, vegetables and orchard crops.

Details concerning use

Parathion methyl is registered for use on citrus, pome fruit, stone fruit, grapevines, vegetables, cotton, tobacco, clover seed crops and cruciferous forage crops, with the major uses being for cotton and in orchards. It is used to control mites, scale, aphids, mealy bugs, lucerne fleas and thrips. It is considered a ‘soft chemical’ and is used as an integral part of IPM programs, especially by growers in the stone and pome fruit industries.

The maximum use rate is 2.8 L/ha, corresponding to 1.4 kg ai/ha for Helicoverpa spp. in cotton. For orchards the maximum concentration is 100 mL per 100 L of spray for scale (normally during winter dormancy for control of scale). The current usage in pome fruit orchards is to control codling moth, light brown apple moth and Oriental fruit moth in IPM programs at an application rate of 65 mL per 100 L. Scale is normally controlled by application of winter oil and chemical sprays are not encouraged.

For vegetable use, the rate is 65 mL per 100 L or 700 mL/ha and is also for control of various moths, mites, Jassids and various other bugs.

In orchards it is normal practice to spray to runoff, normally requiring 1500 to 2000 L/ha of spray solution. In extreme situations, for example when atmospheric conditions are dry and hot, this could be as high as 3000 L/ha to achieve complete wetting of the crop. These figures correspond to typical application rates of between 500 g ai/ha and 650 g ai/ha, but could be as high as 1000 g ai/ha.

The use pattern, as stated on the label, is as required for cotton, pome and stone fruit, as necessary at weekly intervals for tobacco and every 10-14 days for vegetable crops. Parathion methyl could be applied up to 12 times per growing season but typically 6-10 applications are made per season. It should be noted that some market gardening operations would have two crops per year, thus up to 20 applications per year are possible from label directions and using program spraying.

The current use in cotton appears to be significantly different from that stated on the label. Parathion methyl is currently applied as a mixture with another pesticide, either a pyrethroid or an organophosphate insecticide, to restore the ‘efficacy of the pyrethroid or other OP’ and prevent the building up of resistant insects. When used
this way, the application rate normally is 2 to 2.2 L/ha, equivalent to 1 to 1.1 kg ai/ha. Application occurs from January to the end of the season, with normally 4 mixed applications per season.

Parathion methyl is normally aerially applied to cotton (using micronairs on fixed wing aircraft) and sometimes on tomatoes and brassica forage crops (unlimited applications allowed but normally 4-5 would be the maximum in one season).

Traditionally application to orchards is by orchard air blasters using high volume equipment. However, many orchardists are now using low volume, and in some cases electrostatic ultra low volume (ULV) equipment. As there are no directions on the label for such equipment, growers convert the current label directions for concentration of spray to a rate per hectare and apply that rate using the LV and electrostatic equipment.

Applications to vegetable crops is normally by horizontal boom spray but taller crops, such as tomatoes and corn are sometimes sprayed using vertical boom sprays. Aerial application is used for some vegetable crops, especially processing tomatoes. Other sprayers are likely to be used in vegetable crops, particularly hand held types for smaller growers or for small plots. The application rate on the label is 65 mL per 100 L or 700 mL/ha.

The labels ban aerial spraying in Tasmania (without specific approval of the Registrar of Pesticides) and prevent the use of back-mounted knapsack equipment in Victoria.

There is no information on types of spray equipment used or any information concerning the use of low volume application equipment. Information on minimising spray drift—size of spray droplets etc., is also not given on the label. Insecticides tend to be applied as either medium to fine droplets (300 to 100 µm) with conventional spray equipment or as fine spray to coarse aerosol (100 to 25 µm) with LV, ULV and electrostatic equipment.

Penncap-M is registered for application to pome fruit, citrus and grapevines at 125 mL per 100 L of spray which corresponds to 450 to 600 g ai/ha of micro-encapsulated parathion methyl (note lower rate than for the EC above). Use is for control of codling moth, light brown apple moth, vine moth, scale, aphids, mealy bugs and loopers.

The proposed label for the micro-encapsulated formulation is for use in cotton, citrus, pome and stone fruit, grapevines, vegetables, cruciferous forage crops, tobacco and clover seed crops, ie all crops for which the EC formulation is registered. The application rates are as for EC.

6.2 Environmental fate and degradation

Hydrolysis
From a single experiment at pH 5, 7 and 9, it may be concluded hydrolysis is relatively slow and parathion methyl is classified as slightly hydrolysing (Netherlands
classification). Hydrolysis is unlikely to be a significant contributor to the overall degradation of parathion methyl in the environment.

**Photolysis**

---Aquatic
Based on a laboratory study performed at pH 5, conducted according to US EPA guidelines, and theoretical studies based on the UV spectrum of parathion methyl (ECETOC methodology), the photodegradation rate in water is rated as moderate. From the laboratory study, the half life under environmental conditions was calculated as 8.7 days as opposed to 15 days in the theoretical studies. Photodegradation could be a route of degradation in the environment in clear water. However, due to the turbidity in the majority of Australia’s aquatic environment (river/streams), direct photodegradation is unlikely to be a significant route of degradation, due to rapid metabolism.

---Soil
In a soil photolysis study performed according to US EPA Guidelines, the half life of photodegradation of parathion methyl in moist or dry soil was calculated to be 16.8 and 19.3 days respectively under environmental conditions (no clouds) from laboratory experiments. This contrasts with the 39 days obtained when tested under ‘outdoor’ conditions in Germany. The photodegradation in soil would be a minor route of environmental degradation, even in Australia with high light levels during summer.

---Vapour
Reactions of parathion methyl in the gas phase under the influence of simulated sun light was studied with consideration to the relevant US EPA Guideline. Parathion methyl is readily degraded in the vapour phase, with an estimated half life of one day in natural sunlight. The major degradation products were 4-nitrophenol and dimethylthiophosphoric acid. Significant degradation of parathion methyl in the environment is possible due to photolysis in the vapour phase.

**Metabolism**
All metabolism studies were performed to US EPA guidelines and used the same single sandy soil.

---Aerobic Soil Metabolism
The degradation of parathion methyl under aerobic conditions in a sandy soil was fast, with a half life of 4.7 days. The major product is carbon dioxide. The degradation pathway appears to be direct metabolism to carbon dioxide or incorporation into the organic fraction of the soil followed by mineralisation.

---Aerobic Aquatic Metabolism
The degradation of parathion methyl in aerobic aqueous conditions using the same soil as above was very fast, with a half life of just 1.1 days over the first seven days. After the first week, the concentration of parathion methyl detected in the aquatic phase is effectively zero. Residues of parathion methyl left in the sediment degraded more slowly, with a half life of 16.5 days.
—Anaerobic Aquatic Metabolism
The degradation of parathion methyl in anaerobic aqueous conditions again using the same single soil was very fast, similar to the aerobic study with the same half life of just 1.1 days over the first seven days. After the first week, the concentration of parathion methyl detected in the aqueous phase is effectively zero.

—Micro-encapsulated
There was no information presented on the soil or aquatic metabolism or degradation of either microencapsulated formulations. Based on statements related to Parashoot the microencapsulated formulations are expected to persist longer than the EC formulations in the environment, releasing the active ingredient more slowly, which will then be metabolised as for the EC.

—Conclusion
It is concluded that microbial degradation of parathion methyl EC in soil and aquatic conditions is very fast under both aerobic and anaerobic conditions. As there were no studies presented on the metabolism of the micro-encapsulated formulations, no definite conclusion can be reached concerning the rate of degradation for these products.

Mobility
—Soil adsorption/desorption
The soil adsorption/desorption of parathion methyl was determined in four sterile soils. It was concluded that parathion methyl is only moderately adsorbed to most soils but stronger adsorption occurs to clay soils. It is rated as having medium mobility in most soils and in clay soils it is rated as having low to medium mobility. Despite there being only one cycle of desorption done in the studies, there was only limited desorption and indicates that binding is moderate to strong.

—Leaching
In a column leaching study using EC formulations, a ME formulation and two different soils there was no detectable parathion methyl residues in the leachate and it was concluded that this together with the ready degradation indicates that leaching of parathion methyl from either formulation is unlikely. However, there is a report of parathion methyl having been found in groundwater in Europe.

—Volatility from Soil
A study on the volatilisation of parathion methyl from a sandy loam soil was conducted according to US EPA guidelines. There was little if any parathion methyl trapped in the volatiles and significant degradation was observed. It was concluded that the volatility from soil is low for the recommended rates of application.

—Literature Reports
In literature reports, experiments using three different soils show that the volatilisation of parathion methyl is less than 3% of the initially applied material. However, the volatilisation from non-adsorbing surfaces is significant and within 2 days of applications up to 1.12 kg ai/ha all is expected to have volatilised.
Volatilisation of parathion methyl from soil is not expected to be a significant route for the dissipation from soil. However, volatilisation of parathion methyl from other non-adsorbing surfaces could be significant.

—Literature
A recent report has detected background levels of parathion methyl together with other agricultural chemicals in the atmosphere, rain and fogwater in France. Parathion methyl has also been detected in fogwater in California but not in fogwater from the Bering sea, Alaska. It is concluded by Environment Australia that these papers clearly indicate that while parathion methyl is expected to be degraded quite rapidly and be non-volatile from soil, sufficient material persists and volatilises to give detectable levels in the atmosphere with the corresponding background contamination and possibilities of long range mobility following extensive usage.

—Field Volatility Studies
It is concluded from a study, conducted according to Germany Guidelines, that the volatilisation of parathion methyl from soil is not expected to be a significant dissipation pathway but volatilisation from leaf surfaces is. In Australia with high summer temperatures the volatilisation of parathion methyl could result in a significant fumigant effect on non-target insects.

In an older study that does not meet modern standards, it was concluded that using oil as the carrier in ULV applications does not significantly limit the dissipation of parathion methyl from non absorbing surfaces. The route of dissipation is unclear but is likely to be a combination of volatilisation and degradation.

—Conclusion
Volatilisation of parathion methyl from soil is not expected to be a significant route for the dissipation from soil. However, volatilisation of parathion methyl from other non-adsorbing surfaces could be significant.

Spray Drift
The spray drift studies for parathion, the ethyl analogue, showed that aerial application leads to significant spray drift. Based on the concentrations in the air and assuming that parathion methyl is approximately half as toxicity to bees that parathion is, then parathion methyl is expected to be toxic to bees up to 800 metres away from aerial applications. As the droplet sizes are approximately the same size of those used in Australia for application of EC formulations, under Australian conditions spray drift is expected to be similar.

Recent literature studies on aerial spray drift show that the 95th percentile from a number of experiments gave spray drift results of 0.35% of the application rate at approximately 300 metres. Thus one in twenty aerial applications result in 0.3% of the application rate as spray drift at 300 metres from the edge of the field being sprayed. Under adverse conditions, ie inversion layers, the 95th percentile for spray drift increases to 1% of the application rate.
The spray drift from ground-based orchard application was significant and parathion was toxic to bees up to 400 metres away. Using the same assumptions as before, parathion methyl is expected to be toxic to bees up to 200 metres way from ground based orchard applications. As the droplet sizes in Australia in ground based orchard applications are expected to be similar as this in this study, the spray drift and the toxicity to bees is expected to be highly relevant.

Micro-encapsulated
No studies on the spray drift from applications of the ME formulations were presented. It is claimed by one registrant that as the micro-encapsulated formulations have higher density than water there will be less (spray)drift. Given that the changes in the specific density of a spray formulation will be very minor and the claim was not supported by any studies, Environment Australia can not accept without supporting data that there will be less spray drift from the ME formulations.

Field Dissipation Studies
Four field studies in cotton and rice were presented which support the results of the laboratory studies in that parathion methyl is very quickly degraded in the soil and that there is no leaching. There were no half-lives determined in the field studies as the degradation was too fast but can be estimated to be <1 day in the soils tested. Parathion methyl or its metabolites were not detected below 10 cm in the soil, confirming the laboratory studies on mobility which showed that leaching was unlikely. Degradation in rice paddy waters was again very fast with a half life of <1 day.

Despite the rapid degradation in soil and in natural water, parathion methyl has been recently detected at low levels in river water in NSW. It has also been detected in dam water and sediment from an agricultural area in Mexico.

Bioaccumulation
The steady state bioaccumulation factors are low, with the highest being 108 times for non-edible tissues. Elimination of parathion methyl from these tissues was rapid, with a half life of 7 hours, indicative of rapid depuration. Bioaccumulation in the aquatic environment is not expected in normal conditions. However, under high environmental stress, the literature suggests bioaccumulation could occur but once the system returns to normal, rapid depletion should occur and prevent any sustained bioaccumulation.

Conclusion
Parathion methyl is readily degradable in soil and aquatic environments and is unlikely to persist beyond 1 week following application. Bioaccumulation is not expected. Due to the very rapid degradation in soil, leaching is not expected.
While parathion methyl is not volatile from soil, it is volatile from other surfaces. As a result of the ready photolysis in the vapour phase, vapours of parathion methyl are not expected to persist in the air. However, despite its demonstrated lack of persistence in laboratory studies, parathion methyl has been detected in air, rainwater and fogwater overseas, ground water in Europe and in surface water in Australia and Mexico.

6.3 Ecotoxicity

Parathion methyl is a highly toxic organophosphate insecticide. It is toxic to most organisms and in particular aquatic invertebrates.

Avian
Parathion methyl (EC) is rated as very highly toxic to birds (bobwhite and mallard) by the acute oral route (LD50 of 6.6 to 9.8 mg/kg) but the toxicity is moderated when ingested as part of the diet (mallard ducks; LC50 of 357 mg/kg actual, and quail LC50 of 91 mg/kg, nominal). Effects on bobwhite quail reproduction and significant number of mortalities were noted at 15.5 ppm (EC) in the feed in a 20 week study, but at 14.7 ppm there were no effects on reproduction or toxicity related effects on mallard ducks over the same period.

Field reports indicate that mixtures of parathion and parathion methyl has been associated with several incidents of bird kills in the USA at rates similar to those used in Australia but parathion, the ethyl analogue, is more likely to be the major toxicant involved.

Laboratory studies simulating aerial overspray of birds in a crop with parathion methyl, at rates similar to those used in Australia, showed that while none died the level of cholinesterase inhibition was >50%, indicating that the birds had received a potentially toxic dose. The major route of exposure was mainly oral ingestion through preening and by dermal adsorption of residues. In tests designed to determine the discrimination threshold, it was found that parathion methyl is not repellent to birds but conditioned aversion occurs. However, the chemical is poorly detected by some individuals and with decreasing availability of uncontaminated feeds, significant oral exposure is possible.

Parathion methyl has been associated with changed behaviours in ducks when nesting ducks have been exposed (aerially oversprayed) at the highest Australian rate in the field and under controlled conditions. These behavioural changes during nesting and brood development have been associated with reduced duckling survival in some species of ducks, particularly those that are open nesters.

The both microencapsulated formulations assessed are rated as highly toxic to quail and Penncap-M as moderately toxic to mallards but the mallard results are not considered reliable. There were no dietary studies presented and the effect of dietary exposure from the ME formulations is unclear. Based on a statement presented by Colin Campbell, it is expected that the dietary toxicity of the micro-encapsulated formulations is similar to the EC formulations.
Aquatic
The toxicity to aquatic organisms is very high, especially to invertebrates. The reported acute toxicity to fish on the US EPA’s ASTER data base ranges from LD50’s of 59 µg/L for spot to 75 mg/L for northern puffer fish, with the results for spot considered reliable (see results in Table 23). The submitted study shows an LC50 of between 4 and 12 mg/L for golden orfe. Life cycle studies have not been performed but the embryonic and larval life stages of Sheepshead minnow have been tested and the maximum acceptable tolerated dose was determined to be between 12 and 26 µg/L. The early life stages are considered to be normally the most sensitive. (Note that the acute to chronic ratio is very high, with the acute LC50 = 12 mg/L, from Table 23). Parathion methyl is extremely toxic to invertebrates, with acute toxicity figures for daphnia and mysid shrimp (EC50) of 5.8 µg/L and 0.34 µg/L respectively. The chronic toxicity to daphnia and mysid shrimp has been determined and the MATC found to be between 0.43 and 0.85 µg/L for daphnia and 0.11 to 0.37 µg/L for mysid. The acute to chronic ratio for daphnia and mysid shrimp is lower than for fish.

