Ministry for Primary Industries
Manatū Ahu Matua

A Review of the Use of Water and Natural Fertilisers during the Growing, Harvesting and Packing of Horticultural Produce

MPI Technical Paper No: 2016/10

Prepared for the Ministry for Primary Industries by Rob Lake (ESR), Jane Lancaster (Catalyst® R&D Ltd), Nicola King (ESR), and Marion Castle (MPI)

ISBN No: 978-1-77665-200-6 (online)
ISSN No: 2253-3923 (online)

September 2011

New Zealand Government

Growing and Protecting New Zealand

Disclaimer

While every effort has been made to ensure the information in this publication is accurate, the Ministry for Primary Industries does not accept any responsibility or liability for error of fact, omission, interpretation or opinion that may be present, nor for the consequences of any decisions based on this information.

Requests for further copies should be directed to:

Publications Logistics Officer
Ministry for Primary Industries
PO Box 2526
WELLINGTON 6140

Email: brand@mpi.govt.nz
Telephone: 0800 00 83 33
Facsimile: 04-894 0300

This publication is also available on the Ministry for Primary Industries website at http://www.mpi.govt.nz/news-and-resources/publications/

Scientific Interpretative Summary

This SIS is prepared by MPI risk assessors to provide context to the following report for MPI risk managers and external readers.

A review of the use of water and natural fertilisers during the growing, harvesting and packing of Horticultural produce

ESR Report 11024

Over the past few years there have been a number of foodborne outbreaks overseas associated with the consumption of fresh produce. Good agricultural practices during the growing and harvesting of fresh produce, if implemented effectively, will minimise contamination from biological and chemical hazards. MPI commissioned this review to provide an overview of good agricultural practice and good hygienic practice in the horticulture industry and supply chains in New Zealand.

The assurance programmes used in the New Zealand horticulture industry, including requirements of suppliers that may apply to fresh produce, were reviewed. Particular attention was given to guidance material and requirements for water and natural fertiliser usage through the supply chain including production. The requirements were compared against those published by the *Codex Alimentarius Commission* and published international legislation, guidance or assurance programmes. It is noted that the more common assurance programmes provide food safety advice through a range of different practices.

Forty conventional and organic growers (there are approximately 1750 berry and leafy vegetable growers) and packhouses in New Zealand were surveyed (questionnaire and follow-up telephone survey) to determine how they use water and natural fertilisers, and how well they know and manage any hazards. The survey provided a snap-shot of water and natural fertiliser use and revealed that the majority of the growers knew of and managed potential contamination of water and natural fertilisers. However, the risk management controls that are implemented generally tended to be based on experience and/or historical knowledge. The report suggested that for individual food businesses, the use of a more formal risk assessment and better documentation of decision making processes would improve the effectiveness of control programmes.

Client report FW11024

A REVIEW OF THE USE OF WATER AND NATURAL FERTILISERS DURING THE GROWING, HARVESTING AND PACKING OF HORTICULTURAL PRODUCE

VOLUME 1: OVERVIEW AND MAIN FINDINGS

Prepared for the Ministry of Agriculture and Forestry
under Agreement 11875

Dr Stephen On
Food Safety Programme Leader

Dr Rob Lake
Project Leader

Wendy Williamson
Peer Reviewer

Institute of Environmental Science & Research Limited
Christchurch Science Centre
Location address: 27 Creyke Road, Ilam, Christchurch
Postal address: P O Box 29 181, Christchurch, New Zealand
Website: www.esr.cri.nz

A CROWN RESEARCH INSTITUTE

REVIEW OF THE USE OF WATER AND NATURAL FERTILISERS DURING THE GROWING, HARVESTING AND PACKING OF HORTICULTURAL PRODUCE

VOLUME 1: OVERVIEW AND MAIN FINDINGS

Prepared for the Ministry of Agriculture and Forestry
under Agreement 11875

by

Rob Lake (ESR)
Jane Lancaster (Catalyst® R&D Ltd)
Nicola King (ESR)

September 2011

ACKNOWLEDGEMENTS

The authors would like to thank the following people and organisations for their contribution to this volume:

The horticulture growers who generously gave their time and knowledge to this study by participating in the survey.

Horticulture New Zealand for their assistance with many parts of this project.

Organics Association of New Zealand for providing the 2010 CSAFE report

Plant and Food Research

Maurice Wilson and Andrew Ball (ESR).

Standards New Zealand for granting permission to reproduce text from NZS 8410:2003 (Volume 4).

REFERENCES TO WEBSITES

All of the websites referred to in this document were available for access in April 2011, unless specified.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

CAC	Codex Alimentarius Commission
CFU	Colony Forming Unit (a laboratory measurement of the number of bacteria in a sample)
C:N	Carbon:nitrogen
DWSNZ	Drinking-water Standards New Zealand
GAP	Good agricultural practice(s)
HEA	Horticulture Export Authority
HortNZ	Horticulture New Zealand
MAF	Ministry of Agriculture and Forestry (New Zealand)
MfE	Ministry for the Environment (New Zealand)
MoH	Ministry of Health (New Zealand)
MPN	Most Probable Number (a laboratory measurement that approximates the concentration of bacteria in a sample)
NZTDS	New Zealand Total Diet Study
NZWWA	New Zealand Water and Wastes Association
OOAP	Official Organic Assurance Programme
PAH	Polycyclic aromatic hydrocarbons
PFU	Plaque Forming Unit (a laboratory measurement that approximates the concentration of viruses in a sample)
RTE	Ready-to-eat
SQF	Safe Quality Food
USFDA	United States Food and Drug Administration
VTEC/STEC	Vero cytotoxic *Escherichia coli*/Shiga toxin producing *Escherichia coli*
WQA	Woolworths Quality Assurance

SUMMARY

Horticultural produce may expose consumers to the risk of foodborne illness because it is often consumed raw or with minimal processing. Contamination of horticultural produce may originate from a number of sources including the soil, birds and animals, water used during growth and processing, humans and equipment. Horticultural produce is grown in environments where contamination can be minimised but not prevented. For ready-to-eat (RTE) or minimally processed fresh produce there are no critical control points that would allow contamination to be managed to eliminate risk of human exposure.

Fertiliser and water are key horticultural inputs, but it is possible for both to carry chemicals and microbes that are harmful to human health. This is particularly true for fertilisers such as composts and manures, which are examples of biological or “natural” fertilisers, and for untreated water. However, growers can also manage the risk of these inputs contaminating their produce by controlling their quality, and how and when they are applied.

Regulators are interested in how horticultural practices affect the risk of foodborne illness, and whether additional risk management is required. The Ministry of Agriculture and Forestry (MAF) commissioned this study to determine whether chemical and microbiological hazards are likely to be present on horticultural products at levels of concern as a result of:

- The application of natural fertilisers during horticultural production;
- The application of water during horticultural production; and
- The use of water during harvesting and post-harvesting activities.

This project has provided:

- an overview of the horticultural sector in New Zealand from published sources;
- an overview of scientific issues associated with the use of natural fertilisers and water for growing and processing horticultural produce;
- a summary of previous New Zealand studies of the food safety of horticultural produce;
- a snap shot survey of New Zealand vegetable and berry growers to provide an indication of current practices and risk management; and
- a review of relevant horticultural assurance programmes, and how they address issues to do with natural fertilisers and water.

The project report is presented in four volumes:

1. Project overview with the main findings.
2. Various appendices providing more detailed information and tables on the horticultural sector and scientific literature.
3. Grower survey and summary of responses.
4. Legislation and assurance programme overview, with analysis of how the assurance programmes address natural fertilisers and water use.

The New Zealand horticultural sector comprises a large number of small scale growers, with the majority (67%) of farms being less than ten hectares in area. The survey of growers found that farms often grew multiple crops, and practices related to natural fertiliser and water use were highly variable. Based on information from Statistics New Zealand there appear to be approximately 7,500 horticultural farms in New Zealand. Information from an

annual overview of organic production in this country, as well as a review of registrations on organic accreditation websites, suggest that there are approximately 500 organic horticultural operations in New Zealand.

A total of 40 growers participated in the survey, which targeted leafy vegetable and berry growers based on the likelihood of the produce being eaten raw, grown close to the ground, and receiving significant applied water. Obviously this represents a very small proportion of the estimated 1,750 growers of vegetables and berries in New Zealand

Most of the growers were able to provide information about the quality of the water and natural fertiliser inputs they used, and applied these inputs in ways that would reduce the risk of chemical or microbial contamination. We recorded some potentially unsafe practices that either increased the possibility of produce becoming contaminated, or the potential for water or fertiliser contamination had not been assessed. However, the potentially unsafe practices identified were not associated with specific growers or grower groups (organic or conventional, assurance programme certified or not certified).

Testing of water supplies appeared to be infrequent. Not all growers kept records of their water test results. As most growers use groundwater or potable water for irrigation and/or processing, the risk of contamination of produce should be very low. However, some growers use surface waters and a documented assessment of potential risks would be worthwhile, if not already being done.

Although many of the growers in the survey were members of an assurance programme, most risk management appeared to be based on experience, and not formalised or documented. Laboratory testing of natural fertilisers was absent, with growers relying on suppliers to control potential contamination.

Using wash water with a lower temperature than produce may promote the internalisation of pathogens. Post harvest washing water may contain high levels of bacterial numbers if not treated or regularly changed. The temperatures reported for post harvest water used by the growers in the survey are likely to have been lower that that of the produce. However, the majority of growers interviewed described practices that would limit the risk of internalisation (low risk of water contamination (i.e. groundwater bore or town supply), treatment of water with chlorine, frequent changing of water, low contact time between water and produce).

There do not appear to be issues associated with heavy metal contamination of New Zealand horticultural produce, based on limited survey results from produce (New Zealand Total Diet Survey), and minimal use of sewage sludges as fertiliser. One issue that could be considered is the possible presence of mercury in the fish-based fertiliser products used by a number of growers.

The assurance programmes reviewed in Volume 4 are not primarily written to address food safety issues, and in particular the organic programmes concentrate on preserving the organic status of the produce. The food safety aspects of the programmes being used in New Zealand could be improved by addressing additional issues (e.g. quality control of water for ice and cooling, and providing criteria to assess microbial and chemical quality). Material from overseas assurance programmes reviewed in Volume 4 may be useful for this purpose.

The questions asked by the original project description from MAF are as follows.

Growing practices

Good Agricultural Practices

a. What is the extent of application of natural fertilisers during primary production of horticultural produce (conventional and organic) in New Zealand?

The grower survey involved only 40 vegetable and berry growers, compared to the estimated 1,750 vegetable and berry growers in New Zealand. The survey provides useful information on grower practices but the participating growers may not be representative of New Zealand growers as a whole and do not form a statistically significant sample.

Half of the surveyed growers used natural fertilisers in some form. Most were foliar sprays made from fish or seaweed extracts, which should have lower risk of contamination by zoonotic pathogens than other sources of natural fertiliser. Most natural fertilisers are applied between crops which will also mitigate risk, although the intervals between application and planting were variable, and some were only a few weeks. Some growers commented that information on recommended withholding periods was not provided by their supplier. Generally, it appears that growers rely on fertiliser suppliers to manage the quality of the fertiliser products.

b. What are the currently available guidance and control measures?

The existing legislation, standards and assurance programmes are reviewed in Volume 4.

c. Are internationally available guidelines for the application of water and natural fertilisers applicable to New Zealand?

We consider that the guidelines and assurance programmes from overseas, as described in Volume 4, could be used to augment the existing New Zealand assurance programmes

Risk Management

d. Is the application of natural fertilisers and potentially contaminated water (different sources) under conditions of primary production in New Zealand likely to lead to significant microbial contamination?

See below.

e. Is residual contamination likely to occur at a level that may constitute a foodborne risk to consumers?

The information collected by this project from published sources and the grower survey has shown that the New Zealand horticultural sector comprises a large number of generally small scale farms, growing multiple crops, and with variable practices in relation to water and natural fertilisers. It is not possible to estimate the probability or level of residual contamination of horticultural produce from these data, particularly due to limited information on composting practices of fertiliser suppliers.

Surveys of the prevalence of pathogens in the faeces of sheep, dairy cattle, and chickens in New Zealand indicate that, with the possible exception of Salmonella, bacterial and protozoan hazards occur in up to 80% of samples. Natural fertilisers containing livestock *manure were all applied to soil prior to crops being planted by the growers surveyed. Although pathogens have been shown to survive in soil for several weeks, the numbers decline. Composting, and allowing time intervals between natural fertiliser application and planting, as practised by most growers, would reduce the risk of produce contamination.*

Harvesting, post-harvest wash and packing

Good Agricultural Practices

f. What is the extent of application of water during harvesting and post-harvesting activities of horticultural produce (conventional and organic intended for domestic consumers and export) in New Zealand?

Interview and survey results indicated that there is extensive use of water during harvest and post-harvest. Although the sample size was small and results should be treated with caution, of the growers who responded to the survey, 20% used water to wash or moisten produce in the field during harvest, and 63% used water to transport, wash, cool and/or moisten produce after harvest.

g. What are the currently available guidance and control measures?

The existing legislation, standards and assurance programmes are reviewed in Volume 4.

h. Are the internationally available guidelines for the application of water and natural fertilisers applicable to New Zealand?

We consider that the guidelines and assurance programmes from overseas, as described in Volume 4, could be used to augment the existing New Zealand assurance programmes

Risk Management

i. Is the application of potentially contaminated water under conditions of harvest and packaging in New Zealand likely to lead to significant microbial contamination?

See below

j. Is residual contamination likely to occur at a level that may constitute a food-borne risk to consumers?

Based on data from an extensive survey of surface waters undertaken in New Zealand between 1998 and 2000, the prevalence of Campylobacter is approximately 60%, while the prevalence of other bacterial and protozoan pathogens is up to 10%. The majority of growers used potable water and ground water (bore) supplies. Potable water supplies are at lower risk of being contaminated due to Ministry of Health controls on drinking water. Although there a few data on groundwater (bore) quality, such supplies would be at lower risk from contamination sources such as agricultural runoff. Chemical contamination with heavy metals is rare, apart from some rivers in the geothermal region of the central North Island. Of the growers surveyed, a minority (6/40, 15%) used surface water sources and all but one of these conducted microbial testing annually. Several growers used lower risk water sources (e.g. town supplies of potable water) for post harvest activities.

Growers were generally aware of the potential for contamination from water used on their farms and in packhouses, and managed these risks in a variety of ways (e.g. water testing, water treatment, switching water supplies when potential contamination events such as heavy rainfall occurred). However, documentation supporting these risk assessment or *management activities was uncommon and this made it difficult to assess the efficacy of measures taken, and a history of safe use was sometimes invoked as evidence for a lack of risk.*

The potential for sporadic incidents of contamination of horticultural produce from natural fertilisers or water used for irrigation and processing can never be completely eliminated. Land use in New Zealand has changed markedly in the previous decade. In particular the 25% increase in land use for dairy farming since the last major survey of surface water quality in New Zealand may have affected the quality of water used for horticultural production.

However, this project has provided information on a range of factors which reduce the risk for horticultural produce from New Zealand. These include:

- *Both the conventional and organic horticultural sectors have active producer groups and associations who develop assurance programmes which have sections that address hazards in natural fertilisers and water sources;*
- *Growers in the survey reported applying natural fertilisers to soil prior to planting, which provides a period for a decline in the numbers of any pathogens present;*
- *Most (85%) of the growers in the survey used potable or groundwater sources of water which will be at lower risk of contamination; and,*
- *Grower awareness of the potential for contamination from natural fertilisers and water sources and measures taken to control this.*

Surveys of horticultural produce in New Zealand have rarely found microbial pathogens in samples (although unsatisfactory concentrations of E. coli contamination in some leafy greens samples indicate potential problems). The Total Diet Survey and other surveys have shown that heavy metals can occasionally be detected in New Zealand produce, but dietary intakes are well below levels which would present safety concerns.

The use of more formalised and documented risk assessment tools by the horticultural sector within the context of assurance programmes could help to promote awareness of food safety issues and comprehensive assessment of contamination sources.

1 INTRODUCTION

Horticultural produce may expose consumers to the risk of foodborne illness because it is often consumed raw or with minimal processing. Contamination of horticultural produce may originate from a number of sources including the soil, birds and animals, water used during growth and processing, humans and equipment. Horticultural produce is grown in environments where contamination can be minimised but not prevented. For ready-to-eat (RTE) or minimally processed fresh produce there are no critical control points that would allow contamination to be managed to eliminate risk of human exposure.

Growers can manage these sources of contamination by applying good agricultural practices, such as excluding animals, keeping equipment clean, ensuring worker hygiene, managing the quality of water and method of application. Regulators are interested in how horticultural practices affect the risk of foodborne illness, and whether additional risk management is required.

Fertiliser and water are key horticultural inputs, but it is possible for both to carry chemicals and microbes that are harmful to human health. This is particularly true for fertilisers such as composts and manures, which are examples of biological or "natural" fertilisers, and for untreated water. However, growers can also manage the risk of these inputs contaminating their produce by controlling their quality, and how and when they are applied.

The 2008/09 New Zealand microbiological survey of fresh produce (Section 3.4) and a review of outbreak data (Section 3.7.2 below) suggest that the risk of foodborne illness from consuming fresh produce is low for New Zealand. However it is not possible to ignore the outbreaks that have occurred overseas, often involving large numbers of cases (Section 3.5 Volume 2). It is important for regulators to understand how horticultural practices might increase or decrease the risk of foodborne illness so that they can decide where regulatory controls are needed.

Regulators are interested in how horticultural practices affect the risk of foodborne illness, and whether additional risk management is required. The Ministry of Agriculture and Forestry (MAF) commissioned this study to determine whether chemical and microbiological hazards are likely to be present on horticultural products at levels of concern as a result of:

- The application of natural fertilisers during horticultural production;
- The application of water during horticultural production; and
- The use of water during harvesting and post-harvesting activities.

1.1 Study scope

The horticultural produce considered by this study included fruit, vegetables, nuts, seeds, herbs, spices, cereal grains, fungi and grasses grown in New Zealand (organically or conventionally) for domestic sale or for export, and that are intended to be consumed raw (whole or as pieces) or subject to further processing.[1] This study also included raw dried or semi-dried products (e.g. prunes, spices, dried herbs). Wine grapes and wild foods were excluded from the project scope.

[1] As described in Schedule 2 of the Food Bill 2010, available at: http://www.legislation.govt.nz/

This study gathered information on the use of natural fertilisers and water from planting through to packing and storage, ready for transportation to retailers, distributers, exporters, further processing, etc.

The natural fertilisers included in this study were those produced from animal, plant and human waste products (or by-products), that may or may not be treated by composting, fermentation, pasteurisation, etc. This study did not consider biological activators, or non-biological fertilisers and soil conditioners such as crushed mineral deposits (Table 1).

Table 1: The natural fertilisers included in this study

Included in this study	Excluded from this study
Animal products: - livestock manures - compost from manures - mulch of animal origin - poultry litter - fish by-products (e.g. fishmeal) - worm by-products (vermicast) - marine bird manure (guano) Plant products: - compost from plant material - mulch from plant material - peat - food plant by-products (e.g. kitchen waste, cocoa husks, oilseed cake) - wood by-products (e.g. sawdust, bark, ash, charcoal) - seaweed, seaweed meal or algae preparations - stillage (by-product of distillation) - straw Human waste: - biosolids - sewage effluent from wastewater treatment facilities	Crushed mineral deposits, including: - calcium, e.g. dolomite, limestone - phosphate, e.g. rock phosphate - potassium, e.g. potash, sylvinite - perlite - pumice - vermiculite - zeolites Biological activators: - biodynamic preparations - microbial activators - plant-based preparations

Both potable and non-potable water[2] were included in this study, where the water was used for irrigation or any post-harvesting activities where water came into contact with the produce (e.g. washing). This study only considered irrigation water in relation to food safety and did not assess other aspects of irrigation water use such as the efficiency of watering systems and water budgets. The study also considered water used as a solute for products sprayed onto produce.

[2] For this document potable water is defined as water from a source that is used as a drinking water supply for people, and subject to the monitoring and controls for registered drinking water supplies by the Ministry of Health using the New Zealand Drinking Water Standards. Non-potable water is water that is not intended for human consumption.

The biological hazards included in this study were bacteria, protozoa and viruses that principally cause enteric disease in humans. This study also considered chemicals that are hazardous to human health and that may be naturally associated with the water or natural fertilisers (e.g. heavy metals). Table 2 lists the hazards, and also lists excluded hazards.

Table 2: The hazards included in this study

Included in this study	Excluded from this study
Bacterial pathogens: - Non-typhoid *Salmonella* spp. - *Campylobacter* spp. - *Listeria* spp. - Shiga-toxin *E. coli* (STEC, e.g. *E. coli* O157) - *Arcobacter* spp. - *Shigella* spp. - *Vibrio* spp. - *Yersinia* spp. - *Bacillus cereus* - *Cronobacter* spp. (*Enterobacter sakazakii)* - *Aeromonas* spp. Enteric viruses, particularly: - Norovirus - Rotavirus - Adenovirus - Heptatitis A Protozoa, particularly: - *Giardia* spp. - *Cryptosporidium* spp. - *Entamoeba histolytica* - *Balantidum coli* - *Toxoplasma gondii* Helminths: - Roundworms, hookworms, tapeworms, flukes Heavy metals (toxic metals):[1] - Arsenic - Cadmium - Mercury and methylmercury - Lead - Tin Environmental contaminants: - Dioxins - Polychlorinated biphenyls (PCBs) - Polycyclic aromatic hydrocarbons (PAHs) - Organochlorine pesticides	Bacterial pathogens: - *Salmonella* Typhi and Paratyphi (from humans) - *Mycobacterium bovis* (meat, milk, inhaled) - *Staphylococcus aureus* (cooked food) - *Clostridium* spp. (cooked, canned food) - *Legionella pneumophila*[2] Agrichemicals Cyanobacteria (cyanotoxins)

1. Heavy metals (or toxic metals) that are identified in the Codex Alimentarius Commission's general standard for contaminants and toxins in food and feed (CODEX STAN 193-1995).
2. This is a risk for people irrigating or spreading natural fertilisers but the bacterium is not a cause of gastrointestinal disease.

Further information on these hazards can be obtained from these sources:

- Microbial pathogen data sheets, available from http://www.foodsafety.govt.nz/science-risk/hazard-data-sheets/pathogen-data-sheets.htm
- Chemical information sheets, available from http://www.foodsafety.govt.nz/science-risk/hazard-data-sheets/chemical-information-sheets.htm
- Appendix 1 of the report *Review of non-commercial wild food in New Zealand* (Turner *et al.*, 2005), available from http://www.foodsmart.govt.nz/food-safety/hunting-collecting-fishing/wild-foods-review/index.htm

1.2 This report and project timeline

The process and key dates for this project were as follows:

- 13 August 2010: project methodology and scope (see Appendix 1 Volume 2) agreed.
- August–October 2010: Part 1 of the project involving collation of scientific information, preparation of an overview of the horticultural sector in New Zealand, consultation with industry groups (principally Horticulture New Zealand (HortNZ)), development of target sectors for grower survey.
- 22 October 2010: Teleconference with MAF to discuss material from Part 1 as provided to NZFSA, and agree scope and plans for grower survey.
- November 2010: Development of survey instruments and procedures.
- December 2010 – March 2011: Part 2 of the project: grower survey (a delay in this part of the project was caused by the Christchurch earthquake). Review of assurance programmes.
- March – April 2011: Part 3 of the project: report writing and internal peer review.
- 6 May 2011: Provision of draft report to MAF.