The toxicity of parathion methyl to Australian freshwater crayfish is not available but EC50 of 2.4 µg/L and LC50 of 40 µg/L to an American freshwater crayfish species have been reported. These values are old, nominal and are considered not reliable.

Parathion methyl is moderately toxic to green algae, with EC50s of 3.0 and 5.6 mg/L for two species of Selenastrum.

A microencapsulated formulation of parathion methyl is significantly less toxic to fish than the EC formulation in static testing. However, there was no significant difference in toxicities of the EC and the ME formulations in static daphnia tests. A similar result is expected for other sensitive aquatic invertebrates. At 100 mg/L this microencapsulated formulation is non-toxic to the algae Scenedesmus subspicatus.

There were no tests provided for the Penncap-M encapsulation formulation to aquatic organisms. A daphnia study is said to be preparation but is some months away from completion. The registrant of one microencapsulated formulation claims that micro-encapsulated formulation do not effect fish and aquatic fauna due to sedimentation. The results with another microencapsulated formulation refute this claim in respect of daphnia and presumably similar feeding organisms.

Non-Target Invertebrates
Parathion methyl (EC formulation) is very highly toxic to bees by all routes of exposure. The results available for one micro-encapsulated formulation indicate that it is less toxic than the EC formulation, although it is still rated as toxic to bees by contact exposure and moderately toxic by oral exposure. Residues of microencapsulated formulation on foliage were toxic to bees in a force contact test for up to 8 days after application. In field tests it was shown that application of either the EC or Penncap-M, another micro-encapsulated formulation, to rape, corn and sunflower crops and allowing bees to forage immediately afterwards did not result in a significant difference in the concentration of parathion methyl residues in pollen gathered by the bees. However, while both showed significant toxic effects on the foraging bees, there was a significant decrease in mortalities from Penncap-M during the first two days.
No data on the toxicity to earthworms or other soil micro-invertebrates for the EC formulation was presented or found by Environment Australia. Based on the similar toxicity of the oxygen analogues (oxons) forms of parathion and parathion methyl, parathion methyl is expected to have a similar toxicity to earthworms as parathion, which has an LC50 = 65 mg/kg in artificial soil. The toxicity of a micro-encapsulated parathion methyl formulation was determined as LC50 = 520 mg/kg dry soil (208 mg ai/kg of dry soil) and the NOEC (mortality) of 250 mg/kg dry soil (100 mg ai/kg dry soil). However, Environment Australia assigned the NOEC as <250 mg/kg of soil, based on the stiffness and coiling behaviour and noted that in the range finding study a NOEC of <0.25 mg/kg in soil was possible, based on the stiffness of the worms noted at 0.25 mg/kg.

Parathion methyl (EC formulation) is very toxic to all the non-target invertebrates (bees, lacewing and carabid beetles) tested. Tests on a microencapsulated formulation showed it was harmless to slightly harmful to a predatory mite and harmful to a parasitic wasp, according to IOBC criteria.

6.4 Predicted Environmental Hazard

Terrestrial organisms

Mammals
Terrestrial animals are at risk from parathion methyl when applications of the chemical are made or afterwards by contact with sprayed surfaces or from the fumigant action of the insecticide. Aerial applications could overspray larger non-target organisms, such as marsupials but this is not considered a common occurrence due to the low height of the spray aircraft at application, ie close to crop height, and it is expected that these animals will move some distance from the area where spray operations are occurring, while smaller mammals will be undercover. Similarly, overspray by tractor powered equipment is considered unlikely as animals will move some distance from the area where spray operations are occurring or be undercover. Most mammals are not expected to be oversprayed directly.

It is difficult to assess the risk to larger terrestrial organisms that enter sprayed areas and are dermally exposed to residues. Animals that enter recently sprayed areas are at some risk of exposure but as there are few, if any, reports of dead or dying animals, it is considered likely that the risk is relatively low.

Birds
Parathion methyl is very highly toxic and has the potential to harm birds through ingestion of residues. For fruit sprayed at 1 kg ai/ha, the highest rate likely to be used, the concentration of parathion on the fruit is calculated as 13 mg/kg. Using the dietary LC50 = 357 mg/kg in the diet and assuming that these species ingest approximately 50% of their dietary intake as fruit, then the hazard is calculated as being low. As the dietary EC50 is based on 5 days of exposure and the initial residues are expected to degrade rapidly, the actual dose received will be lower and the hazard is expected to be lower. However, some caution should be applied as this is based on a single reliable acute dietary result.
Secondary effects on birds are possible from birds eating insects that are dead or dying from use of parathion methyl. The concentration of residues on large insects from applications at 1 kg ai/ha is calculated as 13 mg ai/kg (wet weight), the same as above. The hazard is low from dietary intake of residues on insects.

There shouldn’t be a significant increase in risk to birds from the direct effects of use of the micro-encapsulated formulations as they are used at a lower rate than above or are proposed to be used at the same as rate.

Birds entering an area that has been recently sprayed could be exposed either dermally or orally from preening contaminated feathers or drinking contaminated water. This type of exposure is difficult to estimate but given the low hazard from residues on feed stuffs, this route of exposure is not expected to cause a significant increase in the overall hazard.

Aerial spraying could affect ducks and possibly other birds during their nesting and when they are raising their broods. While it is unlikely that birds would be in the cotton fields, they are likely to be in and around the dams and possibly field margins on the cotton farms. Poorly controlled aerial application could result in them being directly sprayed.

**Bees**

Bees are at risk if spraying occurs when they are present in the crop. Using the lowest application rate in orchards (500 g ai/ha) the estimated dose is 3 µg ai per bee, and significantly above the EC50 of 0.04 µg ai per bee. If bees are aerially oversprayed the hazard is expected to be higher than that for orchards. In order to limit the exposure of bees to the pesticide, the crop should not be sprayed when there are bees present, when the crop (or ground covers) are in flower or if likely to be in flower shortly afterwards, ie within 3 days of spraying. The same restriction should apply to the micro-encapsulated formulations, given that these formulations are of similar toxicity to bees.

Spray drift is expected to be extremely toxic to bees and there is a significant hazard to bees from aerial application of parathion methyl. There are recent reports of aerial application of parathion methyl causing significant mortality to bees, mainly in the Gunnedah area.

**Soil Invertebrates**

Earthworms and other soil dwelling invertebrates could be exposed to the pesticide, and at an application rate of 1.0 kg ai/ha, the top 5 cm of soil would contain parathion methyl residues at 1.5 mg/kg of soil (assumes no crop cover, density of soil 1300 kg.m\(^{-3}\)). As this concentration is significantly below the expected EC50, significant effects on earthworms are not expected.

For the micro-encapsulated formulations, the top 5 cm would contain residues at 1.5 mg ai/kg of soil at the application rate of 1.0 kg ai/ha, maximum rate for orchards. There is unlikely to be any mortality to worms but is should be noted that worms exposed to these residues could be effected, ie stiffer than normal, based on the range finding studies. This could lead to increase predation and reduces fitness and therefore be a significant environmental hazard.
Other soil invertebrates may be significantly affected unless they can move away from the sprayed areas or have become resistant to parathion methyl in the past. There are no toxicity data available for these organisms and the hazard cannot be determined.

Conclusion

While overall hazard to birds appears low, there are a number of uncertainties and sufficient reports from overseas of adverse effects in a variety of situations that hazard from Australian usage under certain circumstances cannot be ruled out. The hazard to bees is high, particularly from aerial application, and there is a possible hazard to soil invertebrates but there is limited toxicity data for these organisms. Terrestrial mammals are not expected to show significant affects when parathion methyl is used according to current label directions. The micro-encapsulated formulation is expected to have a similar hazard to terrestrial organisms as the EC formulation.

To strengthen the current warning label with regard to bees, the label for all formulations should be modified to read:

Do not spray any plants in flower, including ground covers and adjacent foliage, or while bees are present. Spray drift is also highly toxic to bees and at considerable distance.

Aquatic organisms

Direct overspray onto water

Aquatic organisms are the most sensitive to the toxic effects of parathion methyl, based on the ecotoxicity data reviewed. Application by boomspray and orchard air blasters is unlikely to result in direct overspray, however, aerial application could lead to such direct over spray and is of concern. A concentration of 0.73 mg/L in shallow water was calculated by Environment Australia using a typical rate used in cotton and is unlikely to cause mortalities in the majority of fish species. Effects on daphnia and other aquatic insect/invertebrates from direct overspray are likely to be severe, based on the tests reviewed. Similar effects are likely on other aquatic invertebrates and there could be a significant risk to freshwater crayfish.

Spray Drift

Aerial Applications

Some land-use considerations

Aerial application is the normal practice for applying pesticides to cotton. The major cotton growing areas in Australia are northern NSW and central to south-eastern Queensland with WA as minor area. In northern NSW significant numbers of cotton fields are close to water with other cotton growing regions likely to be similar. Environment Australia recognises that some of these waterways are drainage systems but a number are expected to be natural streams/rivers.
The cotton industry has recognised that farming practices must become more responsive to community concerns, and has therefore worked to implement a research program which is addressing the movement, fate and effects of pesticides in the riverine environment. The industry has also developed a Best Management Practices Manual for Cotton Growers which sets out principles and practices for good communication, pesticide application, farm design, IPM, and soil and water management.

Acute hazard

—Emulsifiable Concentrate
From data on aerial spray drift presented to Environment Australia and considering that the slope of the curve for the acute toxicity to daphnia is very steep (NOEC is only half the LC50), effects on daphnia in a still pond (15 cm deep) are calculated to occur at approximately 400 metres or less from the site of application. Within 24 hours of application and a reduction of 90% of the original concentration due to degradation and adsorption, the hazard is significantly reduced and effects on daphnia are only expected to remain within 50 metres of the site of application. With repopulation of the affected area occurring from unaffected areas and toxic effects being of short duration, significant long term effects on populations of daphnia are not expected. However, daphnia are not the most sensitive organism and for the more sensitive organisms, there is an unacceptable hazard up to 400 m from the application site even after 24 hours.

It is clear from the efficacy report that parathion methyl is used by the cotton industry as mixtures with other insecticides as an ‘efficacy restorer’. As this practice increases the efficacy and therefore the toxicity to insects in the crop, it is also likely to increase the environmental hazard.

A buffer zone or in-crop buffer is desirable, as given in the newly launched Best Management Practices Manual for Cotton Growers, which currently suggests a downwind buffer of 300 metres for aerial applications. While adoption of this would reduce the hazard to environmentally sensitive areas, additional measures such as vegetative buffers are required to reduce the hazard to more acceptable levels, especially at the high rates used. Until such measures are implemented through the cotton industry as standard practice, aerial application of parathion methyl is likely to cause significant impacts on sensitive aquatic organisms 400 metres and beyond the application site.

In conclusion, and taking into account the unknown effects of applications of mixed insecticides, Environment Australia cannot rule out that an unacceptable hazard exists through aerial application of parathion methyl in the current fashion, due to both possible direct overspray and spray drift.

While we are aware of no actual aquatic mortality incidents, the reports of bee deaths are a clear indication that unacceptable spray drift occurs. Continuation of this practice is thus difficult to defend, although a ban at this stage would only lead to the greater use of equally toxic and more persistent insecticides. Clearly the aerial application of parathion methyl is of concern and it should be phased out as less toxic
chemicals become available. In the mean time the recommendations in the Best Management Practices Manual for Cotton Growers should be implemented as soon as possible to help minimise the impacts of continued usage of parathion methyl in the cotton industry.

—Other crops
The considerations above were for cotton and are expected to apply to other situations where aerial application occurs. Given the hazard with aerial applications, and that there are alternatives to this method of application, Environment Australia considers that aerial application in non-cotton crops is not acceptable.

—Micro-Encapsulated Formulations
While Penncap-M is not expected to be aerially sprayed as it is for orchards crops only, it is possible that proposed uses for microencapsulated formulation include cotton and vegetable crops that are aerially sprayed. Assuming that aerially application of microencapsulated formulations gives the same spray drift as the EC formulations, then a similar hazard calculation to that above indicates that there is an hazard to daphnia up to 400 metres away and for sensitive aquatic invertebrates up to 800 metres away from the application site. Also, as the active ingredient in the microencapsulated material is expected to be slowly released to the aquatic compartment, the effects are likely to be prolonged and significant reduction in the hazard within the first few days is not expected. Environment Australia considers that aerial application of the micro-encapsulated formulation is not acceptable, based on currently available studies.

Ground based spraying

Orchards applications

—Land use considerations
No data exists for the occurrence of orchard crops close to water bodies, but Environment Australia expects that ponds and drainage channels (both man-made/modified or natural) would be a common feature of the landscape in which pome fruits are grown, with subsequent movement of parathion methyl into “natural” receiving waters such as swamps, marshes, lakes and rivers. Indeed, it is likely that man-made drainage channels would frequently be within 10 m of the crop, but are of less concern than natural waterbodies because of their expected lower biodiversity and ecological significance.

—Emulsifiable Concentrate
The major use of parathion methyl currently is for pome fruit orchards, which are sprayed by orchard air blasters or similar equipment. From the information on spray drift presented to Environment Australia, a simple model based on this data was developed.

Calculations based on the model show that the hazard to fish in shallow water is minimal from use of orchard air blast equipment from spray drift at the highest application rate (1 kg ai/ha). There is a high hazard to daphnia at 50 metres away in shallow water from drift at the highest rate and only decreases to acceptable levels at 100 metres away or greater. For the more sensitive aquatic invertebrates the hazard
extends to 200 metres. After 24 hours, there are still likely to be significant effects on sensitive aquatic invertebrates 50 metres away, particularly at the highest rate.

The degradation of parathion methyl is rapid, half life of 1.1 days, so that after another 24 hours, ie 2 days after spraying, the concentration is expected to be halved and the hazard correspondingly reduced. Effects on the most sensitive organisms 50 metres away are still likely after 2 days at the highest rate but unlikely between 500 and 750 kg ai/ha.

A potential hazard exist from use of parathion methyl in orchards using conventional air blast equipment but this hazard is lower than with parathion, a potential alternative chemical for IPM. While this is mainly due to the more rapid degradation, the some what lower toxicity of parathion methyl is a major factor.

The efficacy report clearly identifies that spray equipment other than the high volume conventional sprayers is increasingly being used by orchardists and is of concern due to the higher potential for spray drift. Environment Australia does not have data for the spray drift from such applications but considers that the assumptions used above could underestimate the distance that the drift would affect. Further information is required before a conclusion about the hazard to aquatic organisms from such applications can be determined.

Electrostatically charged sprays are expected to limit horizontal movement and localise the spray to surfaces in and beside the orchard and thereby reduce the hazard.

A recovery period is required to minimise the impact of repeated applications, especially as parathion methyl may be used up to 8 times a season. As parathion methyl is most likely to affect aquatic invertebrates, a minimum recovery period of at least 14 days between applications is desirable. Considering the above and that the most sensitive subpopulations are likely to have already been significantly effected, it is recommended that the label rate be reduced to a maximum of 650 g ai/ha.

—Micro-encapsulated Formulations
Both microencapsulated formulations are expected to be applied by orchard air blasters. As for the aerial application above, assuming that ground application of the microencapsulated products gives the same spray drift as the EC formulations, the hazard has been calculated as above. This shows that there a significant hazard to daphnia at 50 metres away for application of micro-encapsulated formulations, and is only acceptable to Environment Australia at 100 metres for applications between 500 and 750 g ai/ha. As effects are likely to be more prolonged, the higher application rates are not acceptable. It is recommended that the application rates for all micro-encapsulated products be reduced to that of Penncap-M.

Applications by boom spray
—Emulsifiable Concentrate
Recent literature reports have shown that as close as 1.7 metres to the spray boom there is less than 2% spray drift for ≥95% of applications, even in winds of 20 km/hr. Another figure used by Environment Australia for spray drift from boom spray 5
metres away from the site of application is 1%, based on studies using herbicide applications. Using deeper water (30 cm) and mitigation of the quotient for both degradation and adsorption after 24 hours, the hazard was calculated as low. Use of boom sprays for application of parathion methyl is acceptable.

—Micro-encapsulated Formulations
Given that the toxicity of the micro-encapsulated formulations to daphnia are expected to be similar to the EC formulation, application of these formulations by boom spray are not expected to result in an increase in the acute hazard to that of the EC formulations and therefore application by boom spray of the micro-encapsulated formulations is acceptable.

**Chronic effects**
Once in the aquatic environment, parathion methyl is not expected to persist, with a laboratory half-life of 1.1 days for the initial period of degradation. The field studies showed the degradation could be faster in more biologically active waters, ie rice paddies. This is expected to reduce the concentration of parathion in the aquatic environment to approximately one hundredth of the initial dose in a week. Chronic effects are not expected.

This does not apply to the micro-encapsulated formulations, where there are unsubstantiated claims of prolonged persistence. Until additional data on the environmental degradation is presented, Environment Australia considers that chronic effects on aquatic invertebrates from these new formulations are possible.

**Runoff and leaching**
Runoff from areas where parathion methyl has been applied is not expected to be significantly contaminated. The K_{oc} indicates at least moderate binding to soil particles, which was confirmed in the aquatic metabolism study. The rapid degradation in soil will limit the time when erosion of soil with adsorbed parathion methyl is likely to be problematical.

Further, significant erosion of contaminated soil is not expected due to modern orchard and vineyard management practices including cover crops between rows. Erosion in horticultural (vegetable) crops is also not expected. If heavy rain occurs within days of the application, expected to be a rare event, high dilution is likely which will limit environmental effects.

Leaching of parathion methyl to subsurface water is unlikely, as shown by studies presented to Environment Australia.

**Multiple applications**

—Emulsifiable Concentrate
The above analysis is for a single application but in practice there are expected to be multiple applications. It is expected that in most situations there would be at least 7 days between sprays. For vegetables there are 10-14 days between applications. Assuming the worst case, ie that there is no adsorption to sediment and the half life in water is 1.1 days, then the increase in concentration after 7 days due to carryover is 1.2%. Therefore, an increase in acute toxic effects on aquatic organisms from

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multiple applications is not expected, provided there is at least 7 days between applications.

However, the main problem is repeated effects on sensitive organisms and 7 days between sprays would not allow affected populations to recover. A recovery period is required to minimise the impact of repeated applications, especially as parathion methyl may be used up to 8 times a season. As parathion methyl is most likely to affect aquatic invertebrates, a minimum recovery period of at least 14 days between applications is desirable. This corresponds to 2 life cycles for daphnia, an important invertebrate in aquatic ecosystems.

—Micro-encapsulated Formulations
The label for Penncap-M has a minimum period of 2 weeks between sprays and the proposed label for another microencapsulated formulation does not give a spray interval, apart for some vegetable crops and tobacco of 10-14 days between applications. There were no studies on the metabolism and degradation of the microencapsulated products and therefore the persistence of the micro-encapsulated products in the environment is unknown. Also, as some microencapsulated formulations assessed were very toxic to daphnia and there is a question as to whether the ME formulation constitute a chronic hazard or not, it is not possible to determine the effects of multiple applications.

The effect of multiple application of the ME formulations is unknown.

Effects on algae
Parathion methyl is rated as moderately toxic to algae. As direct application to water is not expected and the spray drift studies show that the concentration in shallow water just 50 m downwind from aerial spraying is greater than two orders of magnitude below the algae EC50, effects on algae are unlikely.

Desirable terrestrial vegetation
As parathion methyl is non-phytotoxic to plants and as direct application to desirable terrestrial plants and vegetation is not expected, significant effects on desirable plants is unlikely.

Controls/Labelling
Parathion methyl must not be allowed to contaminate waterways.

If aerial application is to be retained, the following warnings should be added to the label under the heading of ‘Use’:

“A spray drift minimisation strategy should be employed at all times when applying sprays to or near sensitive areas. Parathion-methyl is highly toxic and all efforts should be taken to minimise spray drift. The strategy envisaged is exemplified by the Australian Cotton Industry Best Management Practices Manual.”
If registration is to continue for any formulation, the following warnings should be added to all labels under the heading of ‘Use’:

“DO NOT apply under meteorological conditions or from spraying equipment which could be expected to cause spray drift onto natural streams, rivers or waterways. Parathion methyl is highly toxic and all efforts should be taken to minimise spray drift.

Dangerous to bees. DO NOT spray any plants in flower, including crop and interspersed non-crop plants while bees are present. Should spray drift occur bees may be at risk several hundred meters downwind depending on conditions.”

**Disposal**

Some of the labels from different companies do not appear to comply with current labelling practices with respect to rinsing and disposal of used containers. All currently registered labels and currently sold products should comply with the current labelling requirements with respect to rinsing and disposal of containers, ie

Triple rinse or pressure rinse empty containers before disposal. Add rinsings to the spray tank. Do not dispose of undiluted chemical on site. Break, crush or puncture and bury empty containers in a local authority landfill. If not available, bury the containers below 500 mm in a disposal pit specifically marked and set up for this purpose, clear of waterways, vegetation and roots. Empty containers and product should not be burnt.

For refillable containers the following should be added:

Empty contents fully into application equipment. Close all valves and return to point of supply for refill or storage.

**6.5 Conclusions**

Parathion methyl is very highly toxic to aquatic invertebrates, birds and mammals. It is considered a ‘soft chemical’ and is used in cotton, orchards and vegetables to control a range of insects including aphids, caterpillars, *Helicoverpa* spp and other moths and butterflies, mites, weevils, jassids and scale. Parathion methyl is an integral part of IPM programs, especially in the stone and pome fruit industries.

Parathion methyl readily degrades in natural systems, with the first half-life of approximately 1 day in aqueous conditions, both aerobic and anaerobic. It degrades in soil but the process is slower, with a half-life of 4.7 days. Parathion methyl is moderately bound to soil and together with the rapid degradation is not expected to leach.

Parathion methyl is sufficiently volatile to have a fumigant effect, and volatilisation is expected to be a significant method of loss, particularly from foliage. When it
deposits on soil, parathion methyl will be bound to the soil and volatilisation is limited. Once volatilised it is expected that most of the volatilised material will be degraded or redeposited. Degradation in the air from UV is fast, with a calculated half-life of <1 day.

The chemical is very highly toxic to birds, mammals and aquatic invertebrates. Its toxicity to birds decreases when it is incorporated into the diet, therefore the environmental toxicity depends on the route of exposure. Birds and mammals are not expected to be significantly exposed to the chemical unless they enter an area recently sprayed. However, the direct application of parathion methyl to aquatic systems is expected to significantly affect aquatic invertebrates and must be avoided.

Spray drift from aerial applications present a very significant hazard to aquatic invertebrates and at considerable distance from the site of application. A buffer zone or in-crop buffer is highly desirable, as given in the recently launched Best Management Practices Manual for Cotton Growers, which currently suggests a downwind buffer of 300 metres for aerial applications. While this would significantly reduce the hazard to environmentally sensitive areas, additional measures such as vegetative buffers are required to reduce the hazards to more acceptable levels. Until such measures are implemented through the cotton industry as standard practice, aerial application of parathion methyl is likely to cause significant impacts on sensitive aquatic organisms to 400 metres from the application site.

Also, it is clear from the efficacy report that parathion methyl is used by the cotton industry as mixtures with other insecticides as an ‘efficacy restorer’. This use of parathion methyl as a ‘efficacy restorer’ is expected to increase the hazard and Environment Australia has considerable concerns over such uses.

In conclusion, and taking into account the unknown effects of applications of mixed insecticides, Environment Australia cannot rule out that an unacceptable hazard exists through aerial application of parathion methyl in the current fashion, due to both possible direct overspray and spray drift.

While we are aware of no actual aquatic mortality incidents, the reports of bee deaths are a clear indication that unacceptable spray drift can occur. Continuation of this practice is thus difficult to defend, although a ban at this stage would only lead to the greater use of equally toxic and more persistent insecticides in cotton. Aerial application of parathion methyl should be phased out as less toxic chemicals become available.

In the mean time the recommendations in the Best Management Practices Manual for Cotton Growers should be implemented as soon as possible to help minimise the impacts of continued usage of parathion methyl in the cotton industry. Information on spray drift from mixed applications should also be provided.

Calculations for the spray drift from conventional high volume orchard air blast equipment shows there is a high hazard to daphnia at 50 metres away in shallow water at the highest rate (1 kg ai/ha) and only decreases to acceptable levels at 100 metres away. For the more sensitive aquatic invertebrates the hazard extends to 200 metres. After 24 hours, there is still likely to be significant effects on these sensitive aquatic
invertebrates 50 metres away, particularly at the highest rate. Effects on the most sensitive organisms 50 metres away are still likely after 2 days at the highest rate but unlikely at the lowest rate.

Parathion methyl has been used for the last 30 years and large numbers of aquatic invertebrates are likely to have been affected during this time. While the calculations clearly show that the hazard to sensitive organisms is high, past exposure of these aquatic organisms may be expected to have resulted in the current populations being more tolerant to parathion-methyl. Considering the above, and that the most sensitive subpopulations are likely to have already been significantly effected, it is recommended that the label rate be reduced to <650 g ai/ha, which corresponds to 2000 L/ha for application dilutions of 65 mL per 100L.

For orchards (especially citrus) with very large trees where a higher application volume could be required, it is considered that in order to limit the environmental damage the last 3 downwind rows should not be sprayed, ie an in-crop buffer. This is based on evidence from citrus orchards indicating these rows are largely responsible for the majority of the spray drift.

Modern LV and ULV equipment used by some growers is of concern due to the higher potential for spray drift from the small droplet size used. Environment Australia does not have data for the spray drift from such equipment and further information is required before a conclusion about the hazard to aquatic organisms from such equipment can be determined.

A potential hazard exists from use of parathion methyl but this hazard is lower than with parathion, a potential alternative chemical for IPM, due mainly to the more rapid degradation and the lower toxicity of parathion methyl. Thus, Environment Australia considers that parathion methyl should be used for IPM whenever possible.

A recovery period is required to minimise the impact of repeated applications, especially as parathion methyl may be used up to 8 times a season. As parathion methyl is most likely to affect aquatic invertebrates, a minimum recovery period of at least 14 days between applications is desirable.

Due to the very limited spray drift hazard that occurs with use of boom-sprayers, normally used for vegetable crops, application use of parathion methyl in vegetable crops is acceptable to Environment Australia.

Due to possible chronic effects from use of the microencapsulated formulations and the possible increase in use likely for these formulations, Environment Australia cannot support further expansions in use until additional studies are done on the metabolism and degradation of these formulations. Aerial application is also considered to be too hazardous until additional information is presented.
7. INTERIM REGULATORY MEASURES FOR PARATHION-METHYL

7.1 Introduction

As stated in the draft report released for public comment, the review covered all aspects related to the registration of parathion-methyl. Assessments conducted as part of the review process considered its impact on public health, occupational health and safety (OHS), and the environment. On the basis of the available data and theoretical modelling the OHS and environment assessments in particular, pointed to significant concerns relating to its pre-existing use pattern. The draft report also highlighted that for some use patterns and agricultural practices, there were insufficient Australian data on which to base regulatory decisions with any reasonable degree of confidence.

The NRA has considered all public comments obtained on the draft report. A summary of the main public comments and the NRA responses to these comments is at Attachment 1.

The NRA now proposes to implement a series of interim regulatory measures to mitigate occupational exposure and environmental risks and to fill the data gaps that have been identified.

Certain interim regulatory measures involve the development of additional data. Where appropriate, these data will be eligible for data protection in accordance with Part 3 of the Agvet Code. Those submitting data must provide appropriate protocols/study designs for generating the data by 31 December 1999.

7.2 Interim Regime of Use

An interim use regime with the following elements will apply for parathion-methyl to mitigate potential risks to workers and the environment while data is generated:

• certain labelling and other restrictions (as per section 7.3 below) would apply;

• registrants would carry the primary responsibility of ensuring that users are aware of and complying with these restrictions;

• during the period required to generate the outstanding data, parathion-methyl is recommended to be used only by persons having appropriate training in the use of chemicals;

• product labels would be strengthened to include appropriate environmental and occupational exposure warnings to reduce potential exposure;

• aerial application requires the use of suitable spray drift minimisation strategies such as large droplet placement technology and other measures to limit environmental exposure.
At the end of the period required to generate the necessary data, (3 years) the NRA will revisit the use of parathion-methyl, assessing both the data provided to fill the identified data gaps and the effectiveness of the proposed changes in use practices in mitigating risk to users and the environment.

7.3. Interim Restrictions and Data Requirements

The following restrictions will apply to products containing parathion-methyl while the data identified at Table 7.1 are being generated.

<table>
<thead>
<tr>
<th>Interim Recommendation</th>
<th>Key date</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IMPORTANT NOTICE</strong></td>
<td></td>
</tr>
<tr>
<td>Certain Interim Review Recommendations require the development of additional data. Where appropriate these data will be eligible for data protection in accordance with Part 3 of the Agvet Code. Those submitting data must confirm the commitment to do so by submitting appropriate protocols for generating the data by 31 December 1999. If protocols are not provided by that date, then the use related to that data requirement may be cancelled.</td>
<td>31 December 1999</td>
</tr>
<tr>
<td><strong>Pest monitoring</strong></td>
<td></td>
</tr>
<tr>
<td>Labels are to contain the following statement:</td>
<td>31 December 1999</td>
</tr>
<tr>
<td>1. Parathion-methyl should only be applied if monitoring indicates that pest population exceeds thresholds.</td>
<td></td>
</tr>
<tr>
<td><strong>Application methods</strong></td>
<td></td>
</tr>
<tr>
<td>Labels are to contain the following statements regarding application methods:</td>
<td>31 December 1999</td>
</tr>
<tr>
<td>2. <strong>Ground Application</strong></td>
<td></td>
</tr>
<tr>
<td>(a) Only apply parathion-methyl by air blast, electrostatic and boom spraying</td>
<td></td>
</tr>
<tr>
<td>(b) It is highly desirable that closed mixing/loading systems are in place and enclosed cabs are used. It is preferable that enclosed cabs are equipped with air-conditioning and pesticide filters.</td>
<td>31 December 1999</td>
</tr>
<tr>
<td>3. <strong>Aerial Application</strong></td>
<td>31 December 1999</td>
</tr>
<tr>
<td>Where possible during the aerial application of this chemical, enclosed vehicle cabs equipped with air conditioning and pesticide filters should be used in preference to relying on personal protective equipment.</td>
<td></td>
</tr>
<tr>
<td>4. <strong>Human Flaggers</strong></td>
<td>31 December 1999</td>
</tr>
<tr>
<td>Human flaggers used in aerial application should be protected by engineering controls such as enclosed cabs.</td>
<td></td>
</tr>
</tbody>
</table>
### Re-entry

The following re-entry period (REP) statement is to be specified on the label. [Note: This is an interim re-entry period pending the submission of data specified in “Requirements for further data”, to establish a final REP.]

5. **Do not allow entry for 5 days after treatment.** If bug checking or exceptional circumstances require prior entry, limit duration of entry and wear cotton overalls buttoned to the neck and wrist or long trousers and long sleeved shirt, and chemical resistant gloves. Clothing must be laundered after each day’s use.

6. **Hand Weeders:** Do not allow re-entry into treated areas for 5 days after treatment. After this period, wear shoes, or boots, socks, long trousers, long sleeved shirt, gloves and hat.

### Disposal

Labels are to contain the following statement:

7. **Triple or preferably pressure rinse containers before disposal or recycling.** Add rinsings to spray tank. Do not dispose of undiluted chemicals on site. If recycling, replace cap and return clean containers to recycle or designated collection point. If not recycling, break, crush or puncture and bury empty containers in a local authority landfill. If no landfill is available, bury the containers below 500 mm in a disposal pit specifically marked and set up for this purpose clear of waterways, desirable vegetation and tree roots. Empty containers and product should not be burnt.

8. For refillable containers the following would be added to the label:

   For returnable containers, empty contents fully into application equipment. Close all valves and return to point of supply for refill or storage.

### Safety Directions

Labels are to contain the following statement:

9. **Very dangerous.** Particularly the concentrate. Product and spray are poisonous if absorbed by skin contact, inhaled or swallowed. Repeated minor exposure may have a cumulative poisoning effect. Avoid contact with eyes skin and clothing. Do not inhale spray mist. When opening container, preparing the spray and using the prepared spray, wear protective waterproof clothing, cotton overalls buttoned to the neck and wrist and washable hat, elbow-length PVC gloves, impervious footwear and full facepiece respirator with combined gas and dust
cartridge. If clothing becomes contaminated with product, or wet with spray, remove clothing immediately. If product or spray on skin immediately wash area with soap and water. After use and before drinking or smoking, wash hands, arms and face thoroughly with soap and water. After each days use, wash gloves, respirator (and if rubber wash with detergent and warm water) and contaminated clothing. Obtain an emergency supply of atropine tablets 0.6 mg.