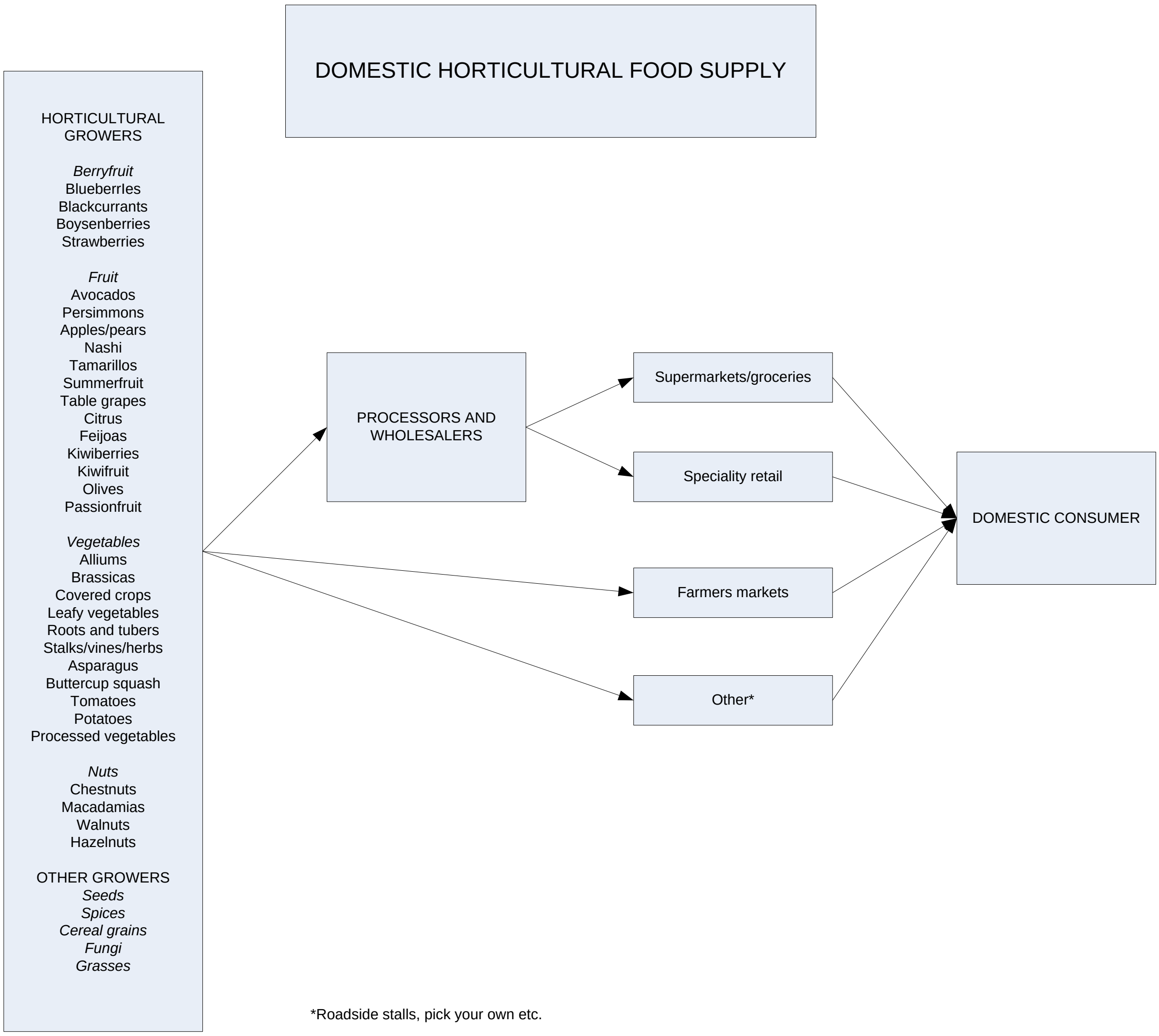
The project report is presented in four volumes:

1. Project overview with the main findings.
2. Various appendices providing more detailed information and tables on the horticultural sector and scientific literature.
3. Grower survey and summary of responses.
4. Legislation and assurance programme overview, with analysis of how the assurance programmes address natural fertilisers and water use.

2 THE HORTICULTURE INDUSTRY IN NEW ZEALAND

An overview of the domestic horticultural supply is given in Figure 1.

Figure 1: Domestic horticultural food supply



2.1 Horticulture New Zealand (HortNZ)

HortNZ is an Incorporated Society under The Incorporated Societies Act 1908. Its members are mainly Active Grower Members (persons actively engaged in the commercial production of horticultural crops who, in the 12 month period preceding the date of application for membership, have paid a levy, directly or indirectly, to the society).

HortNZ also provides services to product groups and district associations.

All commercial growers of the fruit and vegetables listed below are legally required under the Commodity Levies (Vegetables and Fruit) Order 2007 to pay a levy to HortNZ on the sale of those fruit and vegetables grown in New Zealand:

- Fruit (except berryfruit, olives and grapes);
- Fresh tomatoes;
- Fresh vegetables;
- Processed vegetables;
- Potatoes; and
- Other vegetables (asparagus, kabocha, processed tomatoes).

Some horticultural crops are represented by Product Groups that are affiliated to, but separate from HortNZ. Many of these Product Groups also have Commodity Levy Orders requiring growers to pay a levy directly to that Product Group.

For example, berryfruit growers are members of HortNZ through a subscription paid by their product group(s), so HortNZ does not collect levies from the growers directly. The four berryfruit product groups previously managed by New Zealand Berryfruit Growers' Federation (BerryFed) have been independent groups since 2000 (Strawberry Growers of New Zealand; Blueberries New Zealand; New Zealand Boysenberry Council; and Blackcurrants New Zealand). There is no product group for raspberries, but South Island raspberry interests are represented by the two co-operative companies established by raspberry growers.

The 22 product groups affiliated to HortNZ are:

1. Pipfruit (Pipfruit NZ Inc.)
2. Kiwifruit (New Zealand Kiwifruit Growers Inc)
3. Summerfruit (peaches, plums, nectarines, cherries & apricots) (Summerfruit NZ)*
4. Nashi (Nashi NZ Inc)
5. Citrus (New Zealand Citrus Growers New Zealand Inc)
6. Tamarillos (NZ Tamarillo Growers Association)*
7. Feijoas (New Zealand Feijoa Growers Association)
8. Avocados (New Zealand Avocado Growers Association)*
9. Boysenberries (Berryfruit New Zealand)*
10. Strawberries (Strawberry Growers New Zealand)
11. Blackcurrants (Blackcurrants New Zealand Inc)*
12. Blueberries (Blueberries New Zealand)
13. Kiwiberries (NZ Kiwiberry Growers Inc)
14. Olives (Olives New Zealand)
15. Passionfruit (New Zealand Passionfruit Growers Association)
16. Persimmons (Persimmon Industry Council New Zealand)*
17. Fresh tomatoes (Tomatoes NZ)
18. Fresh vegetables (segregated into six subgroups) (Fresh Vegetable Product Group)
19. Potatoes (Potatoes New Zealand)
20. Kabocha (pumpkin squash) (NZ Buttercup Squash Council)*
21. Processed vegetables (includes Potatoes New Zealand, Asparagus Council, Process Product Group)
22. Asparagus.(New Zealand Asparagus Council)

* These seven product groups are also registered under the Horticulture Export Authority (HEA) for development of export marketing strategies and the licensing of exporters under those strategies. Further details on exports are given in Section 2.6.

HortNZ does not represent grape growers or mushroom growers and these growers do not pay levies to HortNZ. The onion producers association, Onions New Zealand is also not affiliated with HortNZ. Onions New Zealand is focussed on exports of fresh onions, which represents about 80% of the crop.

2.2 Growers and areas planted

Summary data on the areas planted, and the number of farms for horticultural crops in New Zealand are presented in Table 3 and Table 4. More detailed data on grower numbers and areas planted by individual crops or regions have been assembled from MAF and industry publications and are given in Appendix 2 Volume 2.

Table 3: Data for Major Crops to June 2009 Area Planted (hectares) (Statistics New Zealand)

Crop	Area planted (hectares)
Fruit and nuts	
Kiwifruit	13,287
Apples	9,284
Pears (including nashi)	723
Stonefruit[1]	2,233
Citrus	1,871
Avocados	4,117
Berries	2,446
Nuts	1,094
Vegetables	
Onions	4,511
Brassicas	3,660
Covered crops[2]	2,144
Lettuce and leafy vegetables	2,210
Peas and beans	6,724
Roots and tubers (carrots and kumaras)	2,517
Potatoes	11,398
Stalks (sweetcorn, pumpkin, melon)	6,324
Buttercup squash	6,825
Tomatoes	745

1. Also known as summerfruit: cherries, apricots, nectarines, peaches and plums.
2. Capsicum, cucumber, cooking herbs, lettuce and salad greens, mushrooms, tomatoes, others.

Table 4: Farm numbers by type (as at 30 June 2007, ANZSIC06 classification, Statistics New Zealand)

Crop	Number of farms
Mushroom growing	18
Vegetable growing (under cover)	462
Vegetable growing (outdoor)	1,047
Kiwifruit growing	2,247
Berryfruit growing	243
Apple and pear growing	708
Stonefruit growing	357
Citrus fruit growing	330
Olive growing	435
Other fruit and tree nut growing	1602

2.2.1 Nuts, seeds, herbs, spices, cereal grains, fungi and grasses

The majority of crops relevant to this project are fruits and vegetables. A number of other crops were reviewed for potential inclusion in the survey and report.

Nuts: Nut growers were not selected for grower interviews. Outbreaks and recalls internationally have been due to microbial contamination, particularly in North America. However, the source of contamination is rarely identified in investigations of such incidents, and contamination may occur during mechanical processing, as apparently occurred in an international outbreak of salmonellosis associated with raw almonds (Isaacs *et al.*, 2005).

Seeds: A product association for edible seeds in New Zealand was not located. The New Zealand Grain and Seed Association does not appear to be involved in edible seed production[3]. Processing of edible seeds (alfalfa, hemp, linseed, melon, poppy, pumpkin, sesame, sunflower) involves drying, either in the sun or in ovens. A United Kingdom survey of dried seeds for *Salmonella* found the highest prevalence of contamination to be in melon seeds (4/47 samples (8.5%)) (Willis *et al.*, 2009). The sources of edible seeds in New Zealand need to be further investigated, but many supplies are likely to be imported.

Herbs: These are included with the stalks/vines product group of HortNZ and therefore were amongst the vegetable growers selected for the survey.

Spices: Saffron is grown as a commercial crop in New Zealand. Saffron is hand-picked, used in small quantities, and often in cooked dishes; it was considered that this crop would

[3] http://www.nzgsta.co.nz/

not require further investigation. Some New Zealand websites promoting hydroponic home growing of spices have been found, but there did not appear to be commercial growing of other spices.

Cereal grains: A recently completed Risk Profile on *Salmonella* in cereal grains described controls and these included consents for spray irrigation of farmland with effluent, which should prevent contamination of cereals on adjoining land[4]. The Risk Profile also stated “Spray irrigation of farm effluent is also practiced in New Zealand and this provides a potential route for contamination of adjacent cereal crops by animal faecal material. However, the edible grain of cereal crops is enclosed within an outer casing (husk, glume, etc.) until harvest, that may protect the grain against direct deposition”.

Fungi: Contact with New Zealand Mushroom Growers Association confirmed that compost used for production is sterilised before mixing with mushroom spawn. Consequently, they were not chosen for grower interviews.

Grasses: Cereal grains may be germinated and grown hydroponically as grasses and used fresh as health drinks. The New Zealand Grain and Seed Trade Association has no information on this usage, as it represents a tiny proportion of their trade.

2.3 From the grower to the consumer: supermarkets/groceries, speciality retail, farmers markets

There are two major supermarket groups in New Zealand.

Progressive Enterprises:[5] This is Woolworths Brand’s Supermarket subsidiary, including:

- Countdown: 104 stores
- Woolworths: 26 stores
- Foodtown: 20 stores
- Woolworths Quickstop and Micro Stores: 22 stores (probably do not carry fresh fruit and vegetables)
- Fresh Choice and Supervalue: 51 stores (these are part of the Progressive Group but are individually owned franchise operations)

Foodstuffs NZ Ltd:[6] Foodstuffs is a group of three regional cooperative groups and includes:

- Pak and Save: 45 stores
- New World: 132 stores
- Four Square: 282 stores
- Write Price: 3 stores
- Shopwrite: 2 stores
- On The Spot: 147 stores (probably do not carry fresh fruit and vegetables)

---

[4] http://www.foodsafety.govt.nz/elibrary/industry/salmonella-in-cereals.pdf

[5] http://www.progressive.co.nz/our-company/progressive-enterprises,

[6] http://www.foodstuffs.co.nz/our-brands

Horticultural produce may also reach the consumer via speciality fruit and vegetable retail outlets, farmers markets, roadside stalls, farm shops and mail/internet order services.

Some groceries/dairies and independent fruit and vegetable retailers are represented by the New Zealand Retailers Association Incorporated.[7] This organisation includes membership of 92 groceries and dairies (40 in Auckland, 12 in Wellington, 14 in Canterbury, 5 in Otago, 6 in Bay of Plenty), 27 fruit and vegetable members (11 in Auckland, none in Wellington, 6 in Canterbury). A specialist chain of produce stores in the South Island, Raeward Fresh, has five stores.

In February 2008 there were 469 outlets for "fruit and vegetable retailing" listed by ANZSIC06 code by Statistics New Zealand (note: this excludes "supermarket and grocery stores" of which there were 3,187 in February 2008).

Fifty farmers markets are registered with Farmers Markets New Zealand.[8] Authentic Farmers Markets are defined as "the seller is the grower, the product is grown from within the defined local region of the market, and the market is a food only market". The farmers markets are distributed as follows:

- Northland: 2
- Auckland: 10
- Waikato and Bay of Plenty: 7 (2 authentic)
- East Coast: 4
- Lower North Island: 7
- Top of the South: 3 (1 authentic)
- Canterbury Region: 10 (2 authentic)
- Southern and Otago: 7

Twenty six "pick your own" farms were registered with a dedicated website as at May 2011[9]. In addition, there are likely to be a large number of roadside stalls selling horticultural produce, but no data were located to indicate how many operate regularly.

2.4 Organic growers

Organic is a labelling term that denotes products that have been produced in accordance with organic production standards.

New Zealand has four internationally recognised organic certifications:

- BioGro New Zealand Organic Standards (also used by Organic Farms New Zealand);
- AsureQuality Organic Standard;
- Demeter Standard (administered by the Biodynamic Farming Association); and
- MAF Official Organic Assurance Programme.

[7] http://www.retail.org.nz/
[8] http://www.farmersmarkets.org.nz/
[9] http://www.pickyourown.org/newzealand.htm

An annual report is produced on the organics sector by the University of Otago Centre for the Study of Agriculture, Food and Environment (CSAFE). The 2010 report was provided by the Organics Association of New Zealand (CSAFE, 2010) and provided much of the information for this section.

The land area in certified organic production in 2007 was 63,883 hectares. The 2009 data were largely extrapolated from 2007 figures. There are difficulties due to mixed production but in 2009 there were an estimated 8,175 hectares in organic horticulture and cropping out of a total of 124,464 hectares (most organic production in terms of area is in livestock and pasture).

In 2009 there were an estimated 1,145 licensees, 1,416 licensed operations, and 2,832 certificates for organic production (of any kind) in New Zealand. The higher number of certificates relative to the other two categories is thought to reflect existing organic sector participants bringing new areas into production. No information on the number of specific horticultural licensees was available from the CSAFE report.

Fresh fruit and vegetables remain the largest category of organic exports, and this is made up of 48% apples, 48% kiwifruit, and the rest other fruits (by New Zealand dollar value). Organic vegetable exports are minimal.

Organic horticultural exports in 2009 were worth $85M, and were sent to Europe (37% by value), North America (22%), Australia (19%), Japan (9%), Korea (8%), China (1%), other (4%).

Domestic organic sales were dominated by processed foods, beverages, and dairy, while fresh fruit and vegetables comprised a small proportion of sales (4% by value). However, sales of organic fruits and vegetables appear to be concentrated in organic speciality shops, where they represent 26% of sales value.

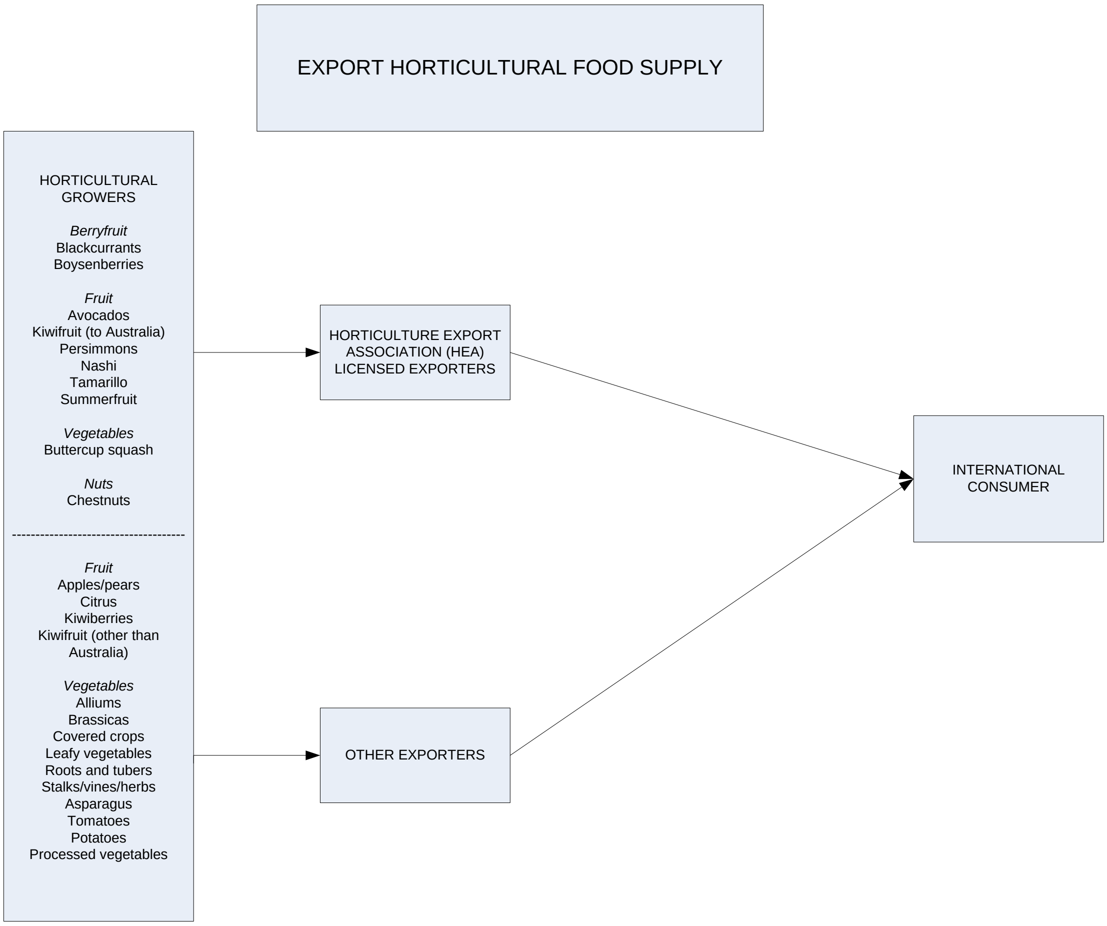
There are three main organics wholesalers in New Zealand: Purefresh, Ceres, and Chantal. Twelve specialist organic retailers have been identified: Huckleberry Farms (3 outlets), Chantal, Ceres, Commonsense Organics, Naturally Organic, Its Healthy, Organic Living Healthfoods, Piko, Seven Fields Organic and Arcadia Organics.

A review in October 2010 of registered organic horticultural producers in databases on websites for AsureQuality and BioGro identified 458 active producers (i.e. excluding those registered but still undergoing conversion). These included: 130 kiwifruit producers, 78 apple producers, 116 other horticultural crops, 24 wine grape producers. However, these data should be treated with caution, as multiple crops were listed per producer.

2.5 Exports

Processed fruit and vegetables are important export commodities, but have not been examined in detail for this project, which concentrates on raw, raw dried, and semidried products consumed in New Zealand. An overview of the horticultural export channel is given in Figure 2. Tables showing the data collated on exports, including amounts, are given in Volume 2 Appendix 2.

Figure 2: Overview of horticultural export channels



According to "Fresh Facts 2010" [10] horticultural exports in 2010 were valued at $3.4 billion. Fresh fruit (mostly apples and kiwifruit) made up the largest component of this, being approximately $1.5 billion. Fresh vegetable exports made up approximately $0.3 billion, with the largest amount being from exports of fresh onions.

2.5.1 Horticulture Export Authority (HEA)[11]:

The New Zealand HEA was established by the New Zealand HEA Act 1987. The primary function of the authority is to promote the effective export marketing of horticultural products. Exported products can be declared a prescribed product, in which case the HEA will administer the Export Market Strategy (EMS) and licensing of that product.

Product groups may also voluntarily decide to join the HEA and develop an EMS. The EMS is developed by the Product Group before being approved by the HEA. HEA's role is in assisting with the formulation of the EMS and approving and enforcing the requirements of the EMS. Enforcement of requirements on growers and packhouses is the responsibility of the Product Group. Enforcement of requirements on exporters is done by HEA via the licence mechanism.

[10] http://www.plantandfood.co.nz/file/freshfacts-brochure-2010.pdf
[11] http://www.hea.co.nz/

Thus the HEA model fits mid-way between the Free Market where anyone can export any grade of fruit or vegetable product to any market, and the single desk where one exporter controls all exports of the particular product category.

2.5.2 Other Export Marketing Organisations

Kiwifruit: Zespri Group Ltd (formerly the New Zealand Kiwifruit Marketing Board) is owned by kiwifruit growers and is responsible for marketing almost all the export kiwifruit from New Zealand (to countries other than Australia). Zespri currently has 3,077 registered orchards to 2,754 growers. Nearly half of the orchards are between 2 and 5 hectares in size.

Apples and pears: The Apple and Pear Marketing Board's selling monopoly was removed in 2001. In 2007 there were over 90 exporters, although 30% of the exporters are responsible for 90% of the export crop. ENZA (the brand name for Turners and Growers Ltd) is the largest wholesale exporter.[12]

[12] http://www.teara.govt.nz/en/apples-and-pears/1

3 HORTICULTURE AND FOOD SAFETY

This section represents a brief summary of information relevant to New Zealand concerning risk from pathogens in horticultural produce. The intention is to inform the project, particularly in terms of information gathering from growers, but is not intended to be an exhaustive review of the international literature. A recent book has covered the field in depth (Fan *et al.*, 2009) and a recent report from the United Kingdom Food Standards Agency has summarised international outbreaks associated with fresh produce (Monaghan *et al.*, 2009). For this section we have collated New Zealand information from published papers, and reports written by ESR and Catalyst.

3.1 Introduction

Recent reviews have highlighted the increasing importance of fruits and vegetables as vehicles for the transmission of microbial pathogens to humans (Berger *et al.*, 2010; Critzer and Doyle, 2010; Lynch *et al.*, 2009). There have been considerable increases in the number of outbreaks and cases associated with raw produce in the USA (Sivapalasingam *et al.*, 2004), although some of these increases will be due to improved laboratory methods for detection (norovirus) and typing (*Salmonella* and *E. coli* O157) (Berger *et al.*, 2010). Produce accounted for 4% of all foodborne outbreaks reported in Australia from 2001-2005 (Kirk *et al.*, 2008; Lynch *et al.*, 2009). A review of 40 food and waterborne outbreaks due to norovirus from around the world between 2000 and 2007 attributed 10% of these outbreaks to contaminated raspberries (Baert *et al.*, 2009).