### Restraints

Labels are to contain the following statements:

10. *DO NOT* apply by hand-held equipment  
11. *DO NOT* apply in greenhouses

### High and Low volume Spraying

Labels are to contain the following statements:

12. **Dilute (high volume) spraying**  
Apply to the point of run off to ensure coverage. Note that the required volume will vary between crops, the size of trees and the change in canopy during the season.

13. **Concentrate (low volume) spraying**  
The rate per 100Litres for concentrate spraying is derived from the volume of dilute spray that would be applied per hectare. This can be determined from calibration, tables or gridlines, or by calculation using tree row volume or unit canopy row formulae.

### Training requirement

14. **The label will carry the following statement under the heading Precautionary Instructions**  
“NRA recommends that a person using, keeping or disposing of this product should have successfully completed an appropriate course of training such as the Farm Chemicals Users Course or similar course qualification.”

### Supply

15. It is recommended that this chemical be supplied only to persons having suitable training in the use of farm chemicals, or persons authorised/permited by relevant state authorities to use farm chemicals.

Registrants are required (as a condition of registration) to ensure that the resellers record details of the purchaser including the level of training and that an information leaflet was supplied with product. [A pro-forma record sheet will be provided to registrants as guidance only.] These records would be required to be retained by the reseller and be made available on request to the...
Use

16. It is recommended that this chemical be used only by persons having suitable training in the use of farm chemicals or persons authorised/ permitted by relevant state authorities to use farm chemicals.

Registrants are required (as a condition of registration) to take steps to ensure that the users are aware of restrictions applying to parathion-methyl. These include the posting on the reseller’s premises a copy of the NRA Gazette Notice outlining interim restrictions on parathion-methyl; informing users via the reseller (and using the information leaflet) that users are required to maintain certain records on the use of parathion-methyl. These records are to include details of pest monitoring and extent and timing of parathion-methyl sprays, the prevailing wind direction, wind velocity and the block sprayed. These records should be retained by users and made available on request to the authorised officers of the State Departments of Agriculture/Primary Industries and in New South Wales, the Environment Protection Authority.

Withholding Periods

17. DO NOT harvest for 14 days after application.

18. DO NOT graze or cut for stock food for 14 days after application.

19. Cotton: DO NOT allow stock to graze in any treated area.

MRLs

20. The following amendments to the MRL Standard are recommended.

<table>
<thead>
<tr>
<th>Table 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compound</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>Delete:</td>
</tr>
<tr>
<td>SO 0691</td>
</tr>
<tr>
<td>OC 0691</td>
</tr>
<tr>
<td>MO 0105</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>MM 0095</td>
</tr>
</tbody>
</table>
### Add:

<table>
<thead>
<tr>
<th>Compound</th>
<th>Animal Feed</th>
<th>MRL mg/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>ML 0106</td>
<td>Milks</td>
<td>*0.05</td>
</tr>
<tr>
<td></td>
<td>Vegetables</td>
<td>1</td>
</tr>
<tr>
<td>VB 0040</td>
<td>Brassica vegetables</td>
<td>T0.1</td>
</tr>
<tr>
<td>VR 0577</td>
<td>Carrot</td>
<td>T0.5</td>
</tr>
<tr>
<td>VS 0624</td>
<td>Celery</td>
<td>T3</td>
</tr>
<tr>
<td>SO 0691</td>
<td>Cottonseed</td>
<td>T1</td>
</tr>
<tr>
<td>FC 0001</td>
<td>Citrus fruit</td>
<td>T1</td>
</tr>
<tr>
<td>MO 0105</td>
<td>Edible offal (mammalian)</td>
<td>T*0.05</td>
</tr>
<tr>
<td>VC 0045</td>
<td>Fruiting vegetables, Cucurbits</td>
<td>T1</td>
</tr>
<tr>
<td>VO 0050</td>
<td>Fruiting vegetables other than Cucurbits</td>
<td>T0.2</td>
</tr>
<tr>
<td></td>
<td>(except sweet corn)</td>
<td></td>
</tr>
<tr>
<td>FB 0269</td>
<td>Grapes</td>
<td>T0.5</td>
</tr>
<tr>
<td>VP 0060</td>
<td>Legume vegetables</td>
<td>T0.5</td>
</tr>
<tr>
<td>MM 0095</td>
<td>Meat [mammalian]</td>
<td>T*0.05</td>
</tr>
<tr>
<td>ML 0106</td>
<td>Milks</td>
<td>T*0.05</td>
</tr>
<tr>
<td>FP 0009</td>
<td>Pome fruits</td>
<td>T0.5</td>
</tr>
<tr>
<td>VR 0589</td>
<td>Potato</td>
<td>*0.05</td>
</tr>
<tr>
<td>VD 0070</td>
<td>Pulses</td>
<td>T0.2</td>
</tr>
<tr>
<td>FS 0012</td>
<td>Stone fruits</td>
<td>T0.2</td>
</tr>
<tr>
<td>VO 0447</td>
<td>Sweet corn</td>
<td>*0.1</td>
</tr>
</tbody>
</table>

### Table 4

<table>
<thead>
<tr>
<th>Compound</th>
<th>Animal Feed</th>
<th>MRL mg/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AL 1023</td>
<td>Clover</td>
<td>T5</td>
</tr>
<tr>
<td>AL 1031</td>
<td>Clover hay or fodder</td>
<td>T25</td>
</tr>
<tr>
<td>AM 0691</td>
<td>Cotton fodder, dry</td>
<td>T10</td>
</tr>
<tr>
<td></td>
<td>Cruciferous forage crops</td>
<td>T5</td>
</tr>
<tr>
<td>AL 0157</td>
<td>Legume animal feeds</td>
<td>T25</td>
</tr>
</tbody>
</table>

### Note:

- T (temporary) refers to MRLs that will expire 3 years after the release date of the interim report or as determined by the NRA. Maintenance of a temporary MRL is dependent on the registrant or person or group wishing to retain the MRL formally undertaking to generate the requested residue data within the allocated time frame.

- Animal feed category “Cotton fodder, dry” does not include Cotton gin trash.

21. All registrants formulating parathion-methyl products in Australia are required to label technical grade parathion-methyl.  

**MSDS**

22. All registrants formulating parathion-methyl products in Australia are required to produce a material safety data sheet for technical grade parathion-methyl in accordance with hazardous substance regulations.
23. All registrants of current parathion-methyl products are required to produce a material safety data sheet in accordance with hazardous substance regulations.  

24. Labels are to contain the following statement:  

*Additional information is listed in the MSDS*

### Protection of the environment

Labels are to contain the following statements:

25. **DO NOT** apply under meteorological conditions or from spraying equipment that could be expected to cause spray drift onto natural streams, rivers or waterways.

26. **DO NOT** spray any plants in flower including ground covers or while bees are present. Should spray drift occur, bees may be at risk several hundred meters downwind depending on atmospheric conditions.

27. **DO NOT** aerially apply near to sensitive areas (such as natural streams, rivers or waterways and human dwellings) without applying measures to limit the spray drift on these areas. A spray drift management strategy such as those in the ‘Best Management Practices Manual for Cotton Growers’ or the ‘Pilots and Operators Manual’ should be applied.

### Compliance

28. The NRA and the relevant State departments will monitor the supply and use regime of parathion-methyl products to ensure the above recommendations are being complied with.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>23.</td>
<td>Ongoing</td>
</tr>
<tr>
<td>24.</td>
<td>31 December 1999</td>
</tr>
<tr>
<td><strong>Protection of the environment</strong></td>
<td></td>
</tr>
<tr>
<td>Labels are to contain the following statements:</td>
<td></td>
</tr>
<tr>
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</tr>
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<td>ongoing</td>
</tr>
</tbody>
</table>
Table 7.1 Requirements for further data

<table>
<thead>
<tr>
<th>The following data are to be submitted to the NRA to address the concerns identified during the review.</th>
<th>30 June 2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial protocols for all studies must be agreed with the NRA prior to the commencement of studies.</td>
<td>31 December 1999</td>
</tr>
</tbody>
</table>

**Human health**

29. A 3-month *dermal toxicity study* of parathion-methyl is required for assessment. | 30 June 2000 |

**Occupational health and safety**

30. For microencapsulated formulations *percutaneous absorption data* are required for assessment. | 30 June 2002 |

31. For all formulations, *measured worker exposure data* for mixers/loaders and applicators are required for assessment. | 30 June 2002 |

32. *Worker re-entry exposure data* for both *thion* and *oxon* residues are required to set a final re-entry period for parathion-methyl. | 30 June 2002 |

**Residues**

33. *Australian confirmatory trial data* (and animal transfer studies where relevant) are required to set MRLs for any uses remaining on the label. | 30 June 2002 |

**Environment**

34. *Environmental toxicity data* relevant to Australian aquatic invertebrate species. | 30 June 2002 |

35. Where LV application equipment is used, information on the actual application rates, dilutions needed for each crop, droplet size and potential spray drift from this equipment, is required for assessment. | 30 June 2002 |

**Tank mixing**

36. Data are required on the environmental (representative data on toxicity to aquatic invertebrate), occupational health, public health and residue effects of tank mixing parathion-methyl with other anticholinesterase compounds. Tank-mixing will be allowed in the interim period subject to the provision of above data within agreed time frames. | 30 June 2002 |
8. PROTECTED INFORMATION STATUS OF SUBMITTED DATA

All data considered as protected registration information by the NRA are identified in the bibliographies of the full interim review report with a letter “P” placed next to them in the left hand margin.
ATTACHMENT 1: Summary of Public Response to the Parathion-methyl Draft Review Report

The NRA released a draft parathion-methyl review report for public comment on 29 July 1998. The draft report contained a new approach to public consultation where the emphasis was on identifying concerns and data gaps flowing from the review. The public comments phase lasted two months during which comments and submissions from the public were obtained on the draft report.

The NRA received a significant response from the public comment phase. The following summary describes the main issues raised in response to the release of the draft report. As expected, the proposed restrictions and data gaps identified in the draft report attracted most comment.

Approximately 40 submissions were received, the majority of which came from grower and commodity organisations, followed by chemical industry, individual growers and State regulatory authorities. Submissions were also received from government organisations, and organisations producing, processing or associated with the following commodities: pome fruits, stone fruits, cotton, oilseeds and grain.

Public comments were in general supportive of the risk management approach taken by the NRA. Key stakeholders have provided commitments and taken some initial steps to generate the required data and implement use restrictions. In consultation with the appropriate stakeholders, the NRA has established an interim regime of use for parathion-methyl while the required information is compiled by the appropriate stakeholders.

While there was acceptance of the need for maximum care and caution in the use of parathion-methyl, several proposed restrictions and label statements attracted vigorous comment from respondents. Those comments and others are presented below. Public concerns and comments are presented in normal font while the NRA responses to those concerns or the manner in which the NRA proposes to address these concerns are in *italics*.

**General comments**

**Limitation of parathion-methyl use to IPM programs**

Some respondents commented on the proposed requirement to restrict the use of parathion-methyl only when used as part of an Integrated Pest Management (IPM) program. While there was widespread recognition that this was a laudable aim, the ability to enforce this requirement was questioned due to the potential difficulties in legally defining an IPM program.

*Following consideration of these comments, the NRA has reassessed its position regarding the recommendation to limit the use of parathion-methyl to IPM programs. The proposed restriction, that the use of parathion-methyl would only be permitted*
when used as part of an Integrated Pest Management (IPM), has been replaced by a label statement that encourages the spraying of parathion-methyl to be tied with appropriate thresholds of pest activity. It is expected that the use of this IPM-consistent statement will also discourage programmed/scheduled spray applications of parathion-methyl.

Epidemiological Information

An absence of data from a program of pesticide illness/injury reporting in Australia posed difficulties for the ECRP risk assessments. While the Australian adverse incident reporting program for agricultural chemicals is being set up, the United States of America have several on-going pesticide illness/injury reporting programs. For instance, in the State of California, the Department of Pesticides Regulation (CDPR) produces an “Annual Summary of Pesticide Related Illness and Injuries”. A review of these summaries for the period 1982 through 1994 showed that seven inadvertent poisoning episodes were attributable to parathion-methyl over the thirteen year period. The CDPR review concluded that despite the potential toxicity of parathion-methyl, the incidence of illness injury associated with its use remains low in California.

Other epidemiological information for parathion-methyl has also emerged from the US EPA. From an analysis of measures of hazard, it was concluded that parathion-methyl had results similar to the median for other cholinesterase inhibitors. Parathion-methyl had very low ratios of handler and field worker poisonings per 1000 applications in California from 1982 to 1989. Only two pesticides (Bacillus thuringiensis and permethrin) had lower ratios.

In the USA parathion-methyl is registered for use in food, forage feed and fiber crops; fruits and nuts, ornamental plants and forest trees, non agricultural land, pastures and rice. In other words, its current use pattern in the USA is more widespread than that in Australia. The tonnage used in the USA is also significantly larger. Three formulation types; microencapsulated, granular and emulsifiable concentrate formulations are registered in the USA, while two formulation types (microencapsulated and emulsifiable concentrate) are registered in Australia. It is reasonable to assume that the level of education and training of most occupational groups applying parathion-methyl in Australia is at least equal to that of the corresponding occupational groups in the USA. It is likely therefore that the observation from the USA regarding a low incidence of illness and injury attributable to the use of parathion-methyl is also relevant to Australia.

Respondents acknowledged the high potential toxicity of parathion-methyl. Similarly, respondents also pointed to the low incidence and injury attributable to this chemical despite a long and widespread use.

The NRA has noted the US epidemiological information and acknowledges that the US worker illness trends associated with the use of parathion-methyl might also have some applicability to the Australian situation.
Re-entry Period

The proposed interim re-entry period of a 14-days attracted most comment. It was noted that parathion-methyl has been used with 3 to 5 day re-entry period for many years. For example, the cotton industry typically observes a 2 to 3-day re-entry period and in pome and stone fruit orchards, a 5 day re-entry period is standard. Some respondents pointed out that the proposed interim re-entry statement does not distinguish between re-entry into a densely cropped field and that into an orchard where the re-entry worker exposure would be significantly different. In addition, orchardists pointed out that the potential for re-entry exposure would vary depending on the type of task such as fruit-thinning, scouting, setting up irrigation and weeding etc. It was suggested that several specific re-entry requirements be set to differentiate between the re-entry tasks and situations encountered in various crops.

The current re-entry period for parathion-methyl set by US EPA is 48 hours and this re-entry period appear likely to be reviewed as a result of the additional requirements pursuant to the Food Quality Protection Act (FQPA).

The re-entry period set by California DPR is 2 days for levels of active below 1Lb ai/acre (approx. 1120g ai/ha) or where a microencapsulated formulation was used. A re-entry interval of 14 days has been set when parathion-methyl is applied to apples, citrus, corn or grapes specifically and for all other crops when the application rates exceed 1Lb ai/acre (approx. 1120g ai/ha). These intervals have been set more than a decade ago largely on retrospective examination of worker illness events. Presently Californian regulatory authorities recommend re-entry intervals on the basis of dislodgeable foliar residues and transfer factors, rather than in response to worker illness events, as was done in the past.

Respondents quoted from the occupational health and safety assessment that “the main cause of occupational exposure to parathion-methyl is expected to be via skin contamination. Inhalational exposure to vapour is not expected to be significant because it has low vapour pressure. Inhalation of spray mist is possible.” These respondents argued that in the re-entry situation there is little or no occupational risk for workers who do not come in to direct contact with treated parts of the tree and for harvesters/fruit handlers who conduct these tasks after the obligatory 14 day withholding period. Crop/situation specific re-entry periods were seen as a possible improvement.

The limited available data for parathion-methyl indicated unacceptable levels of residues on treated plants 4 days after application. The data available for periods after four days, were deemed unacceptable for use in the occupational exposure assessment.

US re-entry interval information for parathion-methyl provides a useful point of comparison. The changing approaches to setting re-entry intervals and parallel moves to using additional safety factors have been noted. The NRA will continue to monitor these developments during the interim period.

The setting of crop specific re-entry periods requires re-entry exposure data from several crops/situations. The NRA has therefore required re-entry exposure studies
from a variety of crops/use situations for assessment. The studies must be conducted according to protocols acceptable to the NRA.

Considering the comments made regarding the proposed re-entry and the fact that the review is about to enter into a phase where measured re-entry exposure data could be collected, a uniform 5-day re-entry period will be specified for parathion-methyl in all crops and use situations. This is an interim measure, while the required worker re-entry exposure data is being generated and analysed. Upon assessment of the data, the issue of appropriate re-entry period(s) will be considered as appropriate.

Currently registered parathion-methyl product labels contain inconsistent re-entry advice. This inconsistency would be addressed in the interim label for parathion-methyl.

The requirement for elbow-length PVC gloves during re-entry

Many respondents argued that the requirement for elbow-length PVC gloves was impractical given the nature of some tasks (eg. pest monitoring) that are carried out during re-entry. It was argued that elbow-length PVC gloves, do not provide the necessary flexibility to conduct these tasks effectively. As a cotton overall buttoned to the wrist and neck is also specified to be worn during re-entry, the aim is to prevent possible dermal exposure through the hands below the wrists. This is achievable by using chemical resistant gloves in conjunction with the overalls buttoned to the wrist and neck.

The NRA has considered these arguments and agrees that the elbow-length PVC gloves would pose practical difficulties for certain (eg pest monitoring) tasks that are carried out during re-entry. The primary purpose is to minimise worker exposure while allowing the unhindered conduct of the required re-entry tasks. To achieve this, the NRA has replaced the requirement for elbow-length PVC gloves with one for chemical resistant gloves (in conjunction with other appropriate PPE) to be worn during re-entry.

Restrictions on tank-mixing of parathion-methyl with other cholinesterase inhibitors

Submissions from the Cotton industry argued that tank-mixing parathion-methyl with other mixing partners has been practiced widely in the cotton industry without deleterious effects to applicators or the environment. In particular, regarding the occupational exposure from tank-mixing in cotton, the existence of blood monitoring data was alluded to in some submissions while none have been presented for assessment.

The proposed label statement prohibiting tank-mixing was also questioned by respondents from the pome fruit industry, where parathion-methyl is tank-mixed with petroleum oil.
The restriction on tank-mixing was proposed for environmental and occupational exposure reasons. The potential concerns identified, relate primarily to tank-mixing of parathion-methyl with other cholinesterase inhibitors. However, no evidence has been presented to the review to demonstrate synergistic or potentiation effects of parathion-methyl and its usual mixing partners in cotton or orchards.

The occupational exposure implications of this practice can be ascertained by examining blood monitoring data that has been mentioned in some submissions. No data of assessable quality have been made available to the review to date. Similarly, no data on environmental implications of the use of anticholinesterase compounds as tank-mixes, have been assessed.

Having considered the arguments put forward by the appropriate stakeholders, there appears to be no compelling reason as to why this practice cannot continue in the interim period. Environmental data and occupational exposure data must be provided on any combinations of parathion-methyl with other OPs, synthetic pyrethroids and carbamates that are used in a given crop/use situation. Protocols for such studies must be agreed prior to commencement of studies.

The NRA also requires results from any environmental monitoring and health surveillance following applications of tank-mixes for assessment.

Limitations on amount of active used per application

The proposed rate limitation to 650 g a.i./ha has attracted vigorous comment from producers of citrus and orchard crops. Parathion-methyl user organisations argued that in most practical situations, a rate of 650g a.i./ha would not be adequate to protect crops because the variability of tree and canopy size and growth stage etc. The efficacy of this rate prescription remains untested under a variety of conditions encountered in normal use situations of parathion-methyl.

Respondents objected that the proposed limitation, if adopted, would force them to use other, possibly more disruptive chemicals to protect their crops from pest infestations. It was argued that most alternative chemicals would also eliminate beneficial insects whereas parathion-methyl use allows significant numbers of beneficial insects to survive. The loss of beneficial insects, especially early in the season, would result in greater pest pressures later in the season leading to the use of more pesticides than would be needed if parathion-methyl was not restricted in this manner.

For crops where larger trees are encountered such as pome fruit and citrus, this limitation was considered to be entirely unworkable due to efficacy concerns and the desirability to maintain populations of beneficial insects in the orchards.

The rate ceiling prescription has been reconsidered in the light of public comments and a higher rate ceiling of 1000g a.i./ha is recommended. Spraying practices that involve the use of higher volumes of spray (eg dormant spray for the control of scale) are deemed unacceptable on the basis of current data and modelling capabilities. However, while the assessment identified potential environmental benefits of use rate
reductions for parathion-methyl, the efficacy of this rate (1000g ai/ha) remains untested in a range of use situations for parathion methyl. Following consideration of the issues relating to the proposed maximum rate, the NRA therefore proposes to allow the use of all current label rates during the interim period. In situations where there are no legal impediments, the NRA encourages research using reduced rates to determine the feasibility of reduced rate prescriptions on label. The results of such research should be made available to the NRA for assessment.

Minimum interval between spray applications

Some respondents objected to the proposed requirement to maintain specific intervals between parathion-methyl applications as this requirement conflicts with IPM and resistance management programs. IPM programs require spraying of pests when the appropriate thresholds are reached. If users are prevented from using parathion-methyl, then a different chemical, arguably more harmful to beneficial insects would be used when the pest population thresholds are reached. This would disrupt IPM programs, resulting in greater use of arguably more ecotoxic chemicals. Resistance management programs could also be compromised due to reduced ability to use different classes of chemical as and when required.

The proposed requirement for spray interval was designed to give populations of aquatic fauna time to recover between successive applications of parathion-methyl. Upon consideration of the comments received, the requirement for a specific interval between spray applications is regarded as being sub-optimal. The requirement for a specific minimum interval between sprays has been withdrawn in favor of an IPM-consistent label recommendation to apply parathion-methyl only when pest numbers have reached appropriate thresholds.

Training requirements for supply and use of parathion-methyl

Some respondents questioned the need for the requirement that the chemical being available only to users having completed current Farmcare course or equivalent qualification. Several respondents raised the issue of establishing equivalence between the various training courses available. One respondent requested specifically that Agsafe accreditation be recognised as equivalent to FarmCare accreditation to avoid duplication in establishing proof of competency. Another respondent stated that the NRA should approve training courses as acceptable for the possession and use of parathion-methyl.

The risk profile identified on the basis of the available data requires that all users of parathion-methyl should be suitably competent in the use of farm chemicals. These competencies include (but not limited to) the ability to apply the chemical in strict adherence to the label directions, use properly calibrated application equipment and maintain appropriate records of its use. It is expected that any nationally-recognised chemical user training program such as the Farm Chemical Users Course could provide these competencies to users.
In this regard, it must be pointed out that the NRA has no current plans or indeed the resources required to establish equivalence between various chemical user training systems that are in place. Wording of the interim recommendations on supply and use of parathion-methyl has been amended to reflect this position.

Manual Flaggers in closed vehicle cabs during aerial operations

It was argued that the compulsory use of closed vehicle cabs could in some situations, increase occupational exposure for human markers during aerial applications.

Aerial applications of parathion-methyl is used mostly in the cotton industry. While it is desirable to reduce the dependence on human markers during aerial applications, it is not practical to eliminate the use of human markers (manual flaggers). Where it is required to use manual flagging, every attempt must be made to protect flaggers from chemical exposure. It is not disputed that under a majority of use conditions, enclosed cabs would contribute to achieving this outcome. Therefore, the statement regarding the use of closed vehicle cabs would remain on the label at least during the interim period.

Worker Exposure Data Requirements

The call for Australian worker exposure data was objected to by some respondents on the grounds that new studies would be expensive and that parathion-methyl had been in use for over 30 years with no pronounced worker safety problems becoming evident. Some respondents questioned the POEM modeling approach cited in the review as being too conservative and based on inadequate data or data not appropriate for Australian conditions. The extent to which theoretical modeling, and in particular, margins of exposure (MOE) were relied upon in the OHS assessment was also questioned.

The NRA recognises that worker exposure studies are costly and take time to complete. However, because of the toxicity of parathion-methyl and the potential hazard to agricultural workers, the NRA must be satisfied that there is no undue hazard to people involved in handling and use of parathion-methyl.

The NRA will still require studies which conform to the established scientific principles and protocols to address the identified safety concerns. It is expected that the studies can be completed within mutually agreed time limits and that most of the studies can be done on a cooperative basis between industries for similar practices and between States, commodity organisations and registrants. Protocols for these studies must be agreed with the NRA prior to commencing studies.

Residue Data Requirements

The proposed requirement that industry provide residue data to fill existing data gaps caused concern for some user groups mainly for the reason that generating the new data would be expensive and time-consuming. This requirement was viewed as an
unnecessary impost given that for many commodities, parathion-methyl residue violations has not been a problem.

Because parathion-methyl has been in use for over three decades, certain existing MRLs were set before current health standards were defined and often without the benefit of specific supporting data. Without actual data to support MRLs for parathion-methyl, it is not possible to ensure that the existing MRLs are set at levels appropriate for current use practices in Australia.

Several commodity organisations have indicated that they will conduct residue studies for their respective commodities. Commodity organisations and the chemical industry may be able to cooperate to produce the required studies within the timeframe set by the NRA. Protocols for such studies must be agreed with the NRA prior to commencing studies.

Importance of parathion-methyl to particular uses

Submissions from the respective grower organisations argued that parathion-methyl is vital to the viability of pome and stone fruit industries, canning fruit industry in the Goulburn Valley and its on-going importance to the production of cotton.

Parathion-methyl is proposed to be available in all use situations subject to the filling of data gaps and the implementation of restrictions which are designed to mitigate risks identified during the assessment phase. The NRA would consider the continued use of parathion-methyl in any crop/use situation on the current label which is supported by the appropriate data. If any uses are not sufficiently supported by data and safety concerns remain, then such uses will not be retained. As was advised in the draft report for parathion-methyl, the NRA will make final decisions on the long-term regulatory position of parathion-methyl following assessment of the additional data. It is re-emphasised that protocols for all studies must be agreed with the NRA prior to commencing studies.
ATTACHMENT 2: PRODUCTS AND ACTIVE CONSTITUENTS AFFECTED BY THIS REVIEW

PRODUCTS

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<tr>
<th>NCRIS</th>
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<td>39718</td>
<td>Folidol M500 Insecticide Spray</td>
<td>Bayer Australia Ltd</td>
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<td>39719</td>
<td>Farmoz Parathion Methyl 500 Insecticide</td>
<td>Farmoz Pty Ltd</td>
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<td>40500</td>
<td>Capmbell Pencapp-M Flowable Microencapsulated Insecticide</td>
<td>Colin Campbell Chemicals Pty Ltd</td>
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<td>48441</td>
<td>Cheminova Parathion Methyl 500 EC Insecticide</td>
<td>Cheminova Australia Pty Ltd</td>
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<td>48224</td>
<td>CropCare Methyl Parathion 500 Insecticide</td>
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ACTIVE CONSTITUENTS

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<td>Bayer Australia Ltd</td>
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<tr>
<td>44197</td>
<td>Parathion-methyl</td>
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ANNEX 1: A FURTHER ASSESSMENT OF THE ENVIRONMENTAL RISK

Explanatory note

This further assessment of the environmental risk has been conducted by Environment Australia in view of several factors. A principal factor has been the recent release of a preliminary draft risk assessment report of parathion-methyl by the US EPA. The US EPA report utilised Spray Drift Task Force data and AgDRIFT model to estimate spray drift from various applications in the US. At this stage, the AgDRIFT model is not approved as a risk assessment tool in the US and may find greater use once approved.

While the new environmental risk assessment also contains parts of text that respond to issues raised during the public comments phase of the ECRP review, several parts of the report including the new ecotoxicity endpoints have not been subject to stakeholder scrutiny or public consultation. For this reason, the new environmental risk assessment is included as an annexe to the report. The new environmental risk assessment would be considered further as necessary following the interim, data collection phase and in light of further developments in the US reregistration process for parathion-methyl.

I.I Introduction

In Australia parathion methyl (EC) is used in cotton, vegetable and orchard crops. It can be used in IPM programs in orchards. Application is normally by air for cotton as a mixture with other insecticides and could be aerially applied to vines and some vegetable crops. Ground based equipment is used for other crops.

The currently registered micro-encapsulated formulation, Penncap-M, is for pome fruit, citrus and grapevines, while another encapsulated product Parashoot is proposed for cotton, vegetable and orchard crops.

Details concerning use

Parathion methyl is registered for use on citrus, pome fruit, stone fruit, grapevines, vegetables, cotton, tobacco, clover seed crops and cruciferous forage crops, with the major uses being for cotton and in orchards. It is used to control mites, scale, aphids, mealy bugs, lucerne fleas and thrips. It is considered a ‘soft chemical’ and is used as an integral part of IPM programs, especially by growers in the stone and pome fruit industries.

The maximum use rate is 2.8 L/ha, corresponding to 1.4 kg ai/ha for helicoverpa in cotton. For orchards the maximum concentration is 100 mL per 100 L of spray for scale (normally during winter dormancy for control of scale). The current usage in pome fruit orchards is to control codling moth, light brown apple moth and Oriental fruit moth in IPM programs at an application rate of 65 mL per 100 L. Scale is
normally controlled by application of winter oil and chemical sprays are not encouraged.

For vegetable use, the rate is 65 mL per 100 L or 700 mL/ha and is also for control of various moths, mites, Jassids and various other bugs.

In orchards it is normal practice to spray to runoff, normally requiring 1500 to 2000 L/ha of spray solution. In extreme situations, for example dry conditions, this could be as high as 3000 L/ha to achieve complete wetting of the crop. These figures correspond to typical application rates of between 500 g ai/ha and 650 g ai/ha, but could be as high as 1000 g ai/ha.

The use pattern, as stated on the label, is as required for cotton, pome and stone fruit, as necessary at weekly intervals for tobacco and every 10-14 days for vegetable crops. Parathion methyl could be applied up to 12 times per growing season but typically 6-10 applications are made per season. It should be noted that some market gardening operations would have two crops per year, thus up to 20 applications per year are possible.

The current use in cotton is significantly different from that stated on the label. Parathion methyl is now applied primarily as a mixture with another pesticide, either a pyrethroid or an organophosphate insecticide, to restore the ‘efficacy of the pyrethroid or other OP’ and prevent the building up of resistant insects. When used this way, the application rate normally is 2 to 2.2 L/ha, equivalent to 1 to 1.1 kg ai/ha. Application occurs from January to the end of the season, with normally 4 mixed applications per season.

Parathion methyl is normally aerially applied to cotton (using micronairs on fixed wing aircraft) and sometimes on tomatoes and brassica forage crops (unlimited applications allowed but normally 4-5 would be the maximum in one season).

Traditionally application to orchards is by orchard air blasters using high volume equipment. However, many orchardists are now using low volume, and in some cases electrostatic ultra low volume (ULV) equipment. As there are no directions on the label for such equipment, growers convert the current label directions for concentration of spray to a rate per hectare and apply that rate using the LV and electrostatic equipment.

Applications to vegetable crops is normally by horizontal boom spray but taller crops, such as tomatoes and corn are sometimes sprayed using vertical boom sprays. Aerial application is used for some vegetable crops, especially processing tomatoes. Other sprayers are likely to be used in vegetable crops, particularly hand held types for smaller growers or for small plots. The application rate on the label is 65 mL per 100 L or 700 mL/ha.

The labels ban aerial spraying in Tasmania (without specific approval of the Registrar of Pesticides) and prevents the use of back-mounted knapsack equipment in Victoria.

There is no information on types of spray equipment used or any information concerning the use of low volume application equipment. Information on minimising
spray drift—size of spray droplets etc., is also not given on the label. Insecticides tend to be applied as either medium to fine droplets (300 to 100 µm) with conventional spray equipment or as fine spray to coarse aerosol (100 to 25 µm) with LV, ULV and electrostatic equipment.

Penncap-M is registered for application to pome fruit, citrus and grapevines at 125 mL per 100 L of spray which corresponds to 450 to 600 g ai/ha of micro-encapsulated parathion methyl (note lower rate than for the EC above). Use is for control of codling moth, light brown apple moth, vine moth, scale, aphids, mealy bugs and loopers.

The proposed label for the micro-encapsulated formulation Parashoot is for use in cotton, citrus, pome and stone fruit, grapevines, vegetables, cruciferous forage crops, tobacco and clover seed crops, ie all crops for which the EC formulation is registered. The application rates are as for EC.

I.II Environmental Fate and Degradation

Hydrolysis

From a single experiment at pH 5, 7 and 9, it may be concluded hydrolysis is relatively slow and parathion methyl is classified as slightly hydrolysing (Netherlands classification). Hydrolysis is unlikely to be a significant contributor to the overall degradation of parathion methyl in the environment.