Produce consumption has also increased, with lettuce production value nearly doubling in the US from 1999 to 2004 (Hanning *et al.*, 2009). The USDA Economic Research Service has predicted increased per capita consumption of almost all fruits and vegetables in the US from 2000 to 2020 due to rising income, education, and changes in the racial mix of the population[13]. The demand for year round consumption may mean longer transportation times from producing regions. Furthermore, increased amounts of produce being processed in the field and horticultural production adjacent to intensive animal production may contribute to the observed increase in attribution of disease outbreaks to produce (Lynch *et al.*, 2009).

Up to 1997, amongst produce associated outbreaks in the United States the predominant pathogen was *Salmonella*, while the food items most frequently implicated were salad, lettuce, juice, melon, sprouts, and berries (Sivapalasingam *et al.*, 2004). A more recent review, specifically of US salmonellosis outbreaks, found that melon (watermelon, cantaloupe), sprouts (mung and alfalfa), tomatoes, mangoes, and lettuce were the most commonly identified produce vehicles in terms of numbers of outbreaks (Hanning *et al.*, 2009). The US Centre for Science in the Public Interest (CSPI) has analysed reported US outbreaks from 1990 to 2005 and attributed 13% of outbreaks and 21% of cases to contaminated produce, with green based salads and lettuce, both contaminated with norovirus, as the most common causes.[14] The CSPI suggested that the change from *Salmonella* to norovirus as the most common pathogen probably reflects improvements in laboratory detection methodology, or increasing prevalence of the pathogen worldwide.

[13] http://www.ers.usda.gov/publications/aib792/aib792-7/aib792-7.pdf accessed 31 August 2011
[14] http://www.cspinet.org/foodsafety/IAFPPoster.pdf accessed 31 August 2011

Sources of contaminants have been identified (Berger *et al.*, 2010; Critzer and Doyle, 2010). These include:

Water

- Runoff from nearby animal pastures.
- Irrigation using a contaminated source.
- Water used in post-harvest processing.

Animal manures or sewage

- Inadequate or no composting.
- Feral animals.

Insects

- Flies.

Source material

- Contaminated seeds.
- Contaminated soil.

Humans

- Infected or ill food harvesters and handlers (particularly for contamination with pathogens with a human reservoir e.g. norovirus, hepatitis A, and *Shigella* (Lynch *et al.*, 2009)).

A number of studies have demonstrated long term (2-4 weeks or more) survival of bacterial pathogens after application to the above ground parts of plants (Berger et al., 2010; Critzer and Doyle, 2010).

Persistence of bacterial pathogens in natural fertilisers added to soil appears to depend partly on initial concentrations, as well as soil type and ambient conditions. High numbers of *E. coli* O157:H7 added to manure compost (7 log_{10} CFU/g) or irrigation water (5 log_{10} CFU/ml) declined in concentration but the organism was still detectable (at <1 log_{10} CFU/g) in soil and on carrots and onions after 3-4 months (Islam et al., 2005). Other experiments have used slurry and solid manure inoculated with lower concentrations of pathogens (2–5 log_{10} CFU/ml or CFU/g *E. coli* O157, *Salmonella*, *Listeria* and *Campylobacter*) (Nicholson *et al.*, 2005). These were described as "worst-case" in terms of pathogen loadings. Pathogens in dairy cattle slurry and dirty water survived for up to three months in storage at <20°C, while *Listeria* survived for up to six months. In experiments with turned and unturned manure compost heaps, where temperatures were often over 55°C, pathogens could not be detected after one week. Following manure spreading to land, the numbers of *E. coli* O157, *Salmonella*, and *Campylobacter* declined rapidly, and were not detectable after one month.

Viruses and protozoa are able to survive and remain infectious on fresh produce, but will not multiply as they require a living animal or human host to do so. Studies on the behaviour of human enteric viruses (e.g. norovirus) on fresh produce are limited since laboratory techniques can currently detect these viruses but cannot determine if the viruses are viable. Seymour and Appleton (2001) summarised a number of studies on the survival of viruses on fruits and vegetables. Collectively, the studies suggest that viruses can survive on fresh produce longer than the product shelf life, particularly when moisture is present on the produce, the produce is stored under cool conditions, or where the produce surface is rough or irregular (Seymour and Appleton, 2001).

3.1.1 Internalisation of microbial pathogens

There is mixed evidence for the internalisation of human pathogens within plant tissues via natural openings or damaged regions (Critzer and Doyle, 2010). Compared to research on internalisation of plant pathogens, studies on human pathogens have a much shorter history. Several studies have demonstrated internalisation of *E. coli* O157 and *Salmonella* into tissues of green leafy vegetables (Ryser *et al.*, 2009). These studies were prompted by outbreaks in the United States associated with leafy greens, particularly lettuce and spinach.

High bacterial concentrations and times have been used in experiments demonstrating internalisation (e.g. apples placed in water containing 7 log_{10} CFU/ml *E. coli* for 20 minutes (Buchanan *et al.*, 1999)). There are data that indicate that *E. coli* populations of at least 6 log_{10} CFU/ml or CFU/g are needed during a contamination event for subsequent internalisation by root systems of leafy greens (reviewed in Ryser et al., 2009).

Further details are given in Appendix 3 Volume 2.

3.1.2 The behaviour of chemical contaminants on fresh produce

Sources of heavy metal chemical contaminants on produce include soil, water, and atmospheric dust. While all plants will, if placed in a nutritionally balanced soil, take up nutrients to the extent needed for growth, there is the potential for bioaccumulation of metals by plants from soils where metal concentrations are higher. This is of particular importance for soils where sewage sludge is applied as fertiliser. Such sludge can contain high levels of metals, particularly if it contains industrial effluent. The degree of accumulation varies according to the metal and the plant involved, and high concentrations of metals may have a detrimental effect on plant growth (Reilly, 1980). Limits on the heavy metal content of sewage sludge are specified in guidelines for the use of these materials. Guidelines for New Zealand are summarised in Volume 4.

3.2 New Zealand reviews and Risk Profiles

Two reviews and two Risk Profiles have covered material relevant to this project. These are briefly summarised below, while further details are provided in Appendix 3 Volume 2.

The most comprehensive review is a discussion document from 2008 intended to provide a preliminary guide to possible risks associated with ready-to-eat (RTE) intact and fresh cut vegetables and fruits, fresh (unpasteurised) juices and sprouts in New Zealand (McIntyre *et al.*, 2008). The review found that *Salmonella* spp. and *E. coli* O157, and to a lesser extent protozoa and viruses, were the pathogens most often reported in the scientific literature as being found on produce. The production practices most commonly reported as problems were contaminated irrigation water and improperly treated manures. The most frequently reported produce types involved in reported incidents were:

- Green leafy vegetables, such as spinach and lettuce;
- Melons, tomatoes and raw berry fruits;

- Unpasteurised fruit juices;
- Sprouted seeds.

A review of risks associated with bacterial pathogens in exported fruits and vegetables (Hudson and Turner, 2002) identified that the highest risk export foods were likely to be lettuces (mainly due to *E. coli* O157), and melons and tomatoes (due to *Salmonella*). However, New Zealand-grown melons were considered to be low risk (outbreaks overseas were primarily associated with poor handling, both in the source country where the fruit was not rinsed and decontaminated, and at the retail end where cross-contamination and temperature abuse of the pre-cut product resulted in outbreaks). New Zealand export tomatoes are grown in hothouses, where growers have more control over the environment and raw materials. There is potential for contamination to be introduced via the irrigation water but the authors did not find evidence of this occurring. Three food-hazard combinations (lettuce and *E. coli*; apples and *Salmonella*; tomatoes and *Salmonella*) were recommended for further investigation based on international data and export values.

A Risk Profile commissioned by the NZFSA (now MAF) was conducted to assess the risks associated with *Listeria monocytogenes* in RTE salads (Lake *et al.*, 2005). It was concluded that RTE salads would be unlikely vehicles for infection in New Zealand, and that good agricultural practices and good manufacturing practices, in conjunction with microbiological testing already being done by the industry, were the best means of managing this risk.

Another Risk Profile concerned Shiga-toxin producing *Escherichia coli* (STEC) in Leafy Vegetables (Gilbert *et al.*, 2006). From overseas information and the fact that *E. coli* O157:H7 had not been detected in New Zealand surveys of domestic vegetables it was concluded that green leafy vegetables were not a likely vehicle foodborne transmission of STEC in New Zealand. However, it was noted that New Zealand data were limited in terms of prevalence and levels of STEC in green leafy vegetables, market size/structure and levels of consumption by the New Zealand population.

3.3 New Zealand surveys of horticultural produce for microbiological hazards

Four surveys of horticultural produce for bacterial pathogens have been conducted in recent years in New Zealand, and are summarised below. Further details are provided in Appendix 3 Volume 2.

A survey of hydroponically grown vegetables in New Zealand examined 291 samples of sprouts, leafy vegetables, and herbs (Graham and Dawson, 2002). *Salmonella*, *Campylobacter*, *E. coli* O157 and *L. monocytogenes* were not found in any samples. All sprout samples were compliant for *B. cereus* (<1000/g), and all but one of the leafy vegetables complied with the coagulase-positive staphylococci criterion (<1000/g). However, *E. coli* was detected in 34 (12%) samples – 15 sprouts (13% of sprout samples), 16 leafy vegetables (14% of samples) and 3 herbs (5% of samples) – suggesting the potential for pathogens to be present in such products.

Based on the recommendations regarding risks from exported produce (Hudson and Turner, 2002), a quantitative study was subsequently initiated to investigate the prevalence of *E. coli* O157:H7 on lettuce and *Salmonella* on apples (Wong, 2003). *E. coli* O157:H7 and salmonellae were not detected in 240 conventionally grown lettuces and 239 conventionally grown apples respectively. *E. coli* O157:H16 was detected in one organic lettuce sample (of

234 tested) but the isolate was later identified as non-verotoxigenic *E. coli* (non-VTEC) due to the absence of *stx*1, *stx*2 and *hly*A virulence genes. One batch of organic apples (from 230) was positive for *S.* Typhimurium DT12a (based on a pooled sample).

A survey of RTE salads (with dressings) from retail outlets in New Zealand was conducted between February 2006 and February 2007 to determine the prevalence of *Listeria monocytogenes* and other *Listeria* species (Wong, 2008). The prevalence of *Listeria* spp. in retail salads containing dressing was 7% (22/302 samples). Of these 22 samples of salads positive for *Listeria* spp., fourteen samples were contaminated with *L. monocytogenes* representing a prevalence of 5%.

A survey of fresh fruits and vegetables for pathogens was conducted during 2008-2009 (McIntyre and Cornelius, 2009). A total of 891 imported conventional (n=226) and domestically grown conventional (n=349) and organic (n=316) fresh fruits and vegetables were purchased from a variety of retail outlets in Auckland and Christchurch over a 15 month period. The produce sampled included melons, tomatoes, strawberries, apples, table grapes, capsicums, carrots, sprouts and leafy greens (lettuce, baby (salad) spinach, kale).

For each sample, concentrations of faecal coliforms and generic *E. coli,* and the prevalence of shiga-toxin producing *E. coli* (STEC) O157, *Salmonella* spp. and *Campylobacter* spp. were determined. *Campylobacter* spp. and *E. coli* O157 were not detected in any sample. However, *Salmonella* Typhimurium phage type RDNC-May06 was detected in two domestic organic lettuces from the same grower, both of which were deemed satisfactory/marginal in terms of limits for faecal coliforms and *E. coli*. A site visit identified bird faeces on hail netting located directly above growing produce, which was particularly concentrated in areas where birds were able to land on metal hoops holding the netting up. It is likely that contamination occurred either through direct defecation onto plants below or indirectly via overhead irrigation and/or precipitation.

In terms of microbiological quality, 95.4% and 96.6% of produce items sampled were satisfactory, based on microbiological limits for faecal coliforms (Ministry of Health) or *E. coli* (Food Standards Australia New Zealand (FSANZ)) respectively. All imported samples (apples, capsicums, grapes, melons and strawberries) were of a satisfactory nature, while at least 54% of marginal and unsatisfactory samples were attributed to domestic conventional and organically grown leafy greens.

No surveys of New Zealand horticultural produce for protozoan hazards have been located. However, the potential for contamination of salad products with *Cryptosporidium* oocysts and *Giardia* cysts from contaminated irrigation water has been demonstrated by a survey in Spain and several other countries (Amoros *et al.*, 2010).

3.4 New Zealand surveys of horticultural produce for chemical hazards

The only source of data on the relevant chemical hazards in horticultural produce in New Zealand that has been located is the New Zealand Total Diet Study (NZTDS). This is a regular survey of agricultural compound residues, contaminants and nutrients in New Zealand foods so that dietary exposure to these chemicals can be estimated. Horticultural produce is sampled as part of this survey, but it is important to note that these foods are a mixture of imported and domestically-grown produce.

The foods are analysed as they would normally be consumed, e.g. apples are rinsed and cored but tested with the skin on, potatoes are cooked, and only the edible flesh of oranges is tested.

Arsenic, cadmium, lead and mercury were detected in horticultural produce during 2009. Eight samples of each product were tested. Arsenic was detected in a number of horticultural product types, but not in all samples and (where present) at low levels (maximum 0.04 mg/kg). The exception was mushrooms where all eight samples were positive, at up to 0.4 mg/kg. Cadmium was detected in most produce samples, but the maximum level detected in any sample (potato with skin) was 0.08 mg/kg. Lead was detected in some samples from most product types, at up to 0.1 mg/kg (prunes). Mercury was only detected in one sample (of eight) of silverbeet (0.003 mg/kg).

Dietary intake analyses from the 2009 NZTDS found that intakes of arsenic and lead from all foods were "as low as reasonably achievable" (ALARA) and unlikely to represent a significant risk to public health, while intakes of cadmium were less than half the provisional tolerable monthly intake from all age groups and intakes of mercury and methyl mercury less than half the provisional tolerable weekly intake (MAF, 2011).

A study of microbiological and heavy metal contamination of watercress growing in streams in the Wellington Region in 2001 measured the concentrations of several heavy metals (arsenic, chromium, lead, cadmium, nickel, copper, zinc and mercury)[15]. In this study all heavy metal concentrations (except for one zinc result) were well below New Zealand Food Regulation limits (as specified in First Table to Regulation 257, Consolidated Food Regulations, Ministry of Health 1984).

Elevated levels of arsenic have been identified in sections of the Waikato river in large part derived from geothermal water discharged by the Wairakei Power Station (see Section 5.3) (Cook and Weinstein, 2005). A study of watercress growing in a section of the Waikato River found elevated levels of arsenic in excess of WHO standards. However, the accumulation of arsenic from river water by watercress has not been found in terrestrial plants in the Taupo volcanic region, and so the arsenic in water and soil is unlikely to be present at levels of concern in horticultural produce (Robinson *et al.*, 1994; Robinson *et al.*, 2005). The lack of accumulation in terrestrial plants was demonstrated in experiments growing ferns in soil spiked with arsenic (Robinson *et al.*, 2006). Although ferns are not commonly used as horticultural produce, these experiments support the conclusion that accumulation of arsenic from soil or irrigation water by horticultural produce is unlikely to present human health risks.

No surveys of the concentrations of environmental contaminants (e.g. polycyclic aromatic hydrocarbons (PAHs)) in New Zealand horticultural produce were located. As these contaminants are usually highest in the lipid fraction of foods, fruits and vegetables are unlikely to contain significant amounts, as they have a low fat content relative to animal products.

[15] http://www.foodsafety.govt.nz/elibrary/industry/Microbiological_Heavy-Science_Research.pdf

3.5 The presence of hazards in horticulture products: Data from other countries

Earlier data (published up to 2002) on the prevalence and concentration of bacterial pathogens in produce surveyed in other countries has been summarised by Hudson and Turner (2002). There were comparatively few studies of fruits, with pathogens most likely to be detected on strawberries and melons. Pathogenic bacteria were not detected in most of the surveys of vegetables, apart from surveys of leafy vegetables (cabbages, celery, lettuce). Where pathogenic bacteria were detected, the prevalence was <10% but bacterial counts were not available to assess the risk these positive samples posed to human health if consumed.

An exception to this generalisation was *Aeromonas* spp., which were detected in almost all of the studies where this organism was tested for, commonly at >30% of samples. Only a few studies analysed the concentration of *Aeromonas* spp. in positive samples, and found concentrations of 10^3-10^5 CFU/g. However, the role of *Aeromonas* in foodborne or waterborne gastroenteritis is still unclear.

McIntyre & Cornelius (2009) summarised ten overseas surveys of *E. coli* O157, *Campylobacter* spp. and *Salmonella* spp. in fresh produce, published between 2001 and 2008. *E. coli* O157 and *Campylobacter* spp. were not detected in any of these studies. *Salmonella* spp. were detected in the produce sampled by seven of these surveys. The *Salmonella*-positive produce included lettuce, tomato, spinach, apple, salad, capsicum and cantaloupe melon.

3.6 New Zealand human health surveillance data

3.6.1 <u>New Zealand outbreaks</u>

New Zealand public health units report outbreaks of notifiable diseases to the national notifiable disease surveillance system, EpiSurv. ESR manages EpiSurv on behalf of the Ministry of Health and reports these outbreak data annually.[16]

Table 5 provides an overview of the outbreaks reported to EpiSurv from 2005 to 2009. These recent data show that most of New Zealand's reported outbreaks are caused by enteric pathogens, but the number of outbreaks each year where foodborne transmission was one of the reported modes of transmission is variable.

[16] The annual outbreak (and other surveillance) reports are available from http://www.surv.esr.cri.nz/index.php

Table 5: Overview of outbreaks in New Zealand (2005-2009)

Year	No. outbreaks (No. cases)	No. enteric outbreaks (No. cases)[1]	% foodborne transmission (No. outbreaks)[2]	Reference
2005	346 (2,436)	338 (2,343)	52.9	(ESR, 2006)
2006	495 (6,302)	481 (6,162)	29.5	(ESR, 2007)
2007	492 (7,988)	477 (7,821)	15.0	(ESR, 2008)
2008	449 (6,503)	428 (6,295)	19.8	(ESR, 2009)
2009	638 (10,734)	586 (10,176)	13.2	(ESR, 2010)

1. Outbreaks caused by agents that cause enteric disease (e.g. *Salmonella* spp., Hepatitis A virus, histamine fish poisoning). The values include outbreaks where no pathogen was identified, which are classified as gastroenteritis.
2. The percentage of the total number of outbreaks for that year where foodborne transmission was identified as a mode of transmission. Outbreak investigators can identify one or more modes of transmission in addition to foodborne transmission (e.g. person-to-person, waterborne).

The method of summarising the implicated foods has varied each year, but the outbreaks that listed horticultural produce were:

- 2005: Vegetables (2 outbreaks, 26 cases)
- 2006: Fruit and vegetables (4 outbreaks, 29 cases)
- 2007: Fresh produce (12 outbreaks, 241 cases)
- 2008: Fresh produce (6 outbreaks, 88 cases)
- 2009: Root vegetables (13 outbreaks, 67 cases), leafy vegetables (5 outbreaks, 48 cases), fruits/nuts (4 outbreaks, 24 cases), vine/stalk vegetables (3 outbreaks, 41 cases).

Horticultural products may also be incorporated into mixed dishes (e.g. kebabs, sandwiches) and not specifically recorded.

All outbreaks recorded as foodborne in the outbreak module of EpiSurv from 1 January 2000 to 16 March 2011 were extracted. The records were examined for outbreaks that implicated any of the produce considered in this study, whether raw or cooked. There were no outbreaks that specifically implicated seeds, spices or grasses. There were 160 outbreaks where specific fruits, herbs, nuts or vegetables were named among the implicated foods, or where an implicated food had fruits or vegetables as the main ingredient (e.g. coleslaw, salad, falafel, chips). The produce component was (or was more than likely to be) consumed raw in 57/160 of these outbreaks.

"Salad" was an implicated food in 38/57 of the raw produce outbreaks (one was "fruit salad"), but the salad ingredients were not specified. In 33 of the "salad" outbreaks there were also other implicated foods, or the description indicated that the salad contained other ingredients that may have caused illness (e.g. "chicken salad"). Of these 33 outbreaks, one was linked to a foodhandler who had been sick with norovirus infection prior to preparing the food and another (campylobacteriosis) was linked to a contaminated water supply at the premises. In the remaining five "salad" outbreaks, where the salad was the only implicated food, the cause of the outbreak was not confirmed. In one of these outbreaks (giardiasis), the implicated food was "salad vegetables from home garden, fertilised with animal manure".

However, the reporting of a suspected food as a vehicle in an outbreak is not often supported by laboratory evidence. There were only three outbreaks where a single fruit or vegetable was identified as an outbreak vehicle through laboratory evidence and/or an epidemiological study:

- In 2002, contaminated blueberries caused an outbreak of Hepatitis A infection (Calder *et al.*, 2003). In a case-control study involving 39 of 43 identified cases, consumption of raw blueberries was the only risk factor statistically associated with infection. Fourteen of the cases had purchased the blueberries from the same orchard and Hepatitis A virus was detected in 3/6 samples of stored frozen blueberries from the coolstore. A site investigation identified a number of likely causes including picking and packing with bare hands, pit toilets without adequate hand washing facilities (no running water, soap or hand towels), no system for rubbish removal (including disposable nappies left by the pickers). Additionally, one of the pit toilets was in the middle of the blueberry plants and may have overflowed into the harvest area. The orchard was not irrigated by bore or stream water, and manures were not used for fertiliser.

- Using a case control study, consumption of raw carrots was identified as the only statistically significant risk factor for a 2005 salmonellosis outbreak involving 19 identified cases of *S.* Saintpaul infection (Neuwelt *et al.*, 2006; Neuwelt *et al.*, 2009). However, after controlling for age and matching telephone number between cases and controls, the adjusted odds ratio for raw carrot consumption was elevated but not significant. A traceback investigation led to three packhouses and four carrot growers in the Ohakune region. None of the farms used organic fertilisers, but three used stream water to wash the carrots after harvesting. Coliforms and *E. coli* were detected in water samples from these three farms, but *Salmonella* was not detected in water or soil samples. Large outdoor tumblers were identified as a possible source of contamination but these were not tested.

- In January 2009 an increase in reported infections with *Salmonella* Typhimurium PT1 in the Gisborne region led to a case-control study to determine the cause (McCallum *et al.*, 2010). Nineteen cases were identified and 14 participated in the study. Cases were statistically more likely to have eaten watermelon than controls and a traceback investigation identified watermelon purchased from roadside stalls supplied by a particular grower as the likely source. *Salmonella* was not isolated from watermelon samples, but investigators noted that watermelons at the stalls were kept in the sun and were very warm, the packhouse was contaminated with wildlife faeces and the watermelon patch was located near a septic tank.

A norovirus outbreak in 2004, involving 12 cases attending a conference, was attributed to grapes consumed in a fruit salad (Hill, 2004). This finding was based on questionnaires sent to 22 conference attendees. There was no further evidence to support this finding.