Photolysis

—Aquatic
Based on a laboratory study performed at pH 5, conducted according to US EPA guidelines, and theoretical studies based on the UV spectrum of parathion methyl (ECETOC methodology), the photodegradation rate in water is rated as moderate. From the laboratory study, the half life under environmental conditions was calculated as 8.7 days as opposed to 15 days in the theoretical studies. Photodegradation could be a route of degradation in the environment in clear water. However, due to the turbidity in the majority of Australia’s aquatic environment (river/streams), direct photodegradation is unlikely to be a significant route of degradation, due to rapid metabolism.

—Soil
In a soil photolysis study performed according to US EPA Guidelines, the half life of photodegradation of parathion methyl in moist or dry soil was calculated to be 16.8 and 19.3 days respectively under environmental conditions (no clouds) from laboratory experiments. This contrasts with the 39 days obtained when tested under ‘outdoor’ conditions in Germany. The photodegradation in soil would be a minor route of environmental degradation, even in Australia with high light levels during summer.
---Vapour
Reactions of parathion methyl in the gas phase under the influence of simulated sunlight was studied with consideration to the relevant US EPA Guideline. Parathion methyl is readily degraded in the vapour phase, with an estimated half life of one day in natural sunlight. The major degradation products were 4-nitrophenol and dimethylthiophosphoric acid. Significant degradation of parathion methyl in the environment is possible due to photolysis in the vapour phase.

**Metabolism**
All metabolism studies were performed to US EPA guidelines and used the same single sandy soil.

---Aerobic Soil Metabolism
The degradation of parathion methyl under aerobic conditions in a sandy soil was fast, with a half life of 4.7 days. The major product is carbon dioxide. The degradation pathway appears to be direct metabolism to carbon dioxide or incorporation into the organic fraction of the soil followed by mineralisation.

---Aerobic Aquatic Metabolism
The degradation of parathion methyl in aerobic aqueous conditions using the same soil as above was very fast, with a half life of just 1.1 days over the first seven days. After the first week, the concentration of parathion methyl detected in the aquatic phase is effectively zero. Residues of parathion methyl left in the sediment degraded more slowly, with a half life of 16.5 days.

---Anaerobic Aquatic Metabolism
The degradation of parathion methyl in anaerobic aqueous conditions again using the same single soil was very fast, similar to the aerobic study with the same half life of just 1.1 days over the first seven days. After the first week, the concentration of parathion methyl detected in the aquatic phase is effectively zero.

---Micro-encapsulated
There was no information presented on the soil or aquatic metabolism or degradation of either microencapsulated formulations. Based on statements related to Parashoot the microencapsulated formulations are expected to persist longer that the EC formulations in the environment, releasing the active ingredient more slowly, which will then be metabolised as for the EC.

---Conclusion
It is concluded that microbial degradation of parathion methyl EC in soil and aquatic conditions is very fast under both aerobic and anaerobic conditions. As there were no studies presented on the metabolism of the micro-encapsulated formulations, no definite conclusion can be reached concerning the rate of degradation for these products.

**Mobility**
—Soil adsorption/desorption
The soil adsorption/desorption of parathion methyl was determined in four sterile soils. It was concluded that parathion methyl is only moderately adsorbed to most soils but stronger adsorption occurs to clay soils. It is rated as having medium mobility in most soils and in clay soils it is rated as having low to medium mobility. Despite there being only one cycle of desorption done in the studies, there was only limited desorption and indicates that binding is moderate to strong.

—Leaching
In a column leaching study using EC formulations, a ME formulation (Parashoot) and two different soils there was no detectable parathion methyl residues in the leachate and it was concluded that this together with the ready degradation indicates that leaching of parathion methyl from either formulation is unlikely. However, there is a report of parathion methyl having been found in groundwater in Europe.

—Volatility from Soil
A study on the volatilisation of parathion methyl from a sandy loam soil was conducted according to US EPA guidelines. There was little if any parathion methyl trapped in the volatiles and significant degradation was observed. It was concluded that the volatility from soil is low for the recommended rates of application.

—Literature Reports
In literature reports, experiments using three different soils show that the volatilisation of parathion methyl is less than 3% of the initially applied material. However, the volatilisation from non-adsorbing surfaces is significant and within 2 days of applications up to 1.12 kg ai/ha all is expected to have volatilised.

—Literature
A recent report has detected background levels of parathion methyl together with other agricultural chemicals in the atmosphere, rain and fogwater in France. Parathion methyl has also been detected in fogwater in California but not in fogwater from the Bering sea, Alaska. It is concluded by Environment Australia that these papers clearly indicate that while parathion methyl is expected to degraded quite rapidly and be non-volatile from soil, sufficient material persists and volatilises to give detectable levels in the atmosphere with the corresponding background contamination and possibilities of long range mobility following extensive usage.

—Field Volatility Studies
It is concluded from a study, conducted according to Germany Guidelines, that the volatilisation of parathion methyl from soil is not expected to be a significant dissipation pathway but volatilisation from leaf surfaces is. In Australia with high summer temperatures the volatilisation of parathion methyl could result in a significant fumigant effect on non-target insects.

In an older study that does not meet modern standards, it was concluded that using oil as the carrier in ULV applications does not significantly limit the dissipation of parathion methyl from non absorbing surfaces. The route of dissipation is unclear but is likely to be a combination of volatilisation and degradation.
—Conclusion
Volatilisation of parathion methyl from soil is not expected to be a significant route for the dissipation from soil. However, volatilisation of parathion methyl from other non-adsorbing surfaces could be significant.

Spray Drift

The spray drift studies for parathion, the ethyl analogue, showed that aerial application leads to significant spray drift. Based on the concentrations in the air and assuming that parathion methyl is approximately half as toxic to bees as parathion is, then parathion methyl is expected to be toxic to bees up to 800 metres away from aerial applications. As the droplet sizes are approximately the same size of those used in Australia for application of EC formulations, under Australian conditions spray drift is expected to be similar.

Recent literature studies on aerial spray drift show that the 95th percentile from a number of experiments gave spray drift results of 0.35% of the application rate at approximately 300 metres. Thus one in twenty aerial applications result in 0.3% of the application rate as spray drift at 300 metres from the edge of the field being sprayed. Under adverse conditions, ie inversion layers, the 95th percentile for spray drift increases to 1% of the application rate.

The spray drift from ground-based orchard application was significant and parathion was toxic to bees up to 400 metres away. Using the same assumptions as before, parathion methyl is expected to be toxic to bees up to 200 metres away from ground based orchard applications. As the droplet sizes in Australia in ground based orchard applications are expected to be similar as those in this study, the spray drift and the toxicity to bees is expected to be highly relevant.

Micro-encapsulated

No studies on the spray drift from applications of the ME formulations were presented. It is claimed by one registrant (Colin Campbell) that as the micro-encapsulated formulations have higher density than water there will be less (spray)drift. Given that the changes in the specific density of a spray formulation will be very minor and the claim was not supported by any studies, Environment Australia does not accept without supporting data that there will be less spray drift from the ME formulations.

Field Dissipation Studies

Four field studies in cotton and rice were presented which support the results of the laboratory studies in that parathion methyl is very quickly degraded in the soil and that there is no leaching. There were no half-lives determined in the field studies as the degradation was too fast but can be estimated to be <1 day in the soils tested. Parathion methyl or its metabolites were not detected below 10 cm in the soil, confirming the laboratory studies on mobility which showed that leaching was
unlikely. Degradation in rice paddy waters was again very fast with a half life of <1 day.

Despite the rapid degradation in soil and in natural water, parathion methyl has been recently detected at low levels in river water in NSW. It has also been detected in dam water and sediment from an agricultural area in Mexico.

**Bioaccumulation**

The steady state bioaccumulation factors are low, with the highest being 108 times for non-edible tissues. Elimination of parathion methyl from these tissues was rapid, with a half life of 7 hours, indicative of rapid depuration. Bioaccumulation in the aquatic environment is not expected in normal conditions. However, under high environmental stress, the literature suggests bioaccumulation could occur but once the system returns to normal, rapid depletion should occur and prevent any sustained bioaccumulation.

**Conclusion**

Parathion methyl is readily degradable in soil and aquatic environments and is unlikely to persist beyond 1 week following application. Bioaccumulation is not expected. Due to the very rapid degradation in soil, leaching is not expected.

While parathion methyl is not volatile from soil, it is volatile from other surfaces. As a result of the ready photolysis in the vapour phase, vapours of parathion methyl are not expected to persist in the air. However, despite its demonstrated lack of persistence in laboratory studies, parathion methyl has been detected in air, rainwater and fogwater overseas, ground water in Europe and in surface water in Australia and Mexico.

**LIII Ecotoxicity**

Parathion methyl is a highly toxic organophosphate insecticide. It is toxic to most organisms and in particular aquatic invertebrates.

**Avian**

Parathion methyl (EC) is rated as very highly toxic to birds (bobwhite and mallard) by the acute oral route (LD50 of 6.6 to 9.8 mg/kg) but the toxicity is moderated when ingested as part of the diet (mallard ducks; LC50 of 357 mg/kg actual, and quail LC50 of 91 mg/kg, nominal). Effects on bobwhite quail reproduction and significant number of mortalities were noted at 15.5 ppm (EC) in the feed in a 20 week study, but at 14.7 ppm there were no effects on reproduction or toxicity related effects on mallard ducks over the same period.

Field reports indicate that mixtures of parathion and parathion methyl has been associated with several incidents of bird kills in the USA at rates similar to those used
in Australia but parathion, the ethyl analogue, is more likely to be the major toxicant involved.

Laboratory studies simulating aerial overspray of birds in a crop with parathion methyl, at rates similar to those used in Australia, showed that while none died the level of cholinesterase inhibition was >50%, indicating that the birds had received a potentially toxic dose. The major route of exposure was mainly oral ingestion through preening and by dermal adsorption of residues. In tests designed to determine the discrimination threshold, it was found that parathion methyl is not repellent to birds but conditioned aversion occurs. However, the chemical is poorly detected by some individuals and with decreasing availability of uncontaminated feeds, significant oral exposure is possible.

Parathion methyl has been associated with changed behaviours in ducks when nesting ducks have been exposed (aerially oversprayed) at the highest Australian rate in the field and under controlled conditions. These behavioural changes during nesting and brood development have been associated with reduced duckling survival in some species of ducks, particularly those that are open nesters.

The both microencapsulated formulations, Penncap-M and Parashoot, are rated as highly toxic to quail and Penncap-M as moderately toxic to mallards but the mallard results are not considered reliable. There were no dietary studies presented and the effect of dietary exposure from the ME formulations is unclear. Based on a statement present by Colin Campbell, it is expected that the dietary toxicity of the micro-encapsulated formulations is similar to the EC formulations.

Aquatic

The toxicity to aquatic organisms is very high, especially to invertebrates. The reported acute toxicity to fish on the US EPA’s ASTER data base ranges from LD50’s of 59 µg/L for spot to 75 mg/L for northern puffer fish, with the results for spot considered reliable. The submitted study shows an LC50 of between 4 and 12 mg/L for golden orfe. Life cycle studies have not been performed but the embryonic and larvae life stages of Sheepshead minnow have been tested and the maximum acceptable tolerated dose was determined to be between 12 and 26 µg/L. The early life stages are considered to be normally the most sensitive. (Note that the acute to chronic ratio is very high, with the acute LC50 = 12 mg/L, from Table 23). Parathion methyl is extremely toxic to invertebrates, with acute toxicity figures for daphnia and mysid shrimp (EC50) of 5.8 µg/L and 0.34 µg/L respectively. The US EPA data base for review studies (reviewed by Ecological Effects Branch biologists and judged to meet US EPA Guideline) show an endpoint for daphnia as 0.14 µg/L. The chronic toxicity to daphnia and mysid shrimp has been determined and the MATC found to be between 0.43 and 0.85 µg/L for daphnia and 0.11 to 0.37 µg/L for mysid. The acute to chronic ratio for daphnia and mysid shrimp is lower than for fish.

The toxicity of parathion methyl to Australian freshwater crayfish is not available but EC50 of 2.4 µg/L and LC50 of 40 µg/L to an American freshwater crayfish species have been reported. These values are old, nominal and are considered not reliable.
Parathion methyl is moderately toxic to green algae, with EC50s of 3.0 and 5.6 mg/L for two species of *Selenastrum*.

The Parashoot microencapsulated formulation of parathion methyl is significantly less toxic to fish than the EC formulation in static testing. However, there was no significant difference in toxicities of the EC and the CS formulations in static daphnia tests. A similar result is expected for other sensitive aquatic invertebrates. At 100 mg/L Parashoot is non-toxic to the algae *Scenedesmus subspicatus*.

There were no tests provided for the Penncap-M encapsulation formulation to aquatic organisms. A daphnia study is said to be preparation but is some months away from completion. It is claimed by the registrant that micro-encapsulated formulation do not effect fish and aquatic fauna due to sedimentation. The Parashoot results refute this claim in respect of daphnia and presumably similar feeding organisms.

**Non-Target Invertebrates**

Parathion methyl (EC formulation) is extremely toxic to bees by all routes of exposure. The micro-encapsulated formulation Parashoot is less toxic than the EC formulation, although it is still rated as toxic to bees by contact exposure and moderately toxic by oral exposure. Residues of Parashoot on foliage were toxic to bees in a force contact test for up to 8 days after application. In field tests it was shown that application of either the EC or Penncap-M, another micro-encapsulated formulation, to rape, corn and sunflower crops and allowing bees to forage immediately afterwards did not result in a significant difference in the concentration of parathion methyl residues in pollen gathered by the bees. However, while both showed significant toxic effects on the foraging bees, there was a significant decrease in mortalities from Penncap-M during the first two days.

No data on the toxicity to earthworms or other soil micro-invertebrates for the EC formulation was available for assessment. Based on the similar toxicity of the oxygen analogues (oxons) forms of parathion and parathion methyl, parathion methyl is expected to have a similar toxicity to earthworms as parathion, which has an LC50 = 65 mg/kg in artificial soil. The toxicity of a micro-encapsulated parathion methyl formulation (Parashoot) was determined as LC50 = 520 mg/kg dry soil (208 mg ai/kg of dry soil) and the NOEC (mortality) of 250 mg/kg dry soil (100 mg ai/kg dry soil). However, Environment Australia assigned the NOEC as <250 mg/kg of soil, based on the stiffness and coiling behaviour and noted that in the range finding study a NOEC of <0.25 mg/kg in soil was possible, based on the stiffness of the worms noted at 0.25 mg/kg.

Parathion methyl (EC formulation) is very toxic to all the non-target invertebrates (bees, lacewing and carabid beetles) tested.
Mammals

Terrestrial animals are at risk from parathion methyl when applications of the chemical are made or afterwards by contact with sprayed surfaces or from the fumigant action of the insecticide. Aerial applications could overspray larger non-target organisms, such as marsupials but this is not considered a common occurrence due to the low height of the spray aircraft at application, ie close to crop height, and it is expected that these animals will move some distance from the area where spray operations are occurring, while smaller mammals will be undercover. Similarly, overspray by tractor powered equipment is considered unlikely as animals will move some distance from the area where spray operations are occurring or be undercover. Most mammals are not expected to be oversprayed directly.

It is difficult to assess the risk to larger terrestrial organisms that enter sprayed areas and are dermally exposed to residues. Animals that enter recently sprayed areas are at some risk of exposure but as there are few, if any, reports of dead or dying animals, it is considered likely that the risk is relatively low.

Birds

Parathion methyl is very highly toxic and has the potential to harm birds through ingestion of residues. For fruit sprayed at 1.5 kg ai/ha\(^{1}\), the highest rate likely to be used when trees have fruit in pome or stone orchards (birds don’t eat citrus fruit), the concentration of parathion methyl on the fruit is calculated as 19.5 mg kg\(^{-1}\) wet weight. Using the dietary LC\(50 = 357\) mg/kg in the diet and assuming that these species ingest approximately 50% of their dietary intake as fruit, then the hazard is calculated as being low. As the dietary EC\(50\) is based on 5 days of exposure and the initial residues are expected to degrade rapidly, the actual dose received will be lower and the hazard is expected to be lower. However, some caution should be applied as this is based on a single reliable acute dietary result.

Secondary effects on birds are possible from birds eating insects that are dead or dying from use of parathion methyl. The concentration of residues on large insects from applications at 1.5 kg ai/ha is calculated as 19.5 mg ai/kg (wet weight), the same as above. The hazard is low from dietary intake of residues on insects.

There shouldn’t be a significant increase in risk to birds from the direct effects of use of the micro-encapsulated formulations as they are used at a lower rate than above or are proposed to be used at the same as rate.

Birds entering an area that has been recently sprayed could be exposed either dermally or orally from preening contaminated feathers or drinking contaminated water. This type of exposure is difficult to estimate but given the low hazard from residues on feed stuffs, this route of exposure is not expected to cause a significant increase in the overall hazard.

Aerial spraying could affect ducks and possibly other birds during their nesting and when they are raising their broods. While it is unlikely that birds would be in the cotton fields, they are likely to be in and around the dams and possibly field margins
on the cotton farms. Poorly controlled aerial application could result in them being directly sprayed.

**Bees**

Bees are at risk if spraying occurs when they are present in the crop. Using the lowest application rate in orchards (500 g ai/ha) the estimated dose is 3 µg ai per bee, and significantly above the EC50 of 0.04 µg ai per bee. If bees are aerially oversprayed the hazard is expected to be higher than that for orchards. In order to limit the exposure of bees to the pesticide, the crop should not be sprayed when there are bees present, when the crop (or ground covers) are in flower or if likely to be in flower shortly afterwards, i.e., within 3 days of spraying. The same restriction should apply to the microencapsulated formulations, given that these formulations are of similar toxicity to bees. There are recent Australian reports of application of Penncap-M causing significant mortalities to bees.

Spray drift is expected to be extremely toxic to bees and there is a significant hazard to bees from aerial application of parathion methyl. There are recent reports of aerial application of parathion methyl causing significant mortality to bees, mainly in the Gunnedah area.

**Soil Invertebrates**

Earthworms and other soil dwelling invertebrates could be exposed to the pesticide, and at an application rate of 1.0 kg ai/ha, the top 5 cm of soil would contain parathion methyl residues at 1.5 mg/kg of soil (assumes no crop cover, density of soil 1300 kg.m⁻³). As this concentration is significantly below the expected EC50, significant effects on earthworms are not expected.

For the micro-encapsulated formulations, the top 5 cm would contain residues at 1.5 mg ai/kg of soil at the application rate of 1.0 kg ai/ha, maximum rate for orchards. There is unlikely to be any mortality to worms but is should be noted that worms exposed to these residues could be effected, i.e., stiffer than normal, based on the range finding studies. This could lead to increased predation and reduces fitness and therefore be a significant environmental hazard.

Other soil invertebrates may be significantly affected unless they can move away from the sprayed areas or have become resistant to parathion methyl in the past. There are no toxicity data available for these organisms and the hazard cannot be determined.

**Conclusion**

While overall hazard to birds appears low, there are a number of uncertainties and sufficient reports from overseas of adverse effects in a variety of situations that hazard from Australian usage under certain circumstances cannot be ruled out. The hazard to bees is high, particularly from aerial application, and there is a possible hazard to soil invertebrates but there is limited toxicity data for these organisms. Terrestrial
mammals are not expected to show significant affects when parathion methyl is used according to current label directions. The micro-encapsulated formulation is expected to have a similar hazard to terrestrial organisms as the EC formulation.

To strengthen the current warning label with regard to bees, the label for all formulations should be modified to read:

DO NOT spray any plants in flower; including ground covers or while bees are present. Should spray drift occur, bees may be at risk several hundred metres downwind depending on atmospheric conditions.

Aquatic Organisms

Direct overspray onto water

Aquatic organisms are the most sensitive to the toxic effects of parathion methyl, based on the ecotoxicity data reviewed. Application by boomspray and orchard air blasters is unlikely to result in direct overspray, however, aerial application could lead to such direct over spray and is of concern. A concentration of 0.73 mg/L in shallow water was calculated by Environment Australia using a typical rate used in cotton and is unlikely to cause mortalities in the majority of fish species. Effects on daphnia and other aquatic insect/invertebrates from direct overspray are likely to be severe, based on the tests reviewed. Similar effects are likely on other aquatic invertebrates and there could be a significant risk to freshwater crayfish.

Spray Drift

Aerial Applications

— Some land-use considerations

Aerial application is the normal practice for applying pesticides to cotton. The major cotton growing areas in Australia are northern NSW and central to south-eastern Queensland with WA as minor area. In northern NSW significant numbers of cotton fields are close to water with other cotton growing regions likely to be similar. Environment Australia recognises that some of these waterways are drainage systems but a number are expected to be natural streams/rivers.

The cotton industry has recognised that farming practices must become more responsive to community concerns, and has therefore worked to implement a research program which is addressing the movement, fate and effects of pesticides in the riverine environment. The industry is also developing a Best Management Practices Manual for Cotton Growers which sets out principles and practices for good communication, pesticide application, farm design, IPM, and soil and water management.
Acute hazard

—*Emulsifiable Concentrate*

From data on aerial spray drift presented to Environment Australia and considering that the slope of the curve for the acute toxicity to daphnia is very steep (NOEC is only half the LC50), effects on daphnia in a still pond (15 cm deep) are calculated to occur at approximately 400 metres or less from the site of application. Within 24 hours of application and a reduction of 90% of the original concentration due to degradation and adsorption, the hazard is significantly reduced and effects on daphnia are only expected to remain within 50 metres of the site of application. With repopulation of the affected area occurring from unaffected areas and toxic effects being of short duration, significant long term effects on populations of daphnia are not expected. However, daphnia are not the most sensitive organism and for the more sensitive organisms, there is an unacceptable hazard up to 400 m from the application site even after 24 hours.

The US EPA has developed a computer-based model for the spray drift, AgDRIFT. Using this model and a range of possible waterbodies, Environment Australia has calculated that the model also show a high hazard and that there is potential for spray drift to significantly impact on the aquatic environment. However, the model also show that by increasing the droplet size, the hazard can be significantly reduced.

It is clear from the efficacy report that parathion methyl is used by the cotton industry as mixtures with other insecticides. As this practice increases the efficacy and therefore the toxicity to insects in the crop, it is also possible that increases in the environmental hazard may occur.

A buffer zone or in-crop buffer is desirable, as given in the newly launched Best Management Practices Manual for Cotton Growers, which currently suggests a downwind buffer of 300 metres for aerial applications. While adoption of this would reduce the hazard to environmentally sensitive areas, additional measures such as large droplets (placement spraying) are required to reduce the hazard to more acceptable levels, especially at the high rates used. Until such measures are implemented through the cotton industry as standard practice, aerial application of parathion methyl is likely to cause significant impacts on sensitive aquatic organisms 400 metres and beyond the application site.

Considering that the effects of applications of mixed insecticides are unknown, there may be a hazard through aerial application of parathion methyl in the current fashion, due to both direct overspray and spray drift.

While we are aware of no actual aquatic mortality incidents, the reports of bee deaths are a clear indication that unacceptable spray drift occurs. Continuation of this practice is thus difficult to defend, though a ban at this stage would only lead to the greater use of equally toxic and more persistent insecticides. In the mean time the recommendations in the Best Management Practices Manual for Cotton Growers should be implemented as soon as possible to help minimise the impacts of continued usage of parathion methyl in the cotton industry.
Other Crops

Vegetables can be aerially treated if the plots of land are large enough to warrant such an application, in particular processing tomatoes and forage brassicas. While the considerations above were for cotton, they are expected to apply to other situations but a lower rate is used for vegetables. Recalculating the hazard based on the lower rates, the hazard is initially high, but after 24 hours the hazard is marginal at 300 metres away from the application site. By analogy with the results for cotton, the US EPA AgDRIFT model would indicate that with coarser droplets, the hazard is further reduced.

A manual for best practice for vegetables growers is unlikely, as these growers are not represented by any single organisation. However, there is a general strategy to minimise contamination of non-target areas in the Pilots and Operators manual (Operation Spray Safe: Pilots and Operators Manual, Aerial Agricultural Association of Australia, 1997). In this strategy a number of procedures for avoiding contamination of non-target area are given to reduce the potential for spray drift. Environment Australia believes such strategies should be used for all aerial application.

In conclusion, aerial application to vegetables is acceptable provided a spray drift management strategy, such as in the BMPM for cotton or in the Pilots and Operators manual (Aerial Agricultural Association of Australia, 1997), is implemented.

MicroEncapsulated Formulations

While Penncap-M is not expected to be aerially sprayed as it is for orchards crops only, the proposed label for Parashoot includes cotton and vegetable crops that are aerially sprayed. Assuming that aerially application of Parashoot gives the same spray drift as the EC formulations, then a similar hazard calculation to that above indicates that there is hazard to daphnia up to 400 metres away and for sensitive aquatic invertebrates up to 800 metres away from the application site. Also, as the active ingredient in the microencapsulated material is expected to be slowly released to the aquatic compartment, the effects are likely to be prolonged and significant reduction in the hazard within the first few days is not expected. Environment Australia considers that aerial application of the microencapsulated formulation is not acceptable, based on currently available studies.

Ground Based Spraying

Orchards applications

Land use considerations

No data exists for the occurrence of orchard crops close to water bodies, but Environment Australia expects that ponds and drainage channels (both man-made/modified or natural) would be a common feature of the landscape in which pome fruits are grown, with subsequent movement of parathion methyl into “natural” receiving waters such as swamps, marshes, lakes and rivers. Indeed, it is likely that man-made drainage channels would frequently be within 10 m of the crop, but are of less concern than natural waterbodies because of their expected lower biodiversity and ecological significance.
Emulsifiable Concentrate

—*Major Use Pattern*

The major use of parathion methyl currently is for pome fruit orchards, which are sprayed by orchard air blasters or similar equipment. From the information on spray drift presented to Environment Australia, a simple model based on this data was developed.

Calculations based on the model show that the hazard to fish in shallow water is minimal from use of orchard air blast equipment from spray drift at the highest application rate (1 kg ai/ha). There is a high hazard to daphnia at 50 metres away in shallow water from drift at the highest rate and only decreases to acceptable levels at 100 metres away or greater. For the more sensitive aquatic invertebrates the hazard extends to 200 metres. After 24 hours, there are still likely to be significant effects on sensitive aquatic invertebrates 50 metres away, particularly at the highest rate.

The degradation of parathion methyl is rapid, half life of 1.1 days, so that after another 24 hours, ie 2 days after spraying, the concentration is expected to be halved and the hazard correspondingly reduced. Effects on the most sensitive organisms 50 metres away are still likely after 2 days at the highest rate but unlikely between 500 and 750 kg ai/ha.

In contrast, calculations for spray drift based in the US EPA AgDRIFT model indicated levels that were significantly less than those in the simple model developed by Environment Australia. Given that the Environment Australia model is based on data from a walnut orchard and the US AgDRIFT was modelled from pome fruit orchards, the US EPA model is considered to be the more accurate of the two. In addition, the AgDRIFT is based on a large number of applications, with all applications used to derive equations used in the model. The results in the model clearly indicate that there is unlikely to be a significant hazard to aquatic invertebrates from orchard application to normal orchards (pome and stone fruit) at 50 metres. For waterbodies closer than 50 m there is a hazard to sensitive invertebrates, which is unacceptable at less than 25 metres.

The results for tall trees from the AgDRIFT model are similar to those in the Environment Australia’s model and show that significant effects on daphnia are not expected, even at the highest rate modelled (1.5 kg ai.ha$^{-1}$, corresponding to 4600 L.ha$^{-1}$) for tall fruit trees. However, there could be significant effects on sensitive aquatic organisms within 100 metres of an orchard that is being sprayed, especially with rates $\geq$1000 g ai.ha$^{-1}$. Effects on the most sensitive organisms are still likely after 2 days at the highest rate but less likely at lower rates.

Given the steep toxicity curves for parathion methyl with aquatic invertebrates and that after 1 day the hazard is significantly reduced, the hazard for normal trees is considered to be able to be mitigated to an acceptable level by risk management steps, eg label statements, for applications at 1000 g ai.ha$^{-1}$ and less. However, for large trees with higher application volumes, the hazard at this rate and above at 100 metres
is unacceptable but not at 150 metres away. It must also be noted that this is for mysid shrimp that is used as a surrogate for sensitive aquatic organisms. However, there are no data available for Australian species and until Australian data is available, the mysid is used as a surrogate species for these and other sensitive species.

A potential hazard exist from use of parathion methyl in orchards using conventional air blast equipment but this hazard is lower than with parathion, a potential alternative chemical for IPM. While this is mainly due to the more rapid degradation, the some what lower toxicity of parathion methyl is a major factor.

—Dormant Spray for Scale
While the above is for trees in full leaf, scale applications are often made when the trees are dormant and therefore there is potential for significant increase in spray drift. The rate used for control of scale is the highest concentration of 100 mL/100 L. However, as the trees are bare, it is expected that the volume of solution applied will be lower than for trees in full leaf (smaller surface area to wet). Assuming the volumes applied are between 1000 and 1500 L.ha\(^{-1}\) (advice is that use on scale is at the semi-dormant stage, tank mixed with oil and once only) then the maximum rate would be 750 g ai.ha\(^{-1}\).

Calculation using the US EPA model shows that this use does have a significantly higher spray drift hazard, despite the lower rate, due to less interception, but after 24 hours this hazard is reduced for daphnia to more acceptable levels. This is not true for mysid shrimp, used as a surrogate for other sensitive aquatic organisms, where the hazard remains high up to 100 metres from the spray site. Further, this assessment used AgDRIFT, where apples were used as dormant trees and for tall pear trees, where in order to ensure coverage of the upper branches and twigs the spray is projected higher into the air, the hazard is expected to be higher. Again Environment Australia cannot support this use based on present information and modelling capacity.

—Other Spray Equipment
The efficacy report clearly identifies that spray equipment other than the high volume conventional sprayers is increasingly being used by orchardists and is of concern due to the higher potential for spray drift. Environment Australia does not have data for the spray drift from such applications but considers that the assumptions used above could underestimate the distance that the drift would affect. Further information is required before a conclusion about the hazard to aquatic organisms from such applications can be determined.

Electrostatically charged sprays are expected to limit horizontal movement and localise the spray to surfaces in and beside the orchard and thereby reduce the hazard.

—Citrus
Using the US EPA AgDRIFT model, calculations show that for applications at 4 kg ai.ha\(^{-1}\), considered a typical application rate for most regions for control of scale, the overall hazard is acceptable after 24 hours. For mysid shrimp, used as a surrogate for more sensitive aquatic organisms, the hazard extends to at least 100 metres, and only becomes acceptable at 150 metres after 24 hours. It should be noted in South Australia, where use is most likely but still occasional, most citrus orchards are some
distance away from permanent water due to the need to ensure adequate drainage. For other areas, such as the Murrumbidgee Irrigation Area (MIA), where waterbodies and drainage channels can be closer than 150 metres, the results clearly show that the hazard is not acceptable.

The US EPA AgDRIFT model does not include information for low volume spraying. However, the spray drift from low volume applications to citrus orchards has previously been studied and modelled. Using this model, calculations show that the low volume spraying gives less drift than for high volume spraying. Therefore the conclusion for high volume application to citrus should cover low volume spray as well.

The other major application method used in citrus is horizontal oscillating boom sprayer, which uses very high volume applications (>10,000 L.ha\(^{-1}\)). Environment Australia does not have any data on representative spray drift but anecdotal evidence indicates that this type of equipment does not produce many fine droplets that are prone to drift. The hazards from spray drift from this equipment is expected to be acceptable in South Australia, but may not be in the MIA.

—Other Considerations
Orchards are present in a range of landforms ranging from river flats to rolling hillsides but mostly they require good drainage and therefore there are likely to be drainage channels etc close to the orchards. These drain into natural waterways or ponds. Also, most orchards tend to be away from the natural permanent waterways as the trees cannot take ‘wet feet’ although pears are more tolerant that other trees and closer to natural waterways.

However, it must be noted that that the hazard from spray drift is a downwind phenomenon and is strongly dependent on timing with respected to atmospheric conditions and how the growers use chemicals, ie not spraying when the wind would allow spray drift to contaminate natural waterways. To limit the extent of spray drift in orchards (especially citrus) with very large trees it is considered if there is a waterbody within 200 metres downwind, an in-crop buffer, ie the last 3 downwind rows not sprayed, should be used. These rows can be sprayed later when the wind is blowing away from the water.