3.6.1.1 Chemical contamination events

Incidents of lead poisoning are reported to EpiSurv. From 1 January 2000 to 16 March 2011 there were 12 outbreaks of lead poisoning. All of the incidents with a reported cause were caused by exposure to lead-based paint. None were linked to food contaminated with lead. No other reports of illness linked to foods contaminated with heavy metals or environmental contaminants were found.

3.6.2 Food Recalls Associated with Fresh Vegetables and Fruits in New Zealand and Australia

Food recalls can be issued for a variety of reasons such as incorrect labelling, or the detection of contaminants or foreign particles (e.g. glass, metal fragments) through routine testing. A food recall does not necessarily mean that all of the recalled products are contaminated or that people have become sick from the contamination; some recalls are precautionary. A recall may be made at the consumer level (i.e. including products that have been sold to consumers), or at the trade level (i.e. including only unsold products to the retail level).

According to NZFSA/MAF records, between January 2001 and April 2011 there were four food recalls issued in New Zealand for potential contamination of a horticultural product with a chemical or microbiological agent, and all of these were issued due to the possibility that the product was contaminated with *Listeria* (Caroline Trewhitt, MAF, pers. comm, April 2011):

- May 2004, coleslaw.
- December 2005, salads.
- June 2009, baby peppers filled with feta.
- January 2011, spinach and salads (bagged and loose).

The January 2011 recall of spinach and salads was prompted by the discovery of *L. monocytogenes* contamination during routine testing (Lowry, 2011). The contamination appeared to have been caused by unusually severe weather in the 48 hours before harvest causing high soil loadings on the produce from rain splash.

In addition, in January 2010, retorted sweet corn in brine produced in New Zealand was stopped at the border of an importing country due to positive Clostridia species testing, and in May 2011 kiwifruit were recalled due to potential contamination by an orchard worker infected with *Salmonella* Typhi.

No recalls listed on the Consumer website for the period January 2003 – September 2010 have been produce-related.[17] A delicatessen salad recall was initiated in March 2004, but all salads (two of which were potato-based) contained ham identified as the source of *L. monocytogenes*.

A list of Australian recalls provided by FSANZ for 1 January 2000–8 October 2010 was reviewed, along with more recent recall information on the FSANZ website.[18] There were seven relevant recalls of fresh produce for microbial contamination during this period:

- Organic alfalfa spouts and organic salad for *Salmonella* contamination, 2003;
- Gourmet lettuce for *Listeria monocytogenes* contamination, 2003;
- Alfalfa sprouts from *Listeria monocytogenes* contamination, 2003;
- Alfalfa sprouts for *Salmonella* Oranienberg contamination, 2006;
- A range of sprout types (mainly alfalfa, onion and salad sprouts as well as bean shoots and mung beans) for *Salmonella* and *Listeria* contamination, 2006;
- Green sprouts for *E. coli* contamination, 2007; and

[17] www.consumer.org.nz
[18] http://www.foodstandards.gov.au/consumerinformation/foodrecalls/archiveconsumerlevelrecalls/

- Pistachios for *Salmonella* contamination, 2009.

No recalls of fresh produce for chemical contamination were listed.

3.7 Outbreaks in other countries

There have been many outbreaks of gastroenteritis in other countries where the vehicle of infection was raw or ready-to-eat fruit or vegetables (see Monaghan *et al*. (2009), Heaton and Jones (2008), Table 8.1 in Jiang and Shepherd, (2009)). However, the exact source of contamination is often not conclusively identified, due to the complexity of production and processing.

Table 10 in Volume 2 Section 3.5 lists outbreaks caused by a wide variety of fruit or vegetables where contaminated irrigation water, post-harvest water or natural fertilisers were confirmed or suspected based on environmental investigations. These outbreaks demonstrate that fresh produce can become contaminated at grower level by pathogenic bacteria or protozoa at concentrations that can cause illness.

This table excludes outbreaks where water or natural fertilisers were a suspected cause but the researchers did not carry out an environmental investigation. For example, during 2005 Danish authorities recorded six point source outbreaks of norovirus infection linked to frozen raspberries imported from Poland that involved over 1,000 cases (Falkenhorst *et al.*, 2005). Faecally-contaminated irrigation water was one suspected cause of contamination, but no grower-level environmental investigations were conducted. Outbreaks where the only suspected cause was direct contamination of the produce by animal faeces have also been excluded from this table, e.g. a 2003 outbreak in Finland, involving 111 cases, was possibly caused by wildlife faeces contaminating carrots during storage and cross-contamination from washing and peeling equipment (Jalava *et al.*, 2006).

Raw sprouts (e.g. alfalfa, mung bean, radish) have caused many outbreaks in addition to those listed in Volume 2, and are a particularly important vehicle for infection. Monaghan *et al*. (2009) lists 27 reported outbreaks caused by contaminated sprouts between 1973 and 2006: 22 were outbreaks of salmonellosis, one was *B. cereus* infection and the remaining four were *E. coli* O157:H7 infection. More recently, a further five outbreaks caused by contaminated sprouts between 2007 and 2010 have been reported. All of these outbreaks involved salmonellosis:

- 2007, Sweden, *S.* Stanley, 51 cases, alfalfa sprouts (Werner *et al.*, 2007).
- 2007, Norway, Denmark and Finland, *S.* Weltevreden, 45 cases, alfalfa sprouts (Emberland *et al.*, 2007).
- 2008, USA, *S.* Typhimurium, 13 cases, alfalfa sprouts (Hanning *et al.*, 2009).
- 2009, USA, *S.* Saintpaul, 228 cases, alfalfa sprouts (Safranek *et al.*, 2009).
- 2010, UK, *S.* Bareilly, 231 cases, bean sprouts (Cleary *et al.*, 2010).

More recently, an outbreak of infection with *E. coli* O104 in Europe affected nearly 1,000 people with nearly 50 fatalities in early 2011. The outbreak was traced to contaminated fenugreek seeds consumed as sprouts.

The likely source of infection for most of these outbreaks was contaminated seed that was inadequately disinfected prior to sprouting (seed disinfection is a critical control point during sprout production). One report noted that contaminated alfalfa sprouts were produced from seeds harvested from a grower who fertilised the alfalfa plants with uncomposted chicken manure and irrigated with non-potable canal water, and that inspectors had observed wildlife faeces and runoff from livestock in the alfalfa fields (Mohle-Boetani *et al.*, 2001). The sprout grower did not disinfect the seeds and grew the sprouts in soil (most use hydroponic techniques). The sprouts produced from these seeds caused two outbreaks in the USA in 1996, one of *S.* Montevideo infection (an estimated 417 cases) and one of *S.* Meleagridis infection (an estimated 75 cases).

3.7.1.1 Chemical contamination events

No overseas reports of chemical poisoning from horticultural produce contaminated with the heavy metals or the environmental contaminants considered in this report have been located.

3.8 Discussion

The prevalence of pathogens found in surveys of New Zealand produce is very low, which is consistent with surveys in other developed countries which did not find *E. coli* O157 or *Campylobacter* but occasionally found *Salmonella* (see Table 8 in McIntyre and Cornelius, 2009).

A proportion (up to 5%) of produce samples in the largest survey of New Zealand produce were of unsatisfactory microbiological quality based on faecal coliform or *E. coli* criteria. Leafy greens samples represented approximately half of these unsatisfactory samples, and these would be eaten often without cooking. This type of produce, which may be grown close to the ground, will be more susceptible to soil contamination exacerbated by weather effects (as illustrated by the 2011 spinach recall).

Only one outbreak of illness (Hepatitis A in blueberries) has been conclusively linked to contamination of a produce food in New Zealand through epidemiological and microbiological analysis, and that contamination appears to have come from human sources rather than manure or irrigation water.

The outbreaks that have been identified overseas appear to result from sporadic contamination events which would be difficult to detect by surveys of horticultural produce. The low prevalence of pathogens found in local surveys to date is reassuring, although the unsatisfactory microbiological quality of some produce suggests that there is potential for pathogens to be present occasionally. New Zealand is fortunate that large scale outbreaks of illness associated with horticultural produce have not yet occurred here, although identification of outbreak vehicles is always a challenge and not all outbreaks are investigated using epidemiological methods. It is possible that the smaller scale of New Zealand production and distribution channels limit the potential for widespread outbreaks.

3.9 Options for Risk Management

A recent review concluded that as there is no certainty that any contamination can be washed off fresh produce, prevention of contamination is a critical control point for produce that will not be cooked before eating (Lynch *et al.*, 2009). This review proposed that improving the prevention of fresh-produce-associated outbreaks requires attention in the five following areas (paraphrased by the current authors):

1. The quality of the water: Water used for applying agrichemicals, for irrigation (where it comes into contact with the edible portions of the plant) and for post-harvest cooling and processing can transfer microbes directly to the produce, unless it is treated to drinking water standards.
2. Protection from faecal contamination: Fresh produce can become contaminated in the field directly or indirectly from animal or human faeces.
3. Washing and sanitising of fresh produce: There are washing and sanitising agents available to reduce surface contamination, although better methods are needed.
4. Management of cold storage and supply chain: Keeping produce cool reduces the opportunity for bacteria to grow (but also reduces the rate of inactivation and can aid persistence).
5. Protecting produce from contamination by food handlers: Preventing ill or infected food handlers from preparing produce.

4 HORTICULTURAL INPUTS AND CONTROLS

The natural fertilisers included in this study were those produced from animal, plant and human waste products (e.g. biosolids, manure, farm effluent, compost, blood and bone meal).

Animal wastes are an important source of nutrients for crop production but may contain a variety of human pathogens (Jiang and Shepherd, 2009). Land spreading of animal manure may introduce enteric pathogens into the food chain directly, or into irrigation water through runoff. Animals may also be allowed to graze land used for horticultural production. Microbiological pathogens can survive in soil for several months following manure application. Composting is often used to treat various types of animal waste, where inactivation is largely due to self heating by microorganism growth.

Horticultural produce can become contaminated at any point along the food chain: growth, harvest, primary processing, packing, transportation, retail display and in the kitchen. The likelihood of contamination is highest when the produce is in the field, during initial processing (e.g. washing and packing) and during preparation in the kitchen (Lynch *et al.*, 2009). In the field, enteric pathogens may contaminate produce by splashing onto the leaves during heavy rain or spray irrigation, internalisation from roots and other openings in plants, biofilm creation on above ground plant parts, and adhesion to roots via soil particles (Jiang and Shepherd, 2009). Studies in the United Kingdom found that delaying the mechanical incorporation of manure into soil (i.e. leaving the manure on the surface for a week) accelerated the decay of pathogen numbers (Hutchison *et al.*, 2004).

The prevalence of microbiological pathogens in the faeces of New Zealand livestock and poultry varies according to the pathogen. The prevalence of *Campylobacter*, *Giardia*, and *Cryptosporidium* in Canterbury lamb faeces is high (80%, 37%, and 29% respectively) while the prevalence of Salmonella and STEC are lower (2-4%) (Moriarty et al., 2011). The prevalence of these pathogens in sheep faeces found in this study was lower (e.g. *Campylobacter* 30%, *Cryptosporidium* 4%). A similar pattern was found for bovine dairy faeces from several farms around New Zealand (Moriarty et al., 2008). *Campylobacter* prevalence was high (approximately 64%), while no *Salmonella* were detected, and STEC found in 1% of samples. The prevalence of *Giardia* and *Cryptosporidium* were 5% each. The natural counts of *C. jejuni* in individual dairy cow pats have been found to be highly variable, ranging from <1 to 1.8 x 10^7 CFU per g (Sinton et al., 2007).

Campylobacter prevalence in faeces taken directly from New Zealand chickens is high (60-80% based on caecal testing at processing[19]) although the prevalence of *Salmonella* in faeces appears to be lower based on the results of chicken carcass testing, which show a prevalence of <1%. The numbers of *Campylobacter* in poultry caecal contents have been found to vary between 1.7 to 8.6 $\log_{10}$ CFU per g (Hansson *et al.*, 2010). However, studies of the presence of pathogens in chicken litter conducted in Australia suggest that there is a rapid decline in numbers after deposition (Chinivasagam *et al.*, 2010). Litter samples were collected at the end of the production cycle from spread litter in a single shed from each of 28 farms. The geometric mean for *Salmonella* was 44 Most Probable Number (MPN) per g for the 20 positive samples. The geometric mean for *Campylobacter* was 30 MPN per g for the 10 positive samples, with 7 of these samples being <100 MPN per g. The low prevalence and

[19] http://www.foodsafety.govt.nz/elibrary/industry/caecal-testing-discussion-document/caecal-testing-review-and-options-assessment.pdf accessed 1 September 2011

incidence of *Campylobacter* were possibly due to the rapid die-off of this organism with drying. *Listeria monocytogenes* was absent in all samples and this organism appeared not to be an issue in litter.

A New Zealand study of bacterial survival in bovine faeces on pasture found that the numbers of *E. coli*, enterococci, faecal streptococci and *Salmonella* may increase in some seasons in the first 1-3 weeks, while numbers of *Campylobacter* did not increase. Thereafter, the counts declined, with the time for 90% inactivation ranging from 6.2 days (*Campylobacter*) to 56 days (enterococci) (Sinton *et al.*, 2007).

Overall, it should be assumed that animal faeces used in natural fertilisers contain pathogens.

4.1 Production of natural fertilisers

Natural or biological fertilisers include mulches, composts, vermicasts and biosolids. Mulch is coarsely broken plant waste that is usually applied to soils to retain moisture and suppress weeds. Mulches may be composted before application.

Compost is the product of a managed aerobic process involving the biological decomposition of plant and animal materials to form a stable product suitable for soil improvement (NZS 8410). The materials used to produce compost range from manures and animal by-products to greenwaste and domestic kitchen waste, so compost production systems vary. Bulking material such as straw or woodchip is usually added prior to composting. The bulking materials increase porosity so that oxygen can circulate, soak up moisture and add carbon, and are particularly important for composting animal wastes.

Vermicast is a solid organic product produced by worms that have processed organic materials such as plant and food waste (these wastes might be composted first). The process, called vermiculture, produces a substrate that is greatly enriched in nitrogen, phosphorus, potassium and microbial enzyme activity beneficial to plant productivity, relative to the surrounding matrix.

Biosolids are defined by the New Zealand Water and Wastes Association (NZWWA) as sewage sludges, or sewage sludges mixed with other materials, that have been treated and/or stabilised to the extent that they are able to be safely and beneficially applied to land (NZWWA, 2003). Biosolids do not include untreated raw sewage sludges or sludges solely from industrial processes (although they may include material delivered from industrial inputs to sewers that are diluted by organic material in domestic sewage inputs), animal manures, or food processing and abattoir wastes.

Sewage sludge is the organic solid material removed from wastewater during the treatment process. It contains pathogens, organic material, nutrients, metals and other chemicals from residential (human waste) and commercial properties, and tradewaste discharges (NZWWA, 2003).

Greywater is household wastewater excluding sewage, i.e. water from bathrooms and laundries. Interest in greywater recycling for domestic gardens appears to be growing in New

Zealand.[20] However, at the time of this report there were no national guidelines for the use of greywater in New Zealand.

Further details on these products are given in Appendix 4 Volume 2.

4.2 The behaviour of pathogens in natural fertiliser during composting

During composting, microbes aerobically and anaerobically digest organic materials and generate heat from this process. From a food safety perspective, the high temperatures reached during the thermophilic stage of composting (50-70 °C) are important for inactivating human pathogens, but ammonia gas production, desiccation, and microbial antagonism also contribute to pathogen reduction (Jiang and Shepherd, 2009). The initial hot composting may be followed by a period of maturation, where temperatures remain steady below 45°C. However, there are relatively few studies regarding the fate of human pathogens during the composting process. Additionally, it is difficult to decide which composting conditions are optimal for killing human pathogens because of the diversity of raw materials and methods.

Recent studies on bacterial pathogen survival during the composting of animal manure have been summarised (Table 8.2, Jiang and Shepherd, 2009). These studies indicate that the period of pathogen survival in compost is highly variable, and subject to a number of factors, including internal temperature, type of animal manure, carbon:nitrogen (C:N) ratio, pH, moisture, size of heaps, ambient temperature, frequency of turning and initial numbers of pathogens.

A common finding of these studies is that bacterial pathogens are better able to survive in the surface of compost heaps where temperatures are cooler. Turning compost piles is critical for maximising pathogen inactivation throughout the entire compost heap.

The rate at which a compost heap reaches thermophilic temperatures is also important. A slow increase in temperature can be caused by any number of factors such as a cool season, a small compost pile, or a too low or too high C:N ratio in the outside layers of a unturned pile (Jiang and Shepherd, 2009). Slow heating provides a lengthened period of warm temperatures that could allow pathogens to multiply before inactivation temperatures are reached, and some studies have suggested that these conditions can also increase pathogen heat resistance (or at least select for strains of bacteria better able to survive the thermophilic phase).

The survival and persistence of bacterial pathogens in manures, composts and the soils to which they are applied may also be enhanced by stresses encountered by the bacteria during passage through an animal gut (e.g. acid stress, osmotic stress), and by seasonal changes in the bacterial loading of manures (e.g. higher shedding in spring) (Heaton and Jones, 2008).

A recent review of the transmission of enteric viruses to fresh produce from the application of manure, biosolids or irrigation water before harvest reported that there was limited information available on the occurrence and removal of human enteric viruses during treatment processes for biosolids and manures (Wei and Kniel, 2010). Virus inactivation can be achieved by alkaline (lime) stabilisation (approx. 3 log reduction), composting and air

[20] http://www.watersmart.co.nz/download.pdf?id=4dbfc063225b049542389229

drying (1-3 log reduction), or mesophilic anaerobic digestion or aerobic digestion (1 log inactivation).

Temperature and moisture are primary factors affecting the survival of viruses in soil, and viruses tend to survive longer when associated with solid particles such as biosolids. Little information is available on the survival of human enteric viruses in animal manure and biosolids before and after land application. Hepatitis A virus has been reported to be very stable in human waste.

Further information is given in Appendix 4 Volume 2.

4.3 Production of natural fertilisers in New Zealand

There are possibly hundreds of publicly and privately owned enterprises in New Zealand that produce a variety of natural fertilisers for sale to the public. The 2002 Waste Minimisation Strategy (MfE, 2002) challenged local authorities to divert organic wastes from landfills and this has stimulated large greenwaste recycling facilities operated by councils or private contractors. There are also many private companies that operate composting or vermiculture systems that utilise waste products such as fish waste or manures, or natural resources such as seaweed. There is no central source of information for the types and volumes of fertilisers produced, or the production systems used.

A 2008 survey of organic waste processing facilities by Sinclair Knight Merz (SKM) for the Ministry for the Environment identified 71 such facilities in New Zealand (SKM, 2008). Most of these were open windrow systems and a small number were in-vessel systems. The majority of material processed was green waste, but some facilities also processed putrescible waste (food waste, fish by-products), biosolids, pig manure, chicken manure, bark, sawdust, and paunch grass. Almost 340,000 tonnes of material were processed annually by the 39 facilities that provided data. Outputs included mulches, composts and vermicasts, but data on the output volume was not requested in the survey.

The New Plymouth District Council (NPDC) operates the only wastewater treatment plant that produces a commercially-available fertiliser in New Zealand. Wastewater microorganisms are separated from clean effluent water and processed into pellets by a high-temperature rotary thermal drier. The pellets are sold under the trademark Bioboost®, and 1,412 tonnes were produced during the year ending 30 June 2009 (NPDC, 2009).

Discussions with scientists from Plant and Food Research indicated that some dairy and pig farmers use wash off or slurries to fertilise maize crops on their farms. These crops are then used for animal feed (silage), and not for human consumption. Natural fertiliser use on cereal (arable) crops for human consumption was considered very unlikely.

ZooDoo is a company producing natural fertilisers from animals in zoos in Auckland and Wellington[21]. According to the website the material is composted, and targeted at home gardeners.

[21] http://www.zoodoo.co.nz/products.php

4.4 Controls for natural fertilisers

Management of the risk of contamination from direct application of manure or sewage as fertiliser can be achieved through either a treatment step before application, or leaving a time interval (withholding period) between application and crop production (Warriner *et al.*, 2009).

The New Zealand Standard for composts, soil conditioners and mulches (NZS 4454, 2005) uses *E. coli* as an indicator for the microbiological quality of compost, but acknowledges a lack of information on how this organism relates to the removal of specific pathogens, such as *Campylobacter*, *Giardia*, *Cryptosporidium* and *Legionella* in the composting process. The Standard identifies a pasteurisation temperature of 55°C or above for a period of time that depends on the composting method and the materials being composted, but usually for a minimum of three consecutive days. More detail on this standard is provided in Volume 4 Section 3.2.2.

Regulatory authorities in the US have provided pathogen specific guidelines for treatments, and specific withholding periods, as described in Appendix 4 Volume 2. The recommendations by the US National Organics Standard Board for compost treatment are the same time and temperature as NZS445.

The D values at 55°C for several of the important bacterial pathogens included in this project (*Campylobacter*, *Salmonella*, *Listeria*, STEC) are under one hour, so the 3 day treatment time recommended for composting should be sufficient to eliminate any of these pathogens present. However, many factors can affect the rate of elimination of pathogens during composting (see Section 4.2) so setting process parameters is difficult. Instead, validation of processes by individual growers or fertiliser producers appears more practical.

5 WATER FOR HORTICULTURAL USE

The water included in this study may be potable or non-potable. This study focuses on the use of water for irrigation and delivery of nutrients and foliar sprays (including hydroponics and organic teas) to growing crops, and water used during and after harvesting for washing, sanitising or cooling.

Microbes that are pathogenic to humans usually enter waterways through faecal contamination caused by agricultural runoff, sewage outlets, overflowing septic tanks, storm water flows, bilge pumping, etc. Some pathogens are particularly well adapted to surviving in an aquatic environment (e.g. *Giardia* spp.), while others would be expected to decline with time, due to the effect of ultraviolet in sunlight. Rivers, lakes, irrigation ponds and other surface waters are more likely to be contaminated with pathogenic microorganisms than ground water sources such as bores and wells which are at least partially protected from direct contamination sources. However, the microbiological purity of water extracted from beneath the ground depends on such factors as bore depth, water table flows and subsurface substrates.

The method of applying irrigation water can also affect the probability of contamination of produce. Irrigation modes include gravity (flood) irrigation, spray irrigation, drip/trickle irrigation, and sub-irrigation. Flood and spray irrigation represent the greatest risk as any contamination within the water may be directly deposited onto the plant itself (Warriner *et al.*, 2009).

5.1 Water as a source of contamination of horticultural produce

Evidence that contaminated water can be a source of pathogens in fruit and vegetables derives from:

- Outbreaks associated with contaminated irrigation water (e.g. *E. coli* O157:H7 in lettuce (Ackers *et al.*, 1998; Ingram *et al.*, 2011));
- Outbreaks associated with contaminated water used for post-harvest processing (e.g. *Shigella sonnei* in parsley (Crowe et al., 1999))
- Outbreaks associated with contaminated water used to apply agricultural sprays (e.g. *C. cayetanensis* in lettuce and raspberries (Herwaldt, 2000);
- Experimental studies examining contamination of produce; and,
- Increased incidence of disease in areas practicing wastewater irrigation with little or no wastewater treatment (Steele and Odumeru, 2004).

Further information on outbreaks overseas is provided in Volume 2 Section 3.5.

Spray irrigation of lettuce plants with water inoculated with *E. coli* K-12 has shown that the organism could be detected on plants up to 7 days after irrigation, although the concentration of bacteria in the water was high (8-9 log_{10} CFU/ml) (Fonseca *et al.*, 2011). Similar studies using *E. coli* O157:H7 in water at 2 or 4 log_{10} CFU/ml found that contamination persisted for up to 10 days from a single irrigation exposure. There were also some results that suggested that the bacterium grew on the plants (Solomon *et al.*, 2003). *E. coli* O157:H7, *Campylobacter*, and *Salmonella* were inoculated into irrigation water at 3 or 5 log_{10} CFU/ml and applied using overhead spray to lettuce and spinach plants (Hutchison *et al.*, 2008). At the lower concentration, pathogens from the irrigated water were not detected on plants after one week. At the higher concentration, some plants were positive after two weeks, but after three weeks the numbers of pathogens had fallen below the detection limit (1 $\log_{10}$ CFU/g).

A review of foodborne pathogens in irrigation water lists studies showing survival of *E. coli* O157:H7 on lettuce stored at 4°C for up to 15 days, and on the surface of fresh and frozen strawberries for at least one month. Rotaviruses inoculated onto the surface of harvested vegetables maintained viability for up to 30 days at 4°C (Steele and Odumeru, 2004).

A survey of eleven growers examining the use of irrigation water in the production of leafy salad vegetables in the United Kingdom found that surface water was the predominant water source, overhead irrigation was the most common application method, and that the gap between the last irrigation and harvest may be less than 24 hours. There is no national standard for irrigation water in the United Kingdom, and water quality monitoring by growers was limited (usually only annual testing) (Tyrrel *et al.*, 2006).

Most standards for the microbial quality of irrigation water have been developed for the use of treated wastewater (Gerba, 2009). However, the Leafy Greens Marketing Agreement from California has set commodity specific food safety guidelines for the production and harvest of lettuce and leafy greens.[22] These include a guideline that irrigation water for foliar application contains ≤126 Most Probable Number (MPN)/100ml of *E. coli*. A study with baby spinach has shown that under growth chamber conditions, pathogens did not survive for more than 24 hours on plants irrigated with water containing ≤126 MPN/100ml of *E. coli* O157:H7 (Ingram *et al.*, 2011)..

The World Health Organisation (WHO) has published guidelines for the safe use of wastewater in agriculture and aquaculture.[23] An acceptable level of risk from consumption of pathogens on food is defined as 10^{-6} disability adjusted life years (DALY). Based on this value, the minimum requirements for irrigation water for use on root crops are <1,000 *E. coli*/100ml, and zero helminth eggs/L. This guideline is based on a wastewater treatment process that provides a 4 log reduction in pathogens, a 2 log reduction due to die-off between the last irrigation and consumption, and a 1 log reduction by washing of salad crops or vegetables with water prior to consumption (Gerba, 2009).

A variety of standards for water reuse on food crops, including greywater, are in place in certain states in the USA, which specify coliform averages (not detected – 200/100ml) and maxima (23 – 400/100ml), along with biological oxygen demand and turbidity standards. These standards are summarised in a report from the US Environmental Protection Agency.[24] However, at least in the US, irrigation with this type of water is seldom practiced as yet (Gerba, 2009).

Canadian guidelines require that irrigation water for food crops contain less than 100 CFU faecal coliforms/100ml (although some provincial requirements are lower) (Steele and Odumeru, 2004; Warriner *et al.*, 2009).

[22] http://www.caleafygreens.ca.gov/
[23] http://www.who.int/water_sanitation_health/wastewater/gsuww/en/index.html
[24] http://www.epa.gov/ord/NRMRL/pubs/625r04108/625r04108chap4.pdf

5.2 Irrigation water in New Zealand

The Ministry for the Environment has published a "Snapshot of water allocation in New Zealand" (MfE, 2006). This report provides an analysis, by Regional Council/Unitary Authority, of consents for irrigation water categorised by a number of criteria of interest to this project. The data were collected by a survey conducted in 2006. Data on water source (groundwater, surface water, storage) and water use are shown in tables in Appendix 5 Volume 2.

These 2006 data indicate that the regions of New Zealand with the most irrigated horticultural land are Hawkes Bay, Bay of Plenty, and Canterbury. Hawkes Bay, Bay of Plenty and Canterbury are the regions with the largest areas cultivated in fruit and vegetables (see Table 1 and Table 2 Volume 2) but the areas reported as planted in these crops (total 89,000 hectares) are markedly larger than the areas reported as irrigated horticultural land (total 49,000 hectares).

It could be expected that surface water is more likely to be contaminated than groundwater, based on the potential for direct contamination by sources such as livestock and pasture runoff. Nationally the water sources reported by the 2006 survey were surface (51%), groundwater (46%), and storage (3%). The regions with largest areas of irrigated horticultural land, and the highest proportion of surface water sources were Bay of Plenty and Canterbury.

5.3 Water quality in New Zealand

The most extensive survey of source waters in New Zealand for microbiological quality was conducted in 1998-2000 across 25 surface water sites throughout New Zealand (McBride et al., 2002). This study determined the prevalence of ten indicators and pathogens. The prevalence of contamination (all samples, all sites) of pathogens relevant to this study was: Adenovirus (32%), *Giardia* cysts (8%), *Cryptosporidium* oocysts (5%), *Campylobacter* (60%), *Salmonella* (10%). Where available, quantitative data indicates that the concentration of bacteria were low (mostly <100 MPN/L for *Salmonella*, <10 MPN/L for *Campylobacter*).

Data on contamination of groundwater in New Zealand are less extensive. A review of aquifers across all 15 regional and district councils in New Zealand found few contamination issues, and those that were identified were associated with shallow aquifers (<30m deep), often potentially contaminated by septic tanks (Sinton, 2001). Monitoring of groundwater involves detection of *E. coli* and/or coliforms, which is not necessarily indicative of the presence of pathogens. The only study of pathogens involved detection of *Campylobacter* in shallow aquifers in a Canterbury dairying region using border dyke irrigation (Close *et al.*, 2008). This scenario could be considered at high risk of contamination, and 11% of samples were positive for *Campylobacter*, albeit at very low concentrations (up to 3.1 MPN/L). Overall, it appears that groundwater is at lower risk of contamination than surface waters.

The Annual Review of Drinking Water Quality for New Zealand 2008-9 reports on compliance with *E. coli* requirements of Drinking Water Standards New Zealand (DWSNZ) 2005 by registered water supplies (Ball *et al.*, 2010). It was reported that the percentage of the New Zealand population served by reticulated drinking water supplies not compliant with the distribution zone *E. coli* requirements of the DWSNZ was 9%. However, many of these supplies did not comply for reasons such as inadequate sampling, or analysis by non-accredited laboratories; the percentage of the population served by registered supplies detected with unacceptable levels of *E. coli* was 2%.

The bioavailability of metals in water is affected by the form of the metal (speciation), transport (dissolved or bound to suspended particulate matter), and attenuation processes (such as adsorption onto surfaces) (Webster-Brown, 2005). The potential for contamination of surface waters from geothermal water sources (geysers, hot springs) and their use (hydrothermal power plant discharge) has been identified (Cook and Weinstein, 2005). Several rivers flowing from the volcanic region in the central North Island (Tarawera, Rangitikei, and Waikato) and Lake Rotorua have been found to contain elevated levels of mercury and/or arsenic.

In New Zealand some of the 2,339 registered drinking water distribution zones are required to monitor for chemicals, based on a previous history of the presence of these chemicals at potentially health significant concentrations (Ball *et al.*, 2010). These "P2 determinands" include fluoride, disinfection by-products, and certain heavy metals, some of which are relevant to this project (arsenic, cadmium, lead). These heavy metals are required to be monitored for a small number of zones, based on questionnaires and testing rounds conducted from 1995 - 2005.[25] Information from the Water Information New Zealand (WINZ) database for 2008/2009 and 2010/2011 was reviewed to locate the zones required to monitor heavy metals and the number of noncompliant zones where samples contained concentrations of metal above the minimum acceptable value (MAV) (See Volume 4 Section 2.2.3). Lead is monitored in the largest number of zones (61 in 2008/2009, 38 in 2010/2011) and the number of zones with samples exceeding the MAV was 6 in 2008/2009 and 3 in 2010/2011. However, in each of these zones, only a small proportion of samples taken each year (<20%) exceeded the MAV. No zones had samples that exceeded the MAV for cadmium in either year.

Arsenic is monitored in 15 zones (samples from 8 zones exceeded the maximum acceptable value (MAV) in 2008/2009 and 2010/2011). These zones were mostly in the Taupo and Edgecumbe areas (Waikato and Bay of Plenty Regional Councils) where there are a large number of horticultural farms, especially growing kiwifruit (See Volume 2). However, the arsenic in these water supplies is unlikely to result in accumulation by horticultural produce (See Section 3.4).

Land use changes in the past ten years may have affected the quality of water used by horticultural producers e.g. land use by the dairy sector increased by 25% between 1998/99 and 2008/09 (Schilling *et al.*, 2010).

[25] http://www.drinkingwater.co.nz/supplies/priority2determinands.asp

6 GROWER SURVEY

To gather information on the way New Zealand horticultural growers use natural fertilisers and water, and potential risks are managed, a survey of growers was conducted for this study. Full details and results are provided in Volume 3.

A total of 40 growers participated in the survey, which targeted leafy vegetable and berry growers based on the likelihood of the produce being eaten raw, grown close to the ground, and receiving significant applied water. Obviously this represents a very small proportion of the estimated 1,750 growers of vegetables and berries in New Zealand (see Table 4). Consequently the survey should be considered a snapshot of practices, rather than a statistically representative sample, which was beyond the resources of the project. Therefore quantitative data such as the number of growers accredited to various assurance programmes should not be considered indicative of the total population.

Efforts were made to include both organic and non-organic growers, those accredited to an assurance programme and those not accredited, growers delivering produce to consumers through a variety of channels, and growers from a variety of regions throughout New Zealand.

The survey found that 12 growers grew only a single crop, while the remainder grew multiple crops, with one growing 33 different crop types. There was no clear pattern as to which growers sold direct to the retailer and which used wholesalers, with a significant number of growers using both channels. The delivery channels of crops to consumers were highly variable across the growers and according to comments during interviews, varied over time according to supply and demand. Some lettuce growers supplied a high proportion of their produce directly to foodservice establishments such as restaurants.

Half of the growers used one or more natural fertilisers. The most commonly used natural fertilisers were foliar sprays made from fish or seaweed, poultry litter, and composted plant waste. Most natural fertilisers containing animal manure were applied to the soil prior to planting, although the time period between final application and planting was not always clearly specified. Sprays made from commercially produced fish or seaweed extracts are commonly applied to the edible parts of plants right up to harvest. Some growers increase the possibility of introducing pathogens onto the edible parts of the plants by applying untreated animal-based natural fertilisers close to (or at) planting (e.g. poultry litter).

Physical barriers (e.g. roads, buffer zones) were important for minimising any contamination from livestock farming activities adjacent to growing areas.

Most growers surveyed used groundwater (bores) as a water source for irrigation and applying plant products, and many had access to town supplies of potable water. Testing of other water supplies was infrequent and treatment was rare. Not all growers kept records of their water test results. According to comments by growers, there was a good awareness of potential problems with water supplies, amounting to informal risk assessments.

A high proportion of growers used water during and/or after harvest. Water was often used for cooling or freshness purposes. This water was often from the same source as that used for irrigation, although some growers added antimicrobial chemicals to their water or restricted usage for this purpose to town supplies.

Regular testing of produce for microbial contaminants was conducted only by conventional growers accredited to New Zealand GAP or New Zealand GAP (GLOBALG.A.P. Equivalent) (see Section 7), and apparently prompted by the producer assurance programme or the retail customer programme.

We recorded some potentially unsafe practices where there was a possibility of produce becoming contaminated, or the potential for water or fertiliser contamination had not been assessed:

- Short or undefined periods of time between application of untreated natural fertilisers to the soil and planting of the crop (emerging seeds or the young leaves of seedlings are likely to come into contact with the soil and if pathogens are still viable these could be transferred to the plant). The scientific literature (see Volume 2) indicates that pathogens from natural fertilisers may be viable in soil for several weeks;
- Fish and seaweed sprays are commonly applied to plants right up to harvest (this study has not investigated the microbiological and chemical quality of these solutions);
- Water sources used for irrigation, application of sprays and washing could not always be guaranteed to be free from contamination where these were not regularly tested or treated (particularly if the water is roof or surface water, which are susceptible to contamination events). Contamination of surface water with pathogens, particularly *Campylobacter*, has been shown to be common (see Section 5.3).

These practices were found across the full range of participants and were not associated with a particular crop, grower, region, method of growing, or assurance programme status.

As an example, some of the NZ GAP or organic certified growers in this study applied poultry litter close to planting lettuce crops, or used surface water for irrigating or washing crops. However, this observation must be treated with caution as the sample was only a small proportion of the total grower population, and may not representative of New Zealand growers as a whole.

From this survey it appears that grower practices associated with natural fertilisers and water are highly variable. Many growers expressed an awareness of potential risks, but their assessments and controls were informal, and partially relied on a history of safe use. Based on the anecdotal comments from growers about improving food safety, there does appear to be a receptive audience for greater education and enhanced food safety measures, as long as these do not become a rigid regulatory burden. For example, some growers used surface waters, which are susceptible to sporadic contamination, and a documented assessment of potential risks would be worthwhile, if not already being done.

7 LAWS, REGULATIONS, STANDARDS AND ASSURANCE PROGRAMMES

Volume 4 of this report compiles information on the laws, regulations, standards and assurance programmes that influence the production of horticultural produce in New Zealand. The legislation, regulations and standards have been assembled and summarised to provide a more complete context of the controls on the use of natural fertilisers and water, but these have not been critically reviewed. The critical review has focused on the assurance programmes. These have been examined from the perspective of how they influence the use of natural fertilisers, and water for irrigation, post harvest processing and spray application.

Horticultural producers must operate in accordance with New Zealand food legislation and associated regulations and standards. There are also legislation and standards that control the taking of water for irrigation, water quality and the application of natural fertilisers to land. A new Food Bill is being considered by Parliament which will update and consolidate existing food legislation and introduce risk-based measures that will apply to the horticultural industry. Section 2 of Volume 4 outlines relevant New Zealand legislation, regulations and mandatory standards, and the new Food Bill. This section also summarises Local Authority rules for application of natural fertilisers and taking of water.

That section covers:

- The Food Bill 2010 (in progress);
- Health Act 1956;
- Health Regulations 1966;
- Food Hygiene Regulations 1974;
- Food Act 1981;
- Food Regulations 1984;
- Australia New Zealand Food Standards Code;
- Food Safety Regulations 2002;
- Resource Management Act 1991;
- Agricultural Compounds and Veterinary Medicines Act 1997;
- MAF Import Standards for fertilisers;
- New Zealand Potable Water Standards; and
- Regional Council and Unitary Authority rules.

There are a number of non-mandatory food guidance documents that are applicable to horticultural products. There are also New Zealand guidelines for the treatment and application of natural fertilisers and the use of water in horticulture. These have been described in Section 3 of Volume 4.

That section covers guidelines for foods:

- Ministry of Health Microbiological Reference Criteria for Food (1995);
- FSANZ Guidelines for the microbiological examination of ready-to-eat foods (2001);

guidelines for natural fertilisers:

- New Zealand Land Treatment Collective (NZLTC) guidelines for sewage effluent;
- New Zealand Standard for composts, soil conditioners and mulches;

- New Zealand Water and Wastes Association (NZWWA) biosolids guidelines;
- FertResearch code of practice;
- Fertmark;

and guidelines for water:

- Australian and New Zealand Environment and Conservation Council (ANZECC) water quality guidelines;
- NZFSA Good Operating Practice.

Assurance programmes are designed to assure buyers that the products they are purchasing have been produced according to an agreed set of standards (e.g. Good Agricultural Practices (GAP)).

General principles for GAP have been described by the Food and Agricultural Organisation.[26] The objective of GAP codes, standards and regulations include, to a varying degree:

- ensuring safety and quality of produce in the food chain
- capturing new market advantages by modifying supply chain governance
- improving natural resources use, workers health and working conditions, and/or
- creating new market opportunities for farmers and exporters in developing countries.

Good Agricultural Practices are "practices that address environmental, economic and social sustainability for on-farm processes, and result in safe and quality food and non-food agricultural products".

An assurance programme usually consists of a set of standards or requirements that ensure the production of safe and high quality food, or to assure consumers that food is produced according to its labelling (e.g. organic foods). Assurance programmes might be put in place by overseas governments, large retailers such as supermarket chains, or by credible, independent industry bodies. If a horticultural producer is to gain access to specific markets, such as export markets, organic markets or major retail outlets, they usually need to be certified under one or several assurance programmes. Certification under an assurance programme is not a legal requirement for horticultural producers.

Section 4 of Volume 4 describes the New Zealand assurance programmes applicable to domestic horticultural production, including those for organic production.

The programmes covered are:

- New Zealand GAP or New Zealand GAP (GLOBALG.A.P. Equivalent);
- New Zealand Organic Standard (NZS8410:2003);
- MAF Official Organic Assurance Programme (OOAP) (exports only);
- BioGro New Zealand Organic Standards;
- AsureQuality Organic Standard;
- Demeter New Zealand (organic);
- Woolworths Quality Assurance (WQA); and

[26] http://www.fao.org/prods/gap/home/principles_en.htm

- New Zealand Avocado Industry Council.

Section 4 of Volume 4 also describes important international codes of practice, particularly the Codex Alimentarius Commission's (CAC) Code of Hygienic Practice for Fresh Fruits and Vegetables, plus some of the assurance programmes put in place by the European Union (GLOBALG.A.P.), United States Safe Quality Food (SQF) and some of the other countries that receive exported New Zealand horticultural products.

The CAC Code of Hygienic Practice for Fresh Fruits and Vegetables is not actually an assurance programme, as it covers food hygiene rather than quality issues. However, it provides the guidelines against which other assurance programmes are measured and so has been discussed alongside the assurance programmes in the sections below.

Section 5 of Volume 4 compares the CAC code of practice, two internationally recognised assurance programmes (GLOBALG.A.P and SQF), and New Zealand assurance programmes and the Organic Standard.

7.1 Process for review

At the beginning of this part of the project, a set of criteria for review of the assurance programmes was agreed with MAF. These criteria were based on those used in a previous UK study (Monaghan *et al.*, 2009), augmented by additional criteria from the project participants and MAF.

Copies of the assurance programmes were assembled from publicly available sources, or from assurance programme organisations. Review of the programmes was then undertaken against the criteria, to create the tables in Section 14 of Volume 4. Following this review, a copy of the relevant section of the assessment was then sent to each of the assurance programme organisations for their review and correction where required, and also (where relevant) to obtain agreement that this report could reproduce the relevant text from the programmes. During the course of this project updated versions of some of the assurance programmes were issued, which required them to be reassessed against the criteria.

The material in Table 2 of Volume 4 describing regional council and unitary authority rules for natural fertilisers was also distributed (by email) to the relevant council officers for their review.

The following general comments are based on examination of the summary tables in Appendices 1 and 2 of Volume 4.

7.2 Criteria concerning natural fertilisers

In general, the organic assurance programmes focus on the types of natural fertilisers permitted for use, while the non-organic assurance programmes provide more guidance on using application methods that will reduce the risk of produce becoming contaminated.

Non-organic assurance programmes:

- Non-organic assurance programmes provide general advice to evaluate risks, and manage and minimise the risk of contamination from natural fertilisers.
- Most ban the use of human sewage sludge (CAC allows use of human sewage provided it meets appropriate standards, New Zealand GAP does not address this issue).
- New Zealand GAP and New Zealand GAP (GLOBALG.A.P. Equivalent) guide growers through a risk assessment process for applying natural fertilisers to help them decide when there is risk that requires management (e.g. if the fertiliser will come into contact with the edible parts of plants).
- GLOBALG.A.P. and SQF advocate risk assessment of natural fertilisers and validation of treatment methods.
- Testing of fertilisers for microbial and chemical quality is not required, but obtaining documentation from suppliers that describes the treatment and testing results of the material is advocated.
- Maximising withholding periods between fertiliser application and harvest is advocated, but no minimums are given.
- The use of fertilisers that have been treated to reduce or eliminate pathogens is encouraged ("proper" treatment of fertilisers is advocated but no specifications are given).
- While records of fertiliser source are required for most programmes, records of fertiliser quality are not, putting the emphasis on the fertiliser supplier to ensure quality.

Organic assurance programmes:

- All have clear rules on what natural fertilisers are permitted, restricted or prohibited for use.
- All prohibit human sewage.
- Evaluation of risks and assessment of microbial quality are not addressed.
- All programmes except MAF OOAP address control of agrichemicals and heavy metal residues in compost (specific metal limits are provided by BioGro and AsureQuality and New Zealand Organic Standard).
- Treatment of natural fertilisers is encouraged (application of uncomposted manure is permitted, but usually with restrictions e.g. BioGro allows the farm's own dairy or pig effluent to be applied and Demeter requires permission).
- Do not address good application practices (e.g. avoiding contact with edible part of plant, withholding periods).
- Records of fertiliser sources and application are required, but little attention is paid to microbial quality.

7.3 Criteria concerning water prior to harvest

Some assurance programmes include requirements for water irrespective of how that water is used during primary production, but most assurance programmes separate out their requirements based on the water use (e.g. irrigation). In general, the non-organic assurance programmes provide more guidance and standards for water than the organic programmes. All of the non-organic assurance programmes require the grower to undertake some form of risk assessment of their water, and for all but SQF, the risk assessment processes specifically include assessing how the water is applied. Demeter is the only organic programme to require some form of risk assessment for water used in primary production. While the organic assurance programmes often refer to ensuring the water is 'adequate', 'clean' or 'potable', the provision of chemical or microbiological standards is minimal. None of the assurance programmes adequately address water used for the application of agrichemicals (which includes solutions used in organic production such as compost teas); most requirements for assurance programmes focus on the correct use of the agrichemicals rather than the water used as a solute.

7.3.1 Criteria concerning water for primary production

These criteria apply to water used for any purpose during primary production.

Non-organic assurance programmes:

- CAC addresses water issues extensively in this generalised category, and testing is advocated (or obtaining results from suppliers), but no standards are given.
- Other non-organic programmes are less comprehensive, largely advocating that growers consider if water is "adequate for intended use", although GLOBALG.A.P. requires a risk assessment for any new production sites that considers water quality, and New Zealand GAP (GLOBALG.A.P. Equivalent) requires an annual risk assessment of water quality.
- New Zealand GAP and New Zealand GAP (GLOBALG.A.P. Equivalent) do address temperature of water where produce is in prolonged contact with water.
- New Zealand GAP (GLOBALG.A.P. Equivalent) prohibits the use of untreated sewage water and CAC refers to WHO guidelines for the use of wastewater.

Organic assurance programmes:

- Few criteria are addressed at this level, apart from general advocacy of water adequacy (NZS8410) and risk minimisation (Demeter).

7.3.2 Criteria concerning water for irrigation (non-hydroponic)

Non-organic assurance programmes:

- Most criteria met by all non-organic standards.
- Although testing of water for chemical or microbial quality is not mandatory, the decision tree for assessing risk provided by New Zealand GAP and New Zealand GAP (GLOBALG.A.P. Equivalent) includes microbial criteria in terms of *E. coli* counts for assessing results from testing of non-potable water, and SQF requires water to meet potable water standards of the country of origin.

Organic assurance programmes:

- Not addressed by organic standards, apart from general recommendations that water is adequate or appropriate.
- BioGro provides a list of maximum levels of heavy metals in water.

7.3.3 Criteria concerning water for hydroponic growing systems

Non-organic assurance programmes:

- Specifically addressed by all standards except SQF.
- The use of "potable" or "clean" water and microbial and chemical testing are advocated, but only some microbial standards are provided.
- The decision tree for New Zealand GAP addresses requirements for microbial testing if not using potable water, and provides *E. coli* criteria.

Organic assurance programmes: Not applicable as hydroponic production is not permitted under organic production.

7.3.4 Criteria concerning water for agricultural chemicals (application)

Non-organic assurance programmes:

- New Zealand GAP and New Zealand GAP (GLOBALG.A.P. Equivalent) do not advocate microbial or chemical testing, only general comments that water should be adequate for intended use or that risks should be evaluated.
- CAC and GLOBALG.A.P. do specifically consider this issue and advocate testing, but only GLOBALG.A.P provides information on appropriate microbial standards.
- SQF does not address this issue specifically.

Organic assurance programmes:

- This water use is only specifically addressed by Demeter in relation to the water used to apply Demeter biodynamic sprays.

7.4 Criteria concerning water for post-harvest processes

The focus of the organic programmes is on water as an additive or processing aid. The non-organic assurance programmes include more comprehensive requirements for the use of water post-harvest.

Non-organic assurance programmes:

- All of the programmes advocate the use of potable water.
- New Zealand GAP and New Zealand GAP (GLOBALG.A.P. Equivalent) both provide guidance for growers to assess the water for risk, which includes *E. coli* criteria.
- All but CAC require water testing or other proof of potability (e.g. declaration by a local authority) where the water comes into contact with the produce (SQF requires that potable water is used for all post-harvest processes and that the quality of this water is monitored). All of the programmes except for GLOBALG.A.P. require that the water temperature and the effectiveness of any treatment is monitored.
- CAC and GLOBALG.A.P. specifically address water quality for cooling (ice), and these two (as well as SQF) address quality and monitoring of recycled water; New Zealand GAP and New Zealand GAP (GLOBALG.A.P. Equivalent) do not specifically address these issues.

Organic assurance programmes:

- All programmes require potable water (or "drinking water") to be used as an additive or processing aid (and by implication ice/cooling water) if it comes in contact with food.

7.5 Summary

- Food safety issues concerning natural fertilisers are addressed by non-organic assurance programmes, but mostly in general terms, and there is reliance on the supplier that the fertilisers have been adequately treated.
- Food safety issues concerning natural fertilisers are less extensively addressed by organic programmes, but they do prohibit human sewage and raw manures.
- Food safety issues concerning water are generally well covered by non-organic programmes, with *E. coli* and some chemical limits specified, but ice/cooling water is not specifically addressed by New Zealand GAP and New Zealand GAP (GLOBALG.A.P. Equivalent).
- Food safety issues concerning irrigation water are less extensively addressed by organic programmes, although potable water is required for all post-harvest processing.

8 DISCUSSION

This project has provided:

- an overview of the horticultural sector in New Zealand from published sources;
- an overview of scientific issues associated with the use of natural fertilisers and water for growing and processing horticultural produce;
- a summary of previous New Zealand studies of the food safety of horticultural produce;
- a snap shot survey of New Zealand vegetable and berry growers to provide an indication of current practices and risk management; and
- a review of relevant horticultural assurance programmes, and how they address issues to do with natural fertilisers and water.

The New Zealand horticultural sector comprises a large number of small scale growers, with the majority (67%) of farms being less than ten hectares in area. The survey of growers found that farms often grew multiple crops, and practices related to natural fertiliser and water use were highly variable. Based on information from Statistics New Zealand there appear to be approximately 7,500 horticultural farms in New Zealand. Information from an annual overview of organic production in this country, as well as a review of registrations on organic accreditation websites, suggest that there are approximately 500 organic horticultural operations in New Zealand.

A total of 40 growers participated in the survey, which targeted leafy vegetable and berry growers based on the likelihood of the produce being eaten raw, grown close to the ground, and receiving significant applied water. Obviously this represents a very small proportion of the estimated 1,750 growers of vegetables and berries in New Zealand

Most of the growers were able to provide information about the quality of the water and natural fertiliser inputs they used, and applied these inputs in ways that would reduce the risk of chemical or microbial contamination. We recorded some potentially unsafe practices where there was the potential for produce contamination, or risks had not been assessed (see Section 6). However, the potentially unsafe practices identified were not associated with specific growers or grower groups (organic or conventional, assurance programme certified or not certified).

Although many of the growers in the survey were members of an assurance programme, most risk management appeared to be based on experience, and not formalised or documented. Laboratory testing of natural fertilisers was absent, with growers relying on suppliers to control potential contamination.

Testing of water supplies appeared to be infrequent. Not all growers kept records of their water test results. As most growers use groundwater or potable water for irrigation and/or processing, the risk of contamination of produce should be very low. However, some growers use surface waters and a documented assessment of potential risks would be worthwhile, if not already being done.

Using wash water with a lower temperature than produce may promote the internalisation of pathogens. Post harvest washing water may contain high levels of bacterial numbers if not treated or regularly changed. The temperatures reported for post harvest water used by the growers in the survey (Volume 3 Section 3.11) are likely to have been lower that that of the produce. However, the majority of growers interviewed described practices that would limit the risk of internalisation (low risk of water contamination (i.e. groundwater bore or town supply), treatment of water with chlorine, frequent changing of water, low contact time between water and produce).

There do not appear to be issues associated with heavy metal contamination of New Zealand horticultural produce, based on limited survey results from produce (NZTDS), and minimal use of sewage sludges as fertiliser. One issue that could be considered is the possible presence of mercury in the fish-based fertiliser products used by a number of growers.

The assurance programmes reviewed in Volume 4 were not primarily written to address food safety issues, and in particular the organic programmes concentrate on preserving the organic status of the produce. The food safety aspects of the programmes being used in New Zealand could be improved by addressing additional issues (e.g. quality control of water for ice and cooling, providing criteria to assess microbial and chemical quality). Material from overseas assurance programmes reviewed in Volume 4 may be useful for this purpose.

The questions asked by the original project description from MAF were as follows.

Growing practices

Good Agricultural Practices

a. What is the extent of application of natural fertilisers during primary production of horticultural produce (conventional and organic) in New Zealand?

The grower survey involved only 40 vegetable and berry growers, compared to the estimated 1,750 vegetable and berry growers in New Zealand. The survey provides useful information on grower practices but the participating growers may not be representative of New Zealand growers as a whole and do not form a statistically significant sample.

Half of the surveyed growers used natural fertilisers in some form. Most were foliar sprays made from fish or seaweed extracts, which should have lower risk of contamination by zoonotic pathogens than other sources of natural fertiliser. Most natural fertilisers are applied between crops which will also mitigate risk, although the intervals between application and planting were variable, and some were only a few weeks. Some growers commented that information on recommended withholding periods was not provided by their supplier. Generally, it appears that growers rely on fertiliser suppliers to manage the quality of the fertiliser products.

b. What are the currently available guidance and control measures?

The existing legislation, standards and assurance programmes, and control measures, are reviewed in Volume 4.

c. Are internationally available guidelines for the application of water and natural fertilisers applicable to New Zealand?

We consider that the guidelines and assurance programmes from overseas, as described in Volume 4, could be used to augment the existing New Zealand assurance programmes

Risk Management

d. Is the application of natural fertilisers and potentially contaminated water (different sources) under conditions of primary production in New Zealand likely to lead to significant microbial contamination?

See below.

e. Is residual contamination likely to occur at a level that may constitute a foodborne risk to consumers?

The information collected by this project from published sources and the grower survey has shown that the New Zealand horticultural sector comprises a large number of generally small scale farms, growing multiple crops, and with variable practices in relation to water and natural fertilisers. It is not possible to estimate the probability or level of residual contamination of horticultural produce from these data, particularly due to limited information on composting practices of fertiliser suppliers.

Surveys of the prevalence of pathogens in the faeces of sheep, dairy cattle, and chickens in New Zealand indicate that, with the possible exception of Salmonella, bacterial and protozoan hazards occur in up to 80% of samples. Natural fertilisers containing livestock manure were all applied to soil prior to crops being planted by the growers surveyed. Although pathogens have been shown to survive in soil for several weeks, the numbers decline. Composting, and allowing time intervals between natural fertiliser application and planting, as practised by most growers, would reduce the risk of produce contamination.

Harvesting, post-harvest wash and packing

Good Agricultural Practices

f. What is the extent of application of water during harvesting and post-harvesting activities of horticultural produce (conventional and organic intended for domestic consumers and export) in New Zealand?

Interview and survey results indicated that there is extensive use of water during harvest and post-harvest. Although the sample size was small and results should be treated with caution, of the growers who responded to the survey, 20% used water to wash or moisten produce in the field during harvest, and 63% used water to transport, wash, cool and/or moisten produce after harvest.

g. What are the currently available guidance and control measures?

The existing legislation, standards and assurance programmes, and control measures are reviewed in Volume 4.

h. Are the internationally available guidelines for the application of water and natural fertilisers applicable to New Zealand?

We consider that the guidelines and assurance programmes from overseas, as described in Volume 4, could be used to augment the existing New Zealand assurance programmes

Risk Management

i. Is the application of potentially contaminated water under conditions of harvest and packaging in New Zealand likely to lead to significant microbial contamination?

See below

j. Is residual contamination likely to occur at a level that may constitute a food-borne risk to consumers?

Based on data from an extensive survey of surface waters undertaken in New Zealand between 1998 and 2000, the prevalence of Campylobacter is approximately 60%, while the prevalence of other bacterial and protozoan pathogens is up to 10%. The majority of growers used potable water and ground water (bore) supplies. Potable water supplies are at lower risk of being contaminated due to Ministry of Health controls on drinking water. Although there a few data on groundwater (bore) quality, such supplies would be at lower risk from contamination sources such as agricultural runoff. Chemical contamination with heavy metals is rare, apart from some rivers in the geothermal region of the central North Island. Of the growers surveyed, a minority (6/40, 15%) used surface water sources and all but one of these conducted microbial testing annually. Several growers used lower risk water sources (e.g. town supplies of potable water) for post harvest activities.

Growers were generally aware of the potential for contamination from water used on their farms and in packhouses, and managed these risks in a variety of ways (e.g. water testing, water treatment, switching water supplies when potential contamination events such as heavy rainfall occurred). However, documentation supporting these risk assessment or management activities was uncommon and this made it difficult to assess the efficacy of measures taken, and a history of safe use was sometimes invoked as evidence for a lack of risk.

The potential for sporadic incidents of contamination of horticultural produce from natural fertilisers or water used for irrigation and processing can never be completely eliminated. Land use in New Zealand has changed markedly in the previous decade. In particular the 25% increase in land use for dairy farming since the last major survey of surface water quality in New Zealand may have affected the quality of water used for horticultural production.

However, this project has provided information on a range of factors which reduce the risk for horticultural produce from New Zealand. These include:

- *Both the conventional and organic horticultural sectors have active producer groups and associations who develop assurance programmes which have sections that address hazards in natural fertilisers and water sources;*
- *Growers in the survey reported applying natural fertilisers to soil prior to planting, which provides a period for a decline in the numbers of any pathogens present;*
- *Most (85%) of the growers in the survey used potable or groundwater sources of water which will be at lower risk of contamination; and,*
- *Grower awareness of the potential for contamination from natural fertilisers and water sources and measures taken to control this.*

Surveys of horticultural produce in New Zealand have rarely found microbial pathogens in samples (although unsatisfactory concentrations of E. coli contamination in some leafy *greens samples indicate potential problems). The Total Diet Survey and other surveys have shown that heavy metals can occasionally be detected in New Zealand produce, but dietary intakes are well below levels which would present safety concerns.*

The use of more formalised and documented risk assessment tools by the horticultural sector within the context of assurance programmes could help to promote awareness of food safety issues and comprehensive assessment of contamination sources.

9 REFERENCES

Ackers M L, Mahon B E, Leahy E, Goode B, Damrow T, Hayes P S, Bibb W F, Rice D H, Barrett T J, Hutwagner L, Griffin P M and Slutsker L (1998) An outbreak of Escherichia coli O157:H7 infections associated with leaf lettuce consumption. Journal of Infectious Diseases; 177: 1588-93.

Amoros I, Alonso J and Cuesta G (2010) *Cryptosporidium* oocysts and *Giardia* cysts on salad products irrigated with contaminated water. Journal of Food Protection; 73: 1138-1140.

Baert L, Uyttendaele M, Stals A, E V A N C, Dierick K, Debevere J and Botteldoorn N (2009) Reported foodborne outbreaks due to noroviruses in Belgium: the link between food and patient investigations in an international context. Epidemiology and Infection; 137: 316-25.

Ball, A, Ritchie J, Ferguson A, Nokes C. (2010) Annual Review of Drinking-Water Quality in New Zealand 2008-9. Client Report FW10033 for the Ministry of Health. Institute of Environmental Science and Research (ESR) Limited. Available from: http://www.moh.govt.nz/moh.nsf/pagesmh/10143/$File/annual-review-drinking-water-nz-200809.pdf Accessed 4 April 2011.

Berger C, Sodha S, Shaw R, Griffin P, Pink D, Hand P and Frankel G (2010) Fresh fruit and vegetables as vehicles for the transmission of human pathogens. Environmental Microbiology; 12: 2385-2397.

Calder L, Simmons G, Thornley C, Taylor P, Pritchard K, Greening G and Bishop J (2003) An outbreak of hepatitis A associated with consumption of raw blueberries. Epidemiology and Infection; 131: 745-751.

Chinivasagam H, Redding M, Runge M and Blackall P (2010) Presence and incidence of food-borne pathogens in Australian chicken litter. British Poultry Science; 51:311-318.

Cleary P, Browning L, Coia J, Cowden J, Fox A, Kearney J, Lane C, Mather H, Quigley C, Syed Q and Tubin-Delic D (2010) A foodborne outbreak of *Salmonella* Bareilly in the United Kingdom, 2010. Eurosurveillance; 15: 19732.

Close M, Dann R, Ball A, Pirie R, Savill M and Smith Z (2008) Microbial groundwater quality and its health implications for a border strip irrigated dairy farm catchment, South Island, New Zealand. Journal of Water and Health; 6: 83-98.

Cook A, Weinstein P. (2005) Volcanic emissions and health risks of metal contaminants. In “Metal Contaminants in New Zealand”. TA Moore, A Black, JA Centano, JS Harding, Trumm DA (eds). Resolutionz press, Christchurch New Zealand: 465-473.

Critzer F J and Doyle M P (2010) Microbial ecology of foodborne pathogens associated with produce. Current Opinion in Biotechnology; 21: 125-130.

Crowe L, Lau W, McLeod L, Anand C, Ciebin B, LeBer C, McCartney S, Easy R, Clark C, Rodgers F, Ellis A, Thomas A, Shields L, Tate B, Klappholz B, LaBerge I, Reporter R, Sato H, Lehnkering E, Mascola L, Waddell J, Waterman S, Suarez J, Hammond R, Hopkins R, Neves P, Horine M, Kludt P, DeMaria Jr. A, Hedberg C, Wicklund J, Besser J, Boxrud D, Hubner B, Osterholm M, Wu F and Beuchat L (1999) Outbreaks of *Shigella sonnei* infection associated with eating fresh parsley - United States and Canada, July-August 1998. Morbidity and Mortality Weekly Report; 48:285-289.

CSAFE (2010) New Zealand Organic Report 2010. A report by the Centre for the Study of Agriculture, Food and Environment, University of Otago. Commissioned by Organics Aotearoa New Zealand (OANZ). University of Otago.

Emberland K E, Ethelberg S, Kuusi M, Vold L, Jensvoll L, Lindstedt B A, Nygård K, Kjelsø C, Torpdahl M, Sørensen G, Jensen T, Lukinmaa S, Niskanen T and Kapperud G (2007) Outbreak of *Salmonella* Weltevreden infections in Norway, Denmark and Finland associated with alfalfa sprouts, July-October 2007. Eurosurveillance; 12: 3321.

ESR (2006) Annual summary of outbreaks in New Zealand 2006. Client Report FW0623 for the Ministry of Health. Institute of Environmental Science and Research (ESR) Limited. http://www.surv.esr.cri.nz/surveillance/annual_outbreak.php.

ESR (2007) Annual summary of outbreaks in New Zealand 2006. Client Report FW0741 for the Ministry of Health. Institute of Environmental Science and Research (ESR) Limited. http://www.surv.esr.cri.nz/surveillance/annual_outbreak.php.

ESR (2008) Annual summary of outbreaks in New Zealand 2007. Client Report FW08035 for the Ministry of Health. Institute of Environmental Science and Research (ESR) Limited. http://www.surv.esr.cri.nz/surveillance/annual_outbreak.php.

ESR (2009) Annual summary of outbreaks in New Zealand 2008. Client Report FW09036 for the Ministry of Health. Institute of Environmental Science and Research (ESR) Limited. http://www.surv.esr.cri.nz/surveillance/annual_outbreak.php.

ESR (2010) Annual summary of outbreaks in New Zealand 2009. Client Report FW10048 for the Ministry of Health. Institute of Environmental Science and Research (ESR) Limited. http://www.surv.esr.cri.nz/surveillance/annual_outbreak.php.

Falkenhorst G, Krusell L, Lisby M, Madsen S, Böttiger B and Mølbak K (2005) Imported frozen raspberries cause a series of norovirus outbreaks in Denmark, 2005. Eurosurveillance; 10: 2795.

Fonseca J, Fallon S, Sanchez C and Nolte K (2011) *Escherichia coli* survival in lettuce fields following its introduction through different irrigation systems. Journal of Applied Microbiology; 110: 893-902.

Gerba C (2009).The role of water and water testing in produce safety. In: Microbial Safety of Fresh Produce, Ed: N. B. Fan X, Doona CJ, Fecherry FE, Gravani RB., 129 - 142. IFT Press, Wiley Blackwell.: Ames, Iowa.

Gilbert S, Lake R, Hudson A and Cressey P (2006) Risk Profile: Shiga-toxin producing *Escherichia coli* in leafy vegetables. Client Report FW00456 for the New Zealand Food Safety Authority. Institute of Environmental Science and Research (ESR) Limited.

Graham C and Dawson C (2002) A survey of hydroponically grown vegetables in New Zealand. New Zealand Journal of Environmental Health; 25: 21-22.

Hanning I, Nutt J and Ricke S (2009) Salmonellosis outbreaks in the United States due to fresh produce: sources and potential intervention measures. Foodborne Pathogens and Disease; 6: 635-648.

Hansson I, Pudas N, Harbom B, Engvall EO. (2010) Within-flock variations of Campylobacter loads in caeca and on carcasses from broilers. International Journal of Food Microbiology; 141(1-2): 51-55.

Heaton J C and Jones K (2008) Microbial contamination of fruit and vegetables and the behaviour of enteropathogens in the phyllosphere: A review. Journal of Applied Microbiology; 104: 613-626.

Herwaldt B L (2000) *Cyclospora cayetanensis*: a review, focusing on the outbreaks of cyclosporiasis in the 1990s. Clinical Infectious Diseases; 31: 1040-57.

Hill S (2004) Norovirus in fruit salad. New Zealand Public Health Surveillance Report; March: 6-7.

Hudson A and Turner N (2002) Risks associated with bacterial pathogens in exported fruit and vegetables. Client Report FW0280 for the New Zealand Food Safety Authority. Institute of Environmental Science and Research (ESR) Limited.

Hutchison M, Averi S and Monaghan J (2008) The airborne distribution of zoonotic agents from livestock waste spreading and microbiological risk to fresh produce from contaminated irrigation sources. Journal of Applied Microbiology; 105: 848-857.

Ingram DT, Patel J, Sharma M. (2011) Effect of repeated irrigation with water containing varying levels of Total Organic Carbon on the persistence of *Escherichia coli* O157:H7 on baby spinach. Journal of Food Protection; 74: 709-717.

Isaacs S, Aramini J, Ciebin B, Farrar JA, *et al*. (2005) An international outbreak of salmonellsis associated with raw almonds contaminated with a rare phage type of *Salmonella* Enteritidis. Journal of Food Protection; 68: 191-198.

Islam M, Doyle M P, Phatak S C, Millner P and Jiang X (2005) Survival of Escherichia coli O157:H7 in soil and on carrots and onions grown in fields treated with contaminated manure composts or irrigation water. Food Microbiology; 22: 63-70.

Jalava K, Hakkinen M, Valkonen M, Nakari U, Palo T, Hallanvuo S, Ollgren J, Siitonen A and JP N (2006) An outbreak of gastrointestinal illness and erythema nodosum from grated carrots contaminated with *Yersinia pseudotuberculosis*. Journal of Infectious Diseases; 194: 1209-1216.

Jiang X and Shepherd M (2009).The role of manure and compost in produce safety. In: Microbial Safety of Fresh Produce, Ed: N. B. Fan X, Doona CJ, Fecherry FE, Gravani RB., 143 - 166. IFT Press, Wiley Blackwell.: Ames, Iowa.

Lake R, Hudson A, Cressey P and Gilbert S (2005) Risk profile: Listeria monocytogenes in ready-to-eat salads. Client Report FW0446 for the New Zealand Food Safety Authority. Institute of Environmental Science and Research (ESR) Limited.

Lowry D (2011) *Listeria monocytogenes* and leafy greens. Spinach case study. Presentation to New Zealand Institute of Food Science and Technology (NZIFST) Listeria Workshop June 2011. Available from: http://www.nzifst.org.nz/myfiles/D_Lowry_Leafy_Greens_case_study_NZIFST_Listeria_WS_0611.pdf (accessed 23 Dec 2011).

Lynch M F, Tauxe R V and Hedberg C W (2009) The growing burden of foodborne outbreaks due to contaminated fresh produce: risks and opportunities. Epidemiology and Infection; 137: 307-315.

MAF (New Zealand Ministry of Agriculture) (2011) 2009 New Zealand Total Diet Study. Agricultural compound residues, selected contaminant and nutrient elements. Wellington: Ministry of Agriculture and Forestry.

McBride G B, Till D G, Ryan T, Ball A, Lewis G, Palmer S and Weinstein P (2002) Freshwater Microbiology Programme: pathogen occurrence and human health risk assessment analysis. Ministry for the Environment. Available from: http://www.mfe.govt.nz/publications/water/freshwater-microbiology-nov02/freshwater-microbiology-main-nov02.pdf. Accessed 4 April 2011

McCallum L, Torok M, Dufour M, Hall A and Cramp G (2010) An outbreak of *Salmonella typhimurium* phage type 1 associated with watermelon in Gisborne, January 2009. New Zealand Medical Journal; 123: http://www.nzma.org.nz/journal/123-1322/4342.

McIntyre L and Cornelius A (2009) Microbiological survey of retail fresh product of imported, domestic conventional and domestic organic origin. Client Report FW09064 for the New Zealand Food Safety Authority. Institute of Environmental Science and Research (ESR) Limited.

McIntyre L, Cressey P and Lake R (2008) Discussion document on pathogens in fruits and vegetables in New Zealand. Client Report FW0737 for the New Zealand Food Safety Authority. Institute of Environmental Science and Research (ESR) Limited.

MfE (2002) The New Zealand Waste Strategy: Towards zero waste and a sustainable New Zealand. Ministry for the Environment.

MfE (2006) Snapshot of water allocation in New Zealand. Prepared for Ministry for the Environment by Aqualinc Research Limited. Available from: http://www.mfe.govt.nz/publications/ser/snapshot-water-allocation-nov06/snapshot-water-allocation-nov06.pdf. Ministry for the Environment.

Mohle-Boetani J, Farrar J, Werner S, Bryant R, Abbott S, Slutsker L and Vugia D (2001) *Escherichia coli* O157 and *Salmonella* infections associated with sprouts in California, 1996-1998. Annals of Internal Medicine; 135: 239-247.

Monaghan J, Thomas D, Goodburn K and Hutchison M (2009) A review of the published literature describing foodborne illness outbreaks associated with ready to eat fresh produce and an overview of current UK fresh produce farming practices. Food Standards Agency. http://www.foodbase.org.uk/results.php?f_report_id=340.

Moriarty E, McEwan N, MacKenzie M, Karki N, Sinton LW, Wood D. (2011) Incidence and prevalence of microbial indicators and pathogens in ovine faeces in New Zealand. New Zealand Journal of Agricultural Research; 54:71-81.

Moriarty E, Sinton LW, MacKenzie M, Karki N, Wood D. (2008) A survey of enteric bacteria and protozoans in fresh bovine faeces on New Zealand dairy farms. Journal of Applied Microbiology; 105: 2015–2025.

Neuwelt P, Simmons G, Thornley C and Mohiuddin J (2006) *Salmonella* outbreak in the Auckland and Waikato regions. New Zealand Public Health Surveillance Report; 4: 6.

Neuwelt P, Thornley C, Simmons G and Mohiuddin J (2009) Outbreak report: Investigation of a *Salmonella* Saintpaul outbreak in the Auckland and Waikato regions. http://www.foodsafety.govt.nz/elibrary/industry/Outbreak_Report-Science_Research.pdf.

NPDC (2009) New Plymouth District Council Annual Report 2008/09. New Plymouth District Council. http://www.newplymouthnz.com/CouncilDocuments/Reports/AnnualReport/.

NZFSA (2009a) 2009 New Zealand Total Diet Study: Analytical results Q3. NZFSA information report. New Zealand Food Safety Authority. http://www.foodsafety.govt.nz/science/research-projects/total-diet-survey/2009.htm.

NZFSA (2009b) 2009 New Zealand Total Diet Study: Analytical results Q2. NZFSA information report. New Zealand Food Safety Authority. http://www.foodsafety.govt.nz/science/research-projects/total-diet-survey/2009.htm.

NZFSA (2010) 2009 New Zealand Total Diet Study: Analytical results Q4. NZFSA information report. New Zealand Food Safety Authority. http://www.foodsafety.govt.nz/science/research-projects/total-diet-survey/2009.htm.

NZS 4454 (2005) New Zealand Standard: Composts, Soil Conditioners and Mulches (NZS 4454:2005). Standards New Zealand.

NZS 8410 (2003) New Zealand Standard: Organic Production (NZS 8410:2003). Standards New Zealand.

NZWWA (2003) Guidelines for the safe application of biosolids to land in New Zealand. New Zealand Water and Wastes Association.

Reilly, C. (1980) Metal Contamination of Food. Applied Science Publishers: London.

Robinson B, Outred H, Brooks R, Kirkman J. (1995) The distribution and fate of arsenic in the Waikato river system, North Island, New Zealand. Chemical Speciation and Bioavailability; 7: 89-96.

Robinson B, Clothier B, Bolan NS, Mahimairaja S, Greven M, Moni C, Marchetti M, van den Dijssel C, Milne G. (2004) Arsenic in the New Zealand environment. SuperSoil 2004: 3rd Australian New Zealand Soils Conference, 5 – 9 December 2004, University of Sydney, Australia.

Robinson BH, Marchetti M, Moni C, Schroeter L, van den Dijssel C, Milne G, Bolan NS, Mahimairaja S (2006). Arsenic accumulation by aquatic and terrestrial plants: Taupo Volcanic Zone, New Zealand. In: Managing Arsenic in the Environment : From Soil to Human Health (Eds. R Naidu, E Smith, G Owens , P Bhattacharya , P Nadebaum). CSIRO publishing, Adelaide, Australia. pp 235 – 247.

Ryser E, Hao J and Yan Z (2009).Internalization of pathogens in produce. In: Microbial Safety of Fresh Produce, Ed: N. B. Fan X, Doona CJ, Fecherry FE, Gravani RB., 55-80. IFT Press, Wiley Blackwell.: Ames, Iowa.

Safranek T, Leschinsky D, Keyser A, O'Keefe A, Timmons T, Holmes S, Garvey A, Von Stein D, Harris M, Quinlisk P, Bidol S, Sheline K, Collins J, Vorhees R, Stella J, Ostroff S, Marriott C, Sandt C, Chmieleski W, Lando J, Saathof-Huber L, Anderson S, Hedican E, Meyer S, Smith K, Miller B, Rigdon C, Salehi E, Kightlinger L, Schaefer L, Hepper C, Wilson S and EIS officers (2009) Outbreak of *Salmonella* serotype Saintpaul infections associated with eating alfalfa sprouts - United States, 2009. Morbidity and Mortality Weekly Report; 58: 500-503.

Schilling C, Zuccollo J, Noxin C. (2010) Dairy’s role in sustaining New Zealand – the sector’s contribution to the economy. New Zealand Insitutue for Economic Research. Available from the Fonterra webiste.

Seymour I J and Appleton H (2001) Foodborne viruses and fresh produce. Journal of Applied Microbiology; 91: 759-773.

Sinton, LW. (2001) Microbial contamination of New Zealand's aquifers. In: Groundwaters of New Zealand. Eds: MR Rosen, PA White. New Zealand Hydrological Society. Caxton Press: Christchurch.

Sinton LW, Braithwaite RR, Hall CH, MacKenzie, ML. (2007) Survival of indicator and pathogenic bacteria in bovine faeces on pasture. Applied and Environmental Microbiology; 73: 7917-7925.

Sivapalasingam S, Friedman C, Cohen L and Tauxe R (2004) Fresh produce: a growing cause of outbreaks of foodborne illness in the United States, 1973 through 1997. Journal of Food Protection; 67: 2342-2353.

SKM (2008) Waste facilities survey – methodology and summary of results. Report for the Ministry for the Environment. Sinclair Knight Merz. http://www.mfe.govt.nz/publications/waste/waste-facilities-survey/index.html.

Solomon E B, Pang H J and Matthews K R (2003) Persistence of *Escherichia coli* O157:H7 on lettuce plants following spray irrigation with contaminated water. Journal of Food Protection; 66: 2198-2202.

Steele M and Odumeru J (2004) Irrigation water as source of foodborne pathogens in fruit and vegetables. Journal of Food Protection; 67: 2839 - 2849.

Turner N, Cressey P, Lake R and Whyte R (2005) Review of non-commercial wild food in New Zealand. New Zealand Food Safety Authority. http://www.foodsmart.govt.nz/food-safety/hunting-collecting-fishing/wild-foods-review/index.htm.

Tyrrel S F, Knox J W and Weatherhead E K (2006) Microbiological water quality requirements for salad irrigation in the United Kingdom. Journal of Food Protection; 69: 2029-2035.

Vannoort R (2009) 2009 New Zealand Total Diet Study. Analytical results - Q1. Client report FW0977 for the New Zealand Food Safety Authority. Institute of Environmental Science and Research (ESR) Limited. http://www.foodsafety.govt.nz/science/research-projects/total-diet-survey/2009.htm.

Warriner K, Huber A, Namvar A, Fan W and Dunfield K (2009) Recent advances in the microbial safety of fresh fruits and vegetables. Advances in Food and Nutrition Research; 57: 155-208.

Wei J and Kniel K E (2010) Pre-harvest viral contamination of crop originating from fecal matter. Food and Environmental Virology; 2: 195-206.

Webster-Brown, J. (2005) A review of trace metal transport and attenuation in surface waters. In "Metal Contaminants in New Zealand". TA Moore, A Black, JA Centano, JS Harding, Trumm DA (eds). Resolutionz press, Christchurch New Zealand: 193-212.

Werner S, Boman K, Einemo I, Erntell M, de Jong B, Lindqvist A, Lofdahl M, Lofdahl S, Meeuwisse A, Ohlen G, Olsson M, Stamer U, Sellstrom E and Andersson Y (2007) Outbreak of *Salmonella* Stanley in Sweden associated with alfalfa sprouts, July-August 2007. Eurosurveillance; 12: 3291.

Wong T (2003) Levels of *Escherichia coli* O157 in lettuces and *Salmonella* in apples. Client Report FW0338 for the New Zealand Food Safety Authority. Institute of Environmental Science and Research (ESR) Limited.

Wong T (2008) Prevalence of Listeria monocytogenes and other Listeria species in ready-to-eat salads (with dressings) from retail outlets in New Zealand. Client Report FW0749 for the New Zealand Food Safety Authority. Institute of Environmental Science and Research (ESR) Limited.

Client report FW11024

A REVIEW OF THE USE OF WATER AND NATURAL FERTILISERS DURING THE GROWING, HARVESTING AND PACKING OF HORTICULTURAL PRODUCE

VOLUME 2: APPENDICES TO VOLUME 1

Prepared for the Ministry of Agriculture and Forestry
under Agreement 11875

Dr Stephen On
Food Safety Programme Leader

Dr Rob Lake
Project Leader

Wendy Williamson
Peer Reviewer

Institute of Environmental Science & Research Limited
Christchurch Science Centre
Location address: 27 Creyke Road, Ilam, Christchurch
Postal address: P O Box 29 181, Christchurch, New Zealand
Website: www.esr.cri.nz

A CROWN RESEARCH INSTITUTE

REVIEW OF THE USE OF WATER AND NATURAL FERTILISERS DURING THE GROWING, HARVESTING AND PACKING OF HORTICULTURAL PRODUCE

VOLUME 2: APPENDICES TO VOLUME 1

Prepared for the Ministry of Agriculture and Forestry
under Agreement 11875

by

Rob Lake (ESR)
Jane Lancaster (Catalyst® R&D Ltd)
Nicola King (ESR)

September 2011

DISCLAIMER

ACKNOWLEDGEMENTS

The authors would like to thank the following people and organisations for their contribution to this volume:

Sarah Ibbotson (Otago Regional Council)

REFERENCES TO WEBSITES

All of the websites referred to in this document were available for access in April 2011, unless specified.

CONTENTS

LIST OF TABLES

1 APPENDIX 1: PROJECT METHODOLOGY AND SCOPE

Project Methodology and Scope

AGREEMENT 11875

A review of the use of water and natural fertilisers during the growing, harvest and packing of horticultural produce.

13 August 2010

Institute of Environmental Science and Research (ESR) Ltd
Christchurch Science Centre, PO Box 29 181, Christchurch 8540
Contact: Dr Rob Lake, Phone 03 3516019, Fax 03 3510010, Email: rob.lake@esr.cri.nz

Project scope

- The horticultural produce included in this study are fruit, vegetables, nuts, seeds, herbs, spices, cereal grains, fungi and grasses grown in New Zealand (organically or conventionally) for domestic sale or for export. They are intended to be consumed raw (whole or as pieces) or subject to further processing. For the purposes of this project (and following recent international foodborne outbreaks, this will also include raw dried or semi-dried product (e.g. prunes, spices, dried herbs).
- This study will gather information on the use of natural fertilisers and water from planting through to packing and storage, ready for transportation to retailers, distributers, exporters, further processing, etc. For the purpose of risk assessment, the effects of transportation, retail handling, and consumer handling and consumption on risk will be estimated from existing knowledge.
- The natural fertilisers included in this study are those produced from animal, plant and human waste products (e.g. biosolids, manure, farm effluent, compost, blood and bone meal).[1]
- The water included in this study may be potable or non-potable (e.g. from untreated bore water, streams) and is the water applied to produce for either irrigation or processing. The focus will be on non-potable water, which is not subject to the NZ Drinking Water Standards.
- The biological hazards included in this study are bacteria, parasites and viruses that principally cause enteric disease in humans. This study will also consider chemicals that are

---

1 For the purposes of this project the following definitions were used:

Organic fertiliser (natural fertiliser): Carbonaceous materials mainly of vegetable and/or animal origin added to the soil specifically for the nutrition of plants and which contain nutrients as per the definition of a fertiliser.

Organic wastes: Any material of animal or plant origin that has not been subjected to a process that assures the content and safety of the material. It includes all unprocessed animal and plant tissues, secretions and excretions such as animal manures, composted vegetable material, solids and effluents from animal or plant production and processing facilities, and unprocessed biosolids and effluent from sewage treatment facilities.

Fertiliser:

(a) a substance or biological compound, or mix of substances or biological compounds that is described as, or held out to be for, or suitable for, sustaining or increasing the growth, productivity, or quality of plants or, indirectly, animals through the application to plants or soil of:

(i) nitrogen, phosphorous, potassium, sulphur, magnesium, calcium, chlorine, and sodium as major nutrients; or

(ii) manganese, iron, zinc, copper, boron, cobalt, molybdenum, iodine, and selenium as minor nutrients; or

(iii) fertiliser additives; and

(b) includes non-nutrient attributes of the materials used in fertiliser; but

(c) does not include substances that are plant growth regulators that modify the physiological functions of plants.

(Fertiliser definition from: http://www.legislation.govt.nz/regulation/public/2001/0101/latest/DLM27755.html) hazardous to human health and that may be naturally associated with the water or natural fertilisers (e.g. heavy metals). Agrichemicals are excluded.

Methods to achieve the requirements of Schedule 1

Note: We have assumed a start date of mid-August 2010 for this proposal.

We have identified a set of questions we will seek to answer to meet the service requirements specified in Schedule 1 (Appendix). To answer these questions, this project will be conducted in four stages:

1. Information gathering (literature review, interviews with industry)

This part of the project will produce an overview of the New Zealand horticultural produce sector and the relevant controls. This will be constructed from:

- Publicly-available information on the produce industry (e.g. production, farm size, location), the manufacture and use of natural fertilisers (e.g. number of producers, volume of output, markets) and major sources of irrigation water;
- New Zealand regulations/guidelines/standards/codes of practice (including regulatory controls under the Resource Management and Health Acts, those produced by industry bodies, and the proposed Food Bill 2010);
- International assurance programmes/guidelines/standards/codes of practice that are relevant to New Zealand exports and domestic production;
- Existing reviews and risk assessments already conducted for NZFSA (see Appendix 2);
- Previous surveys of on-farm practices and management systems;[2]
- An existing analysis of fertiliser use in the horticulture sector already conducted by Catalyst.

This part of the project will also involve interviews with selected industry representatives, including natural fertiliser producers, produce industry bodies (e.g. HortNZ, HEA, Organics Aotearoa New Zealand, BioGro) with respect to produce assurance programmes (e.g. NZ GAP and Global GAP), assurance programme auditors (e.g. AsureQuality), produce markets (supermarkets, farmers markets) and local authorities. The interviews will augment information gathered in the literature review and will support the work to be undertaken in part 3. Consulting with industry organisations will publicise the project and improve cooperation. These organisations may also be able to provide data from benchmarking studies or audits (e.g. for compliance with NZ GAP standards).

Assessment of quality assurance standards: The New Zealand quality assurance standards identified will be reviewed against the international baseline, the Codex Alimentarius Code of Hygienic Practice for Fresh Fruits and Vegetables (CAC/RCP 53-2003). The assessment will follow the approach taken by Monaghan *et al*. (2009) but will only focus on information relevant to the use of natural fertilisers, irrigation water or water during post-harvest processing.[3]

2. Fieldwork: Information gathering on current practices in the horticulture industry

Information will be collected from individual growers on their use of natural fertilisers, irrigation water and water during post-harvest processes. The limited number of interviews to be undertaken means that they will be case studies, not a statistically based sampling of the total number of growers. The questionnaire developed by Monaghan *et al.* (2009) will be adapted for this part of the project (subject to UK Food Standards Agency approval) and growers will also be asked to identify where further guidance or standards are required.

We will consult with industry organisations before deciding on the methods to approach either the individual growers or sector groups. Property visits and interviews with growers are likely to provide the most useful information; surveys using telephone interviews and postal surveys typically have low response rates. The data collection will be undertaken at times appropriate to the specific sectors to

[2] For example, Fairweather *et al.* (2009) New Zealand Farmer Attitude and Opinion Survey 2008: Management systems and farming sustainability. Agriculture Research Group on Sustainability.

[3] Monaghan JM, DJI Thomas, K Goodburn and ML Hutchison (2009) A review of the published literature describing foodborne illness outbreaks associated with ready to eat fresh produce and an overview of current UK fresh produce farming practices. Food Standards Agency Project B17007, United Kingdom.

maximise participation. Property visits will require travel although this could be minimised through using Catalyst and ESR staff in other regions.

Two groups of growers will be targeted:

(i) Growers working within assurance programmes (e.g. NZ GAP, OOAP): The information collected from these growers will validate the information collated in part 1. Selection of these growers will be based on information collated in part 1, considering the potential for contamination from natural fertilisers and water used for irrigation and other horticultural purposes, volume of production, and the likelihood that the product will be consumed raw by the consumer. To make efficient use of resources, growers in 3-4 regions of New Zealand will be targeted.

(ii) Growers who are not in an assurance programme: These case studies will provide information on the practices applied by growers who supply domestic markets where membership of an assurance programme is not required.

Contact with growers who are in an industry assurance programme will be by a range of methods including Approved Supplier databases[4] and through existing links with appropriate staff at sector organisations e.g. Pipfruit NZ, the Avocado Industry Council, Zespri, HEA etc.

A range of measures will be used to identify and contact growers who are not in an assurance programme. This may include:

- Consultation with Horticulture NZ and their sector groups. While major sector groups have industry assurance plans many smaller sectors may not, and we will approach relevant associations to identify groupings and individual growers. Growers/sectors with an export focus will typically have industry programmes so we would focus on those whose production is for domestic consumption.
- Consultation with organisations such as the NZ Biodynamic Association, the New Zealand Biological Producers and Consumers Council (BioGro), Organics Aotearoa New Zealand and Farmers Markets NZ Inc.
- Consultation with retailers/wholesalers/farmers markets regarding their suppliers. Participation in programmes such as NZ GAP, or an FSP, or WQA, is typically driven through wholesalers or retailers e.g. supermarkets requiring suppliers to become accredited. We will consult with them to identify suppliers who have not entered an official assurance system.
- The use of Approved Supplier databases as noted above. This notes growers/organisations that have discontinued participation and could be approached.
- Review of resource consents for the application of human biosolids.

The industry sectors and geographical regions for grower visits will be agreed with NZFSA before fieldwork commences.

3. <u>Reporting: Assessment of potential risk to consumers, and evaluation of current risk management</u>

Reporting will follow the standard format for scientific publications, including the identification of data gaps. The report will identify any regional differences in produce grown, water sources, and practices in relation to organic materials (e.g. biosolids) and water for irrigation and other horticultural purposes.

[4] e.g. http://approvedsuppliersearch.agriquality.co.nz/

Timescales

We aim to agree a final report with MAF by 29 April 2011.

Part 1	Collation of existing literature	August 2010
	Consultation with industry organisations	September 2010
	Assembly into review with focus on NZ perspective	September-October 2010
Part 2	Selection of targets for case studies (sectors, regions, practices) and agreement with NZFSA	October 2010
	Development of survey tools	October-November 2010
	Visits to growers*	November 2010-January 2011
Part 3	Report writing and internal peer review	February 2011
	Draft report to MAF and comments returned	March 2011
	Finalising report and delivery to MAF	April 2011

* It is possible that this work may extend beyond January as a result of peak harvesting periods. NZFSA will be kept informed of any changes in the timescales should this occur.

Scientific personnel:

ESR: Rob Lake, Nicola King, Margaret Leonard, David Wood, Wendy Williamson
Catalyst® R&D Ltd: Jane Lancaster, Malcolm Garnham, Wymond Symes

APPENDIX 1: Investigation questions

1	**Growing practices**
1.1	**Good Agricultural Practices:** ***What is good practice for the use of water and natural fertilisers during the growth of fresh produce, and is this being applied?***
1.1.1	What is the extent of application of natural fertilisers during primary production of horticultural produce (conventional and organic) in New Zealand? - What fertilisers are being used in New Zealand, and for what produce? - How much fertiliser is being applied and how often? - When during the growing phase of the produce is fertiliser being applied? - What methods are used to apply the fertiliser? *These questions will also be applied to irrigation waters.*
1.1.2	What are the currently available guidance and control measures? *Regarding the application of natural fertilisers and irrigation waters during the growing of produce:* - What regulations have been set by the New Zealand Government? - What regulations have been set by New Zealand compliance or regulatory bodies? What guidelines have been produced by New Zealand industry representative bodies?
1.1.3	Are internationally available guidelines for the application of water and natural fertilisers applicable to New Zealand? *Regarding the application of natural fertilisers and irrigation waters during the growing of produce:* - What international regulations or guidelines apply to New Zealand export produce? - What regulations or guidelines have been set by international (Codex, WHO) or regional (EU) organisations?
1.2	**Risk Management:** ***What is the risk of bacterial contamination of the edible part of produce during the growing phase and how is this risk being managed?***
1.2.1	Is the application of natural fertilisers and potentially contaminated water (different sources) under conditions of primary production in New Zealand likely to lead to significant microbial contamination? - What hazards are potentially present in natural fertilisers used in New Zealand and at what concentrations? - What hazards are potentially present in non-potable irrigation waters used in New Zealand and at what concentrations? - Can the method, volume or timing of application cause external or internal contamination of the edible portion of the produce by enteric pathogens or hazardous chemicals? - What controls are in place to reduce or remove hazards in the fertiliser, water or from the produce during the growing phase?
1.2.2	Is residual contamination likely to occur at a level that may constitute a foodborne risk to consumers? - What are the New Zealand standards for microbial/chemical contamination of fresh produce? - What international standards apply to produce exported from New Zealand? - What are the enteric pathogens or chemicals most likely to contaminate produce and at what concentration might these be present?
2	**Harvesting, post-harvest wash and packing**
2.1	**Good Agricultural Practices:** ***What is good practice for the use of water during the harvest of fresh produce, and any post-harvest activities, and is this being applied?***
2.1.1	What is the extent of application of water during harvesting and post-harvesting activities of horticultural produce (conventional and organic intended for domestic consumers and export) in New Zealand? - How is water used during harvesting/washing/packing? - Under what conditions is the produce stored with respect to contamination by residual water? (including whether wet or in water, packaging, controlled temperature/atmosphere) - What controls are in place to ensure water used during harvest and in any post-harvest activities is free of contamination?

2.1.2	What are the currently available guidance and control measures? *Regarding the application of water during the harvesting, packing and storage of produce:* - What regulations have been set by the New Zealand Government? - What regulations have been set by New Zealand compliance or regulatory bodies? - What guidelines have been produced by New Zealand industry representative bodies?
2.1.3	Are the internationally available guidelines for the application of water and natural fertilisers[5] applicable to New Zealand? *Regarding the application of water during the harvesting, packing and storage of produce:* - What international regulations or guidelines apply to New Zealand export produce? - What regulations or guidelines have been set by international (Codex, WHO) or regional (EU) organisations?
2.2	**Risk Management: *What is the risk of bacterial contamination of the edible part of produce during the harvest and post-harvest phases and how is this risk being managed?***
2.2.1	Is the application of potentially contaminated water under conditions of harvest and packaging in New Zealand likely to lead to significant microbial contamination? - What hazards are potentially present in non-potable wash waters used in New Zealand and at what concentrations? - Can the method, volume or timing of application cause external or internal contamination of the edible portion of the produce? - How might contamination concentrations change during storage? - What controls are in place to reduce or remove hazards from the produce during harvest and packing?
2.2.2	Is residual contamination likely to occur at a level that may constitute a food-borne risk to consumers? - Standards for microbial/chemical contamination of fresh produce – section 1.2.2 - What practices are more likely to result in residual contamination that may constitute a foodborne risk to consumers? - What is known about transport and retail storage/presentation that will affect risk? - What is known about produce consumption and domestic handling that will affect risk?

[5] We do not anticipate that natural fertilisers will be used in any post-harvesting activities.

APPENDIX 2: ESR publications and reports relevant to this ROI.

Hudson JA, Billington C, McIntyre L. (2009) Biological control of human pathogens on produce. In: Microbial safety of fresh produce. Eds. I. Fan, Niemira BA, Doona CJ, Feeherry FE, Gravani RB. IFT Press, Wiley-Blackwell; Iowa, USA.

Hudson, J.A. and Graham, C. (2002) Review of the microbiological status and safety of hydroponically grown vegetables. New Zealand Journal of Environmental Health, 25 (2) 23-27.

Graham CF, Dawson C. (2002) A survey of hydroponically grown vegetables in New Zealand. New Zealand Journal of Environmental Health; 25: 21-22.

Whyte R, Hudson JA, Hasell S, Gray M, O'Reilly R. (2001) Traditional Maori food preparation methods and food safety. International Journal of Food Microbiology; 69: 183-190.

Reports for the NZFSA and Ministry of Health:

Wong TL. (2003) Ministry of Agriculture and Forestry Project FMA128 Levels of *Escherichia coli* O157 in lettuces and *Salmonella* in apples. Client Report FW0338. A report for the New Zealand Food Safety Authority. ESR: Christchurch Science Centre.

Gilbert S, Lake R, Hudson JA, Cressey P. (2006) Risk Profile: Shiga-toxin producing *Escherichia coli* in leafy vegetables. Client Report FW00456. A report for the New Zealand Food Safety Authority. ESR: Christchurch Science Centre.

Lake R, Hudson JA, Cressey P, Gilbert S. (2005) Risk Profile: *Listeria monocytogenes* in ready-to-eat salads. Client Report FW00446. A report for the New Zealand Food Safety Authority. ESR: Christchurch Science Centre.

Hudson JA, Turner N. (2002) Risks associated with bacterial pathogens in exported fruit and vegetables. Client Report FW0280. A report for the New Zealand Food Safety Authority. ESR: Christchurch Science Centre.

McIntyre L, Cornelius A. (2009) Microbiological survey of retail fresh produce of imported, domestic conventional and domestic organic origin. Client Report FW09064. A report for the New Zealand Food Safety Authority. ESR: Christchurch Science Centre.

McIntyre L, Cressey P, Lake R. (2008) Discussion document on pathogens in fruit and vegetables in New Zealand. Client Report FW0737. A report for the New Zealand Food Safety Authority. ESR: Christchurch Science Centre.

Lake R, Ball A. (2009) Food processors using self supplied water. Client Report FW08101. A report for the New Zealand Food Safety Authority. ESR: Christchurch Science Centre.

Leonard, M. Wall, K. (2008) Survival of Indicator Organisms in Topsoil after a Raw Sewage Spill on turf. Client Report FW0571. ESR: Christchurch Science Centre.

Ball A, Greening G, Leonard M (2008) Bivalve molluscan shellfish enteric virus guidelines. Client Report FW08038. Report for New Zealand Food Safety Authority. ESR: Christchurch Science Centre.

M. Leonard & H. Kikkert 2006 Efficacy of greywater treatment in New Zealand. FW0682 A report by ESR for the Ministry of Health. ESR: Christchurch Science Centre.

CATALYST reports relevant to this ROI

“Setting a New Zealand Honey Standard for Monofloral Varieties of Honey Produced in New Zealand” A consultation paper for the Bee Products Standards Council 2009

Review of the New Zealand Official Organic Assurance Programme (OOAP). June 2007 for Organics Aotearoa New Zealand

Export Phytosanitary Certification Model and System for horticulture, arable and forestry product. For MAFBNZ 2005-2006

Exports Cost Recovery Project. For MAFBNZ 2006

“Creating value in the horticulture industries”. Submission to FRST prepared for Fruit Grower and Vegetable Growers Federations 2004

“Greenhouse Gas Emissions in the Summerfruit Sector in New Zealand” A Scoping Report for Summerfruit New Zealand 2009

“The development of New Zealand specific emission factors for selected Zespri packaging options” ZESPRI International Ltd 2009

“GHG sources in Horticulture and Arable Industries – a survey of fertiliser practices in the horticulture industries.” 2008

2 APPENDIX 2: THE HORTICULTURAL SECTOR IN NEW ZEALAND (TABLES)

2.1 Statistics New Zealand Data

The following data were all collated from data provided by Statistics New Zealand (http://www.stats.govt.nz/).

2.1.1 Regional data for major crops by area planted

Regional production of major crops only, separated by fruit and nuts (Table 1) and vegetables (Table 2), to June 2009. Some totals may not add up due to variations in confidential (C) and suppressed (S) values. The confidential or suppressed nature of some of the regional data makes for discrepancies in the totals.

2.1.2 Regional data for farm numbers

Table 3 shows the number of farms by the product they grow (based on the ANZSIC06 classification) and regional council region, as at 30 June 2007.

2.1.3 Regional data for farm size

Table 4 shows the number of farms (by ANZSIC06 classification) distributed according to their size, as at 30 June 2007.

2.1.4 Horticultural sector data

Tables 5 and 6 compile information from industry publications and websites, and are organised largely according to product group. Table 5 covers production in New Zealand and Table 6 compiles data on New Zealand exports of horticultural products.

The industry sources were:

- Horticulture New Zealand website, http://www.hortnz.co.nz/ (most information from 2006, but some more recent).
- Ministry of Agriculture and Forestry Agricultural Production Census (most recent was in 2007).
- Fresh Facts 2009 (prepared for Plant and Food Research, most hectare data taken from 2007 Census, but some additional area data and better grower number data from the sectors themselves).

Most data is from the period 2006-2009. Where totals have been reported for a larger group (e.g. berryfruit) these are included, but do not represent a summation of data from individual groups. Grower numbers cannot really be summed, as individual growers are likely to produce a range of crops.

Table 1: Fruit and nuts (area planted, hectares; June 2009)

Regional council area	Kiwifruit	Apples	Pears[1]	Stonefruit[2]	Citrus	Avocados	Berries	Nuts
Northland	600	46	5	10	368	1,544	10	79
Auckland	S	121	29	53	113	90	144	94
Waikato	786	223	46	42	25	S	346	24
Bay of Plenty	10,216	C	8	7	96	2,156	33	36
Gisborne	273	116	4	0	1,071	59	C	C
Hawkes Bay	240	5,409	201	823	43	S	43	8
Taranaki	C	C	0	0	0	59	C	C
Manawatu-Wanganui	141	24	62	11	2	C	40	16
Wellington	C	109	24	22	C	C	3	46
North Island	12,652	6,055	405	996	1,718	4,104	619	346
Tasman	635	2,382	265	30	C	11	643	38
Nelson	C	C	C	0	C	C	0	0
Marlborough	C	34	10	55	0	0	C	14
West Coast	0	0	0	0	0	0	0	0
Canterbury	C	180	13	133	0	C	928	577
Otago	C	572	19	1,000	0	C	14	144
Southland	0	C	0	0	0	0	C	0
South Island	635	3,229	318	1,238	7	13	1,585	749
Total for all regions	**13,287**	**9,284**	**723**	**2,233**	**1,871**	**4,117**	**2,446**	**1,094**

1. Including nashi.
2. Also known as summerfruit: cherries, apricots, nectarines, peaches and plums.

Table 2: Vegetables (area planted, hectares; June 2009)

Regional council area	Onions	Brassicas	Covered crops[1]	Lettuce and leafy vegetables	Peas and beans	Roots and tubers[2]	Potatoes	Stalks[3]	Buttercup squash	Tomatoes
Northland	C	6	223	8	4	1,020	19	62	4	C
Auckland	1,818	877	680	599	55	340	1,508	272	C	5
Waikato	1,265	28	289	346	C	55	2,092	119	C	0
Bay of Plenty	C	C	183	C	C	C	S	122	C	C
Gisborne	C	6	11	C	C	C	C	1,991	1,589	C
Hawkes Bay	427	39	60	30	C	C	1,031	1,838	4,191	388
Taranaki	C	C	56	0	0	S	C	C	0	0
Manawatu-Wanganui	S	854	202	341	12	C	S	286	S	S
Wellington	11	38	14	64	6	C	S	11	C	7
North Island	3,809	2,574	1,717	1,617	86	1,405	6,704	4,836	C	735
Tasman	30	110	45	66	C	C	C	70	11	C
Nelson	0	C	C	C	0	C	C	C	0	0
Marlborough	C	C	9	C	613	0	C	650	0	C
West Coast	0	0	C	C	0	C	0	C	0	0
Canterbury	672	491	267	28	4,321	449	4,336	690	C	4
Otago	C	175	70	63	C	S	139	2	0	C
Southland	C	C	14	C	C	C	C	C	0	0
South Island	702	1,085	428	584	4,976	705	4,693	1,488	C	9
Total	**4,511**	**3,660**	**2,144**	**2,210**	**6,724**	**2,517**	**11,398**	**6,324**	**6,825**	**745**

1. Capsicum, cucumber, cooking herbs, lettuce and salad greens, mushrooms, tomatoes, others.
2. Carrots and kumara.
3. Sweetcorn, pumpkin, melon.

Table 3: Number of farms by ANZSIC06 farm type and region (30 June 2007)

Regional council area	Farm type – growing of:									
	Mushrooms	Vegetables (under cover)	Vegetables (outdoors)	Kiwifruit	Berryfruit	Apples and pears	Stone fruit	Citrus fruit	Olives	Other fruit and tree nuts
Northland	3	39	108	99	9	9	12	57	66	285
Auckland	3	171	156	66	33	30	15	33	45	162
Waikato	3	48	108	147	45	39	9	12	18	81
Bay of Plenty	3	24	30	1812	12	12	6	63	21	669
Gisborne	-	3	42	30	3	18	3	141	3	27
Hawkes Bay	3	15	87	27	9	285	105	9	27	21
Taranaki	-	9	12	3	-	3	3	3	-	36
Manawatu-Wanganui	-	15	123	21	21	27	9	3	9	24
Wellington	3	15	33	-	6	24	9	-	51	27
North Island	12	336	702	2202	138	450	168	324	237	1326
Tasman	-	21	30	39	45	171	12	6	27	21
Nelson	-	3	-	-	-	3	-	-	3	6
Marlborough	-	3	27	-	-	6	27	-	33	15
West Coast	-	9	-	-	-	-	-	-	3	9
Canterbury	6	75	228	-	48	51	39	3	129	183
Otago	-	12	33	-	6	24	111	-	9	33
Southland	-	3	21	-	3	-	3	-	-	9
Chatham Islands	-	-	3	-	-	-	-	-	-	-
South Island	6	126	345	42	105	258	189	6	201	276
Total	**18**	**462**	**1047**	**2247**	**243**	**708**	**357**	**330**	**435**	**1602**

Table 4: Number of farms of each size by ANZSIC06 farm type (30 June 2007)

Farm type – growing of:	Number of farms by size in hectares													
	<5	5-9	10-19	20-39	40-59	60-79	80-99	100-199	200-399	400-599	600-799	800-999	1,000-1,999	2,000-3,999	Total
Mushrooms	12	3	0	3	0	0	0	0	0	0	0	0	0	0	**18**
Vegetables (under cover)	375	51	18	12	3	0	0	0	0	0	0	0	3	3	**462**
Vegetables (outdoors)	300	123	150	138	60	39	36	93	69	21	6	6	6	3	**1,047**
Kiwifruit	924	606	423	177	54	21	15	21	6	0	0	0	0	0	**2,244**
Berryfruit	117	45	39	18	12	6	0	3	3	0	0	0	0	0	**246**
Apples and pears	165	129	153	141	51	21	12	24	6	0	0	3	0	0	**711**
Stonefruit	159	81	57	36	9	3	0	6	9	0	0	0	0	0	**360**
Citrus fruit	165	84	39	21	6	6	3	3	0	0	0	0	0	0	**327**
Olives	270	105	39	15	0	0	0	3	0	0	0	0	0	0	**438**
Other fruit and tree nuts	909	372	177	81	21	15	6	18	6	0	0	0	0	0	**1,602**

Table 5: Horticultural sector data

Produce type	Industry groups	Produce	Grower numbers (approximate)	Area (hectares, approximate)	Ready-to-eat?[1]
Berryfruit		All berryfruit	240	2,700	
	Blueberry Product Group	blueberries	90	500	Yes
	Blackcurrants New Zealand Ltd	blackcurrants	50	1,300	No (all processed)
	Berryfruit Export New Zealand	boysenberries	50	300	Yes
	Strawberry Growers New Zealand	strawberries	100	200	Yes
Other fruit	New Zealand Avocado Growers Association	avocados	100	4,500	No
	Persimmon Industry Council	persimmons	40	180	No
	Pipfruit New Zealand Inc.	apples, pears	520	9,000	Yes
	Nashi New Zealand Inc.	nashi	90	100	Yes
	New Zealand Tamarillo Growers Association	tamarillo	70	200	No
	Summerfruit New Zealand	peaches, nectarines, cherries, apricots, plums	350	2,300	Yes
	Table Grapes Export Council	table grapes	Not known	Not known	Yes
	New Zealand Citrus Growers Inc.	lemons, oranges, mandarins, grapefruit	450	1,800	No
	New Zealand Feijoa Growers Association	feijoas	200	250	No
	New Zealand KiwiBerry	kiwiberry		25	Yes
	New Zealand Kiwifruit Growers Inc.	kiwifruit	2,750	13,000	No
	Olives New Zealand	olives	400	2,200	No
	New Zealand Passionfruit Growers Association	passionfruit	90	50	No

Table 5 (continued)

Produce type	Industry groups	Produce	Grower numbers (approximate)	Area (hectares, approximate)	Ready-to-eat?[1]
Vegetables	HortNZ Fresh Vegetables Product Group (Includes six product groups below)	All fresh vegetables for HortNZ groups	1450	35,000	
	1. Alliums Crop Advisory Group	garlic, leeks, onions, shallots, spring onions	Onions: 130 Garlic: 30 Shallots: 10	Onions: 4,500 Garlic: 270 Shallots: 25	No (except garlic and spring onions)
	2. Brassica Crop Advisory Group	broccoli, brussel sprouts, cabbages, cauliflowers, swedes, turnips, radishes, broccoflowers, Asian greens	All Brassicas: 260 Broccoli: 80 Cabbage: 80 Cauliflower: 100	All Brassicas: 3,900 Broccoli: 2,200 Cabbage: 800 Cauliflower: 850	Yes
	3. Covered Crops Group[2]	capsicums, chillies, cucumbers, eggplants, lettuces, sprouted beans, witloof, courgettes	Capsicums: 130 Lettuce: 310 Beans: 180	2,100 Capsicums: 70 Lettuce: 1,200 Green beans: 700	Yes
	4. Leafy Crops Committee[3]	lettuces, silverbeet, spinach, mesclun, salad leaves, watercress, beans, peas, snow peas	Lettuce: 310 Silverbeet/spinach: 120 Peas: 600	Lettuce: 1,300 Silverbeet/spinach: 350 Peas: 6,791:	Yes
	5. Roots and Tubers Product Committee[4]	carrots, kumara, beetroot, parsnips, yams, taro	Carrots: 110 Kumara: 90	All roots and tubers: 2,500 Carrots: 1,500 Kumara: 1,200	No
	6. Stalks/Vines/Bulbs/Herbs Crop Advisory Group	artichokes, celeriac, celery, courgettes, gherkins, marrows, melons, pumpkins, chokos, fennel, parsley, herbs, rhubarb, squash, sweetcorn	Sweetcorn: 110 Squash: 200 Pumpkin: 100	All stalks/vines: 6,300 Sweetcorn: 6,000 Melons: 260 Pumpkin: 1,000	Yes[5]
	New Zealand Asparagus Council Inc.	asparagus	90	600	No

Table 5 (continued)

Produce type	Industry groups	Produce	Grower numbers (approximate)	Area (hectares, approximate)	Ready-to-eat?[1]
Vegetables (continued)	New Zealand Buttercup Squash Council	buttercup squash	Not known	7,000	No
	Tomatoes New Zealand (Fresh Tomato Product Group)	tomatoes	300	750 (outdoor)	Yes
	Potatoes New Zealand	potatoes	290	10,000	No
	Processed vegetables[6]	potatoes, sweet corn, peas, tomatoes, carrots, beans, asparagus	900 Processed potatoes: 130		No
Nuts		All nuts		1,500	
	New Zealand Chestnut Council	chestnuts	100	300	No
		macadamias		250	No
	NZ Walnut Industry Group	walnuts		500	No
		hazelnuts		400	No
Seeds	The New Zealand Grain and Seed Trade Association		80		No[7]
Cereal grains	Foundation for Arable Research				No[8]
Fungi	New Zealand Truffles Association	truffles			No
	Mushrooms		20	40	Rarely

1. Usually eaten whole (without peeling) with little or no processing.
2. Tomatoes are also a covered crop but a represented separately by Tomatoes New Zealand.
3. Lettuce appears in both leafy and covered product groups.
4. Fresh potatoes are represented by the Potato Product Group.
5. Celery, courgettes, herbs, parsley may be eaten raw.
6. Drawn from other product groups.
7. Primarily seed growing for planting and exports. May not be involved in edible seed production.
8. Rarely (see *Salmonella* in Cereals Risk Profile).

Table 6: Export data for New Zealand horticultural products

Produce type	Industry groups	Produce	HEA Product Group Data[1]		Export data from HortNZ and other websites
			2009 exports (tonnes)	2010 exports (tonnes)	
Berryfruit	Blueberry Product Group	blueberries			Exported but amount unknown
	Blackcurrants New Zealand Ltd	blackcurrants	2055	2029	
	Berryfruit Export New Zealand	boysenberries	1026	1393	
	Strawberry Growers New Zealand	strawberries			No information on exports [2]
Other fruit	New Zealand Avocado Growers Association	avocados	7721	12705	2008-2009 Annual Report: Total production 2,694,979 trays. Exported: 1,392,337 trays (mostly to Australia) 1.3m trays were sold either in the domestic market or for processing
	Persimmon Industry Council	persimmons	1527	1306	80% of production exported, mostly to Thailand
	Pipfruit New Zealand Inc.	apples, pears,			Apples and pears: 14 million cartons exported in year to March 2009, mostly to continental Europe MAF website suggests this is about 272,000 tonnes
	Nashi New Zealand Inc.	nashi	79	23	
	New Zealand Tamarillo Growers Association	tamarillo	45	25	
	Summerfruit New Zealand	peaches, nectarines, cherries, apricots, plums	2979	2817	70% consumed domestically as fresh, 25% exported, 5% processed 2008-2009: Apricots 1035 tonnes (mostly to Australia) Cherries 1536 tonnes (mostly to Taiwan) Nectarines 29 tonnes Peaches 23 tonnes Plums 27 tonnes
	Table Grapes Export Council	table grapes			No information on exports[2]
	New Zealand Citrus Growers Inc.	lemons, oranges, mandarins, grapefruit			Exported but amount unknown

Table 6 (continued)

Produce type	Industry groups	Produce	HEA Product Group Data[1]		Export data from HortNZ and other websites
			2009 exports (tonnes)	2010 exports (tonnes)	
Other fruit (continued)	New Zealand Feijoa Growers Association	feijoas			No information on exports[2]
	New Zealand KiwiBerry	kiwiberry			5 licensed exporters
	New Zealand Kiwifruit Growers Inc.	kiwifruit	14177	15293	Major export crop.
	Olives New Zealand	olives			
	New Zealand Passionfruit Growers Association	passionfruit			No information on exports[2]
Vegetables	HortNZ Fresh Vegetables Product Group (Includes six product groups below)				Fresh vegetables: In 2007 318,605 tonnes exported
	1. Alliums Crop Advisory Group	garlic, leeks, onions, shallots, spring onions			Onions are exported: of 210,000 tonnes produced in 2006, 156,546 tonnes were exported. In 2007 186,030 tonnes onions exported.
	2. Brassica Crop Advisory Group	broccoli, brussel sprouts, cabbages, cauliflowers, swedes, turnips, radishes, broccoflowers, Asian greens			Almost all domestically consumed (a small quantity of cabbage is exported)
	3. Covered Crops Group[3]	capsicums, chillies, cucumbers, eggplants, lettuces, sprouted beans, witloof, courgettes			Of 11,500 tonnes of capsicums produced in 2006, 6,268 tonnes were exported. 6,205 tonnes exported in 2007.
	4. Leafy Crops Committee[4]	lettuces, silverbeet, spinach, mesclun, salad leaves, watercress, beans, peas, snow peas			Majority is domestically consumed, with small amounts of lettuce and chicory exported. Salad vegetables: 428 tonnes exported in 2007.
	5. Roots and Tubers Product Committee[5]	carrots, kumara, beetroot, parsnips, yams, taro			90% of carrots are exported fresh 36 tonnes of fresh kumara are exported

Table 6 (continued)

Produce type	Industry groups	Produce	HEA Product Group Data[1]		Export data from HortNZ and other websites
			2009 exports (tonnes)	2010 exports (tonnes)	
Vegetables (continued)	6. Stalks/Vines/Bulbs/Herbs Crop Advisory Group	artichokes, celeriac, celery, courgettes, gherkins, marrows, melons, pumpkins, chokos, fennel, parsley, herbs, rhubarb, squash, sweetcorn			Fresh (organic) sweetcorn is exported
	New Zealand Asparagus Council Inc.	asparagus			Half exported Approximately 1,080 tonnes exported or processed in 2009
	New Zealand Buttercup Squash Council	buttercup squash	87792	83502	About half production exported (90,000 tonnes), mostly to Japan
	Tomatoes New Zealand (Fresh Tomato Product Group)	tomatoes			About 5% of production ($10m) is exported Small scale exports to Australia commenced in Nov 2009 (150 tonnes)
	Potatoes New Zealand	potatoes			Approximately 25% of production (total production approximately 500,000 tonnes) is exported (mostly as french fries = 79% of export value in 2008) 27,634 tonnes of fresh potatoes exported in 2008 26,000 tonnes fresh and 77,000 tonnes frozen and processed exported in 2007

1. HEA, New Zealand Horticulture Export Authority. Empty cells indicate that the HEA does not administer these crops.
2. These products may not be exported.
3. Tomatoes are also a covered crop but a represented separately by Tomatoes New Zealand.
4. Lettuce appears in both leafy and covered product groups.
5. Fresh potatoes are represented by the Potato Product Group.

3 APPENDIX 3: HORTICULTURE AND FOOD SAFETY

3.1 Behaviour of microbial pathogens in horticultural produce

The two most important intrinsic factors of foods in relation to microbial growth are pH and water activity, and it is generally accepted that foods with a pH greater than 4.6 and a water activity of greater than 0.85 have the potential to support the growth of a variety of bacterial pathogens (McIntyre *et al.*, 2008). Most produce has a high water activity so attention to pH is important for determining which are more likely to support bacterial growth.

Fruits generally contain high concentrations of organic acids and so are of low pH (Hudson and Turner, 2002; McIntyre *et al.*, 2008). However, there is a great deal of variability, for example the flesh of passionfruit is around pH 2-3, oranges pH 3-4 and melons pH 5-7. A risk assessment of fresh fruits grouped them into high acid (pH≤4.0) and low acid (pH>4.0), with the assumption that pathogen growth was unlikely for high acid fruits (citrus fruits, pineapple, kiwifruit, passionfruit