While the above hazard calculations are for ponds, a ‘pulse’ of contaminated water is likely in flowing streams and the acute hazard calculations are used as an approximation of this ‘pulse’. For ponds receiving runoff from orchards or from streams near orchards, further dilution is expected and as these ponds are likely to be significantly deeper, the hazard should be reduced.

—Microencapsulated Formulations
Both microencapsulated formulations, Penncap-M and Parashoot, are expected to be applied by orchard air blasters. As for the aerial application above, assuming that ground application of the microencapsulated products gives the same spray drift as the EC formulations, the hazard was calculated for modern pome fruit trees and tall trees (ie older pear trees) at rates of 1.0. (Note that rate for both products for control of insects is similar, and at 3000 L.ha\(^{-1}\), Penncap would apply 950 g at.ha\(^{-1}\) and
Parashoot 1.0 kg ai.ha$^{-1}$. As there is no metabolism data for these products, the results were not moderated further.

The results shows there is a low hazard to daphnia at 25 metres for ‘normal’ pome fruit and stone fruit at 1.0 kg ai.ha$^{-1}$. However, there was a significant hazard at 50 metres away for applications to tall pome fruit trees at the same rate and was acceptable to Environment Australia at 100 metres. For citrus sprayed at 100 mL/100 L rate is 4.0 kg ai.ha$^{-1}$ (8000 L.ha$^{-1}$ for scale the hazard was not acceptable at 150 metres.

Again the taller trees and citrus are the most likely to result in environmental effects from application of the microencapsulated formulations. This is the same situation as for the EC formulations above. However, this is based on one toxicity study for aquatic invertebrates and therefore there is a low level of confidence in the analysis. Given that the current label for Penncap-M has a lower maximum rate of 650 g ai.ha$^{-1}$, it is recommend that this rate be adopted for other microencapsulated formulations.

Applications By Boom Spray

—*Emulsifiable Concentrate*—Low boom

Recent literature reports have shown that as close as 1.7 metres to the spray boom there is less than 2% spray drift for 95% of applications, even in winds of 20 km/h. Another figure used by Environment Australia for spray drift from boom spray 5 metres away from the site of application is 1%, based on studies using herbicide applications. Using deeper water (30 cm) and mitigation of the quotient for both degradation and adsorption after 24 hours, the hazard was calculated as low.

The US EPA AgDRIFT model gives the drift from boom sprayers, both low booms and high boom sprayers. The low boom sprayers are normally used for vegetables while high boom sprayers are used for tall crops, ie cotton. Calculations using the US EPA surprisingly shows that the spray drift is similar to that in orchards. The US EPA results are Tier 1 and represents a worst case with conservative assumptions. The recent literature reports are real world data and may better approximate the spray drift that would be typical.

Using similar arguments as for orchards, and mitigation of the quotient for both degradation and adsorption, the hazard for daphnia is low. For mysid shrimp the hazard is also significantly lower and apart for waterbodies within 10 metres of the spray boom, the hazard is acceptable. Use of low boom sprays for application of parathion methyl is acceptable.

—*Micro-encapsulated Formulations*

Given that the toxicity of the micro-encapsulated formulations to daphnia are expected to be similar to the EC formulation, application of these formulations by boom spray are not expected to result in an increase in the acute hazard to that of the EC formulations and therefore application by boom spray of the micro-encapsulated formulations is acceptable.
—High boom spraying

The most likely use of this type of equipment would be for dry land cotton from the middle to end of the growing season when parathion methyl is likely to be applied as a mixture at 1.1 kg ai.ha⁻¹. Calculations show a high hazard close to the spraying operations for both daphnia and mysid. Even with a 100 metre and after 24 hours, the hazard to mysid and other sensitive aquatic invertebrates remains high and unacceptable at 150 metres. The AgDRIFT model used for Table 51 is Tier 1 and is for fine droplets, and therefore may not be typical if applications are made using significantly coarser droplets. Dry land cotton crops are normally more than 100 metres away from natural waterways, at least in the major cotton growing areas in NSW and therefore the hazard to aquatic invertebrates is expected to be lower than that calculated. Nevertheless sensitive aquatic organisms could be effected unless spray drift mitigation measures are taken, such as large droplets, and the BMPM for cotton is implemented.

Chronic Effects

Once in the aquatic environment, parathion methyl is not expected to persist, with a laboratory half-life of 1.1 days for the initial period of degradation. The field studies showed the degradation could be faster in more biologically active waters, ie rice paddies. This is expected to reduce the concentration of parathion in the aquatic environment to approximately one hundredth of the initial dose in a week. Chronic effects are not expected.

This does not apply to the micro-encapsulated formulations, where there are unsubstantiated claims of prolonged persistence. Until additional data on the environmental degradation is presented, Environment Australia considers that chronic effects on aquatic invertebrates from these new formulations are possible.

Runoff And Leaching

Runoff from areas where parathion methyl has been applied is not expected to be significantly contaminated. The Koc indicates at least moderate binding to soil particles, which was confirmed in the aquatic metabolism study. The rapid degradation in soil will limit the time when erosion of soil with adsorbed parathion methyl is likely to be problematical.

Further, significant erosion of contaminated soil is not expected due to modern orchard and vineyard management practices including cover crops between rows. Erosion in horticultural (vegetable) crops is also not expected. If heavy rain occurs within days of the application, expected to be a rare event, high dilution is likely which will limit environmental effects.

Leaching of parathion methyl to subsurface water is unlikely, as shown by studies presented to Environment Australia.
Multiple Applications

—*Emulsifiable Concentrate*

The above analysis is for a single application but in practice there are expected to be multiple applications. It is expected that in most situations there would be at least 7 days between sprays. For vegetables there are 10-14 days between applications. Assuming the worst case, i.e., that there is no adsorption to sediment and the half life in water is 1.1 days, then the increase in concentration after 7 days due to carryover is 1.2%. Therefore, an increase in acute toxic effects on aquatic organisms from multiple applications is not expected, provided there is at least 7 days between applications.

However, the main problem is repeated effects on sensitive organisms and 7 days between sprays would not allow affected populations to recover. A recovery period is required to minimise the impact of repeated applications, especially as parathion methyl may be used up to 8 times a season. As parathion methyl is most likely to affect aquatic invertebrates, a minimum recovery period of at least 14 days between applications is desirable. This corresponds to 2 life cycles for daphnia, an important invertebrate in aquatic ecosystems.

—*Micro-encapsulated Formulations*

The label for Penncap-M has a minimum period of 2 weeks between sprays and the proposed label for Parashoot does not give a spray interval, apart for some vegetable crops and tobacco of 10-14 days between applications. There were no studies on the metabolism and degradation of the microencapsulated products and therefore the persistence of the micro-encapsulated products in the environment is unknown. Also, as Parashoot was very toxic to daphnia and there is a question as to whether the ME formulation constitute a chronic hazard or not, it is not possible to determine the effects of multiple applications.

The effect of multiple application of the ME formulations is unknown.

**Hazard to Algae**

Parathion methyl is rated as moderately toxic to algae (EC50 of 3.0 mg.L\(^{-1}\), Table 22). As direct application to water is not expected and the spray drift studies show that the concentration in shallow water just 50 m downwind is 19 µg.L\(^{-1}\), greater than two orders of magnitude below the algae EC50, effects on algae are unlikely. Also, the microencapsulated formulations are not expected to effect algae given the low toxicity of Parashoot (see p 55).

**Desirable terrestrial vegetation**

As parathion methyl is non-phytotoxic (Tomlin, 1994), except that some plants may suffer slight injury (alfalfa, sorghum, some varieties of apples, pears, peach leaves and some ornamentals), and direct application to desirable terrestrial plants and vegetation is not expected, significant effects on desirable plants is unlikely.
**Controls/Labelling**

Parathion methyl must not be allowed to contaminate waterways.

The labels are not satisfactory for instructions on use. For aerial applications, the following warnings should be added to the label under the heading of ‘Use’:

- **DO NOT** aerially apply near to sensitive areas without applying measures to limit the spray drift on these areas. A spray drift management strategy such as those in the ‘Best Management Practices Manual for Cotton Growers’ or the Pilots and Operators Manual should be applied.

As a general warning the following should be added under ‘Use’:

- **DO NOT** apply under meteorological conditions or from spraying equipment that could be expected to cause spray drift onto natural streams, rivers or waterways.

- **DO NOT** spray any plants in flower; including ground covers or while bees are present. Should spray drift occur, bees may be at risk several hundred metres downwind depending on atmospheric conditions.

**Disposal**

Some of the labels from different companies do not appear to comply with current labelling practices with respect to rinsing and disposal of used containers. All currently registered labels and currently sold products should comply with the current labelling requirements with respect to rinsing and disposal of containers, i.e

- Triple rinse or preferably pressure rinse empty containers before disposal or recycling. Add rinsings to the spray tank. Do not dispose of undiluted chemical on site. Return the empty container for recycling where this is an option or for disposal at a landfill authorised to accept that waste. If none of these options are available, bury the containers below 500 mm in a disposal pit specifically marked and set up for this purpose, clear of waterways, vegetation and roots. Empty containers and product should not be burnt.

For refillable containers the following should be added:

- Empty contents fully into application equipment. Close all valves and return to point of supply for refill or storage.

**I.V Conclusions**

Parathion methyl is an organophosphate and is extremely toxic to aquatic invertebrates, birds and mammals. It is considered a ‘soft chemical’ and is used in cotton, orchards and vegetables to control a range of insects including aphids, caterpillars, *helicoverpa* spp, moths, butterflies, mites, weevils, jassids, budworm and
scale. Parathion methyl is an integral part of IPM programs, especially in the stone and pome fruit industries.

Parathion methyl readily degrades in natural systems, with the first half-life of approximately 1 day in aqueous conditions, both aerobic and anaerobic. It degrades in soil but the process is slower, with a half-life of 4.7 days. Parathion methyl is moderately bound to soil and together with the rapid degradation is not expected to leach.

Parathion methyl is sufficiently volatile to have a fumigant effect, and volatilisation is expected to be a significant method of loss, particularly from foliage. When it deposits on soil, parathion methyl will be bound to the soil and volatilisation is limited. Once volatilised it is expected that most of the volatilised material will be degraded or redeposited. Degradation in the air from UV is fast, with a calculated half-life of <1 day.

The chemical is very toxic to birds, mammals and aquatic invertebrates. Its toxicity to birds decreases when it is incorporated into the diet, therefore the environmental toxicity depends on the route of exposure. Birds and mammals are not expected to be significantly exposed to the chemical unless they enter an area recently sprayed. However, the direct application of parathion methyl to aquatic systems is expected to significantly affect aquatic invertebrates and must be avoided.

Spray drift from aerial applications present a very significant hazard to aquatic invertebrates and at considerable distance from the site of application. A buffer zone or in-crop buffer is highly desirable, as given in the newly launched Best Management Practices Manual for Cotton Growers, which currently suggests a downwind buffer of 300 metres for aerial applications. While this would significantly reduce the hazard to sensitive areas, additional measures such as using large droplets are required to reduce the hazards to more acceptable levels. Until such measures are implemented through the cotton industry as standard practice, aerial application of parathion methyl is likely to cause significant impacts on sensitive aquatic organisms to 400 metres from the application site.

Also, it is clear from the efficacy report that parathion methyl is used by the cotton industry as mixtures with other insecticides. This use of parathion methyl in this way is expected to increase the hazard and Environment Australia has considerable concerns over such uses.

In conclusion, and taking into account the unknown effects of applications of mixed insecticides, Environment Australia cannot rule out that an unacceptable hazard exists through aerial application of parathion methyl in the current fashion, due to spray drift. While we are aware of no actual aquatic mortality incidents, the reports of bee deaths are a clear indication that unacceptable spray drift occurs. Continuation of this practice is thus difficult to defend, although a ban at this stage would only lead to the greater use of equally toxic and more persistent insecticides.

The recommendations in the Best Management Practices Manual for Cotton Growers should be implemented as soon as possible to help minimise the impacts of continued usage of parathion methyl (and other highly toxic insecticides) in the cotton industry.
Further to reduce the hazard, we recommend that use of droplets with vdm >250 µm should be explored when there is a sensitive area downwind of the site to be sprayed. Representative data on the toxicity to aquatic invertebrates of the common mixtures used in the cotton industry, ie profenofos, chlorpyrifos, bifenthrin and another synthetic pyrethroid, should also be provided.

Calculations for the spray drift from conventional orchard airblast equipment shows the hazard to fish in shallow water is minimal from use of orchard air blast equipment. For daphnia the hazard is acceptable for normal pome and stone fruit trees and grapes at 1.0 kg ai.ha\(^{-1}\), 65 mL/100 of spray, 3000 L of spray per hectare, the typical rate for non-scale insects. For sensitive aquatic invertebrates there are a hazard at 50 metres away at this rate, which is acceptable 24 hours later. There is a higher hazard from dormant spray for scale, even at lower rates, due to less interception and is considered to be unacceptable.

For taller old trees, there is a high hazard to daphnia at 25 metres away in shallow water from typical drift levels at 1.0 kg ai.ha\(^{-1}\), which is greater for the more sensitive aquatic invertebrates, and decreases to acceptable levels only at 200 metres away and beyond. After 24 hours, there are still likely to be significant effects on these sensitive aquatic invertebrates 50 metres away, particularly at the highest rate expected for tall trees of 1.5 kg ai.ha\(^{-1}\) (see Table 42). Effects on the most sensitive organisms 50 metres away are still likely after 2 days at the highest rate but unlikely at the lower rates. In conclusion Environment Australia cannot support the current use pattern for tall trees, based on present information and modelling capabilities, and can only support a restricted use pattern of maximum of 1.0 kg ai.ha\(^{-1}\) (corresponding to 3000 L at 65 mL/100 L).

For citrus use, with very high applications volumes (8000-10000 L per hectare) and scale as the principal targeted pest, the hazard to aquatic invertebrates from spray drift was calculated to be high. Even 24 hours after application the hazard to sensitive aquatic invertebrates was only acceptable at 150 metres away. However, for the particular conditions in South Australia, where the expected application pattern is only occasional use and only once per season, continued use may in citrus may be acceptable.

For citrus orchards in South Australia, where higher application volumes are required, it is considered that in order to limit the environmental hazard it is recommended that if there is a waterbody within 200 metres downwind, an in-crop buffer, ie the last 3 downwind rows should not be sprayed, should be used. These rows can be sprayed later when the wind is blowing away from the water. This is based on evidence from citrus orchards indicating these rows are largely responsible for the majority of the spray drift (Salyani and Cromwell, 1992).

A potential hazard exists from use of parathion methyl in orchards using conventional air blast equipment but this hazard is lower than with parathion, a potential alternative chemical for IPM. While this is mainly due to the more rapid degradation, the somewhat lower toxicity of parathion methyl is a major factor (EC50s for mysid shrimp = 0.062 and 0.34 µg.L\(^{-1}\) for parathion and parathion methyl respectively).
Modern LV equipment used by some growers is of concern due to the higher potential for spray drift from the small droplet size used. However, the results from Table 45 would indicate that the spray drift from this type of equipment is relatively high and comparable with conventional sprayers. Further information is required before a conclusion about the hazard to aquatic organisms from such equipment can be determined.

A recovery period is required to minimise the impact of repeated applications is highly desirable, especially as parathion methyl may be used up to 8 times a season (see efficacy report). As parathion methyl is most likely to affect aquatic invertebrates, a minimum recovery period of 14 days between applications is highly desirable.

Due to the relatively limited spray drift hazard that occurs with use of boom-sprayers, normally used for vegetable crops, use of parathion methyl in vegetable crops is acceptable to Environment Australia. This also includes other crops treated by boom spray.

The currently registered uses of Penncap-M are considered to have a similar level of hazard as the EC formulations. While there could be a higher chronic hazard from use of Penncap-M, the overall hazard is considered acceptable due to the lower application rates.
NRA ORDER FORM

To receive a copy of the full technical report for the NRA’s evaluation of parathion-methyl, please fill in this form and send it, along with payment of $100 to:

Ms Nikki Dack  
Chemical Review Section  
National Registration Authority for Agricultural and Veterinary Chemicals  
PO Box E240  
Kingston ACT 2604

Alternatively, fax this form, along with your credit card details, to Nikki Dack on (02) 6272 3551.

Name (Mr, Mrs, Ms, Dr)________________________________________
Position _____________________________________________________
Company/organisation _________________________________________
Address _____________________________________________________
Contact phone number (___) ____________________________________

I enclose payment by cheque, money order or credit card for $__________

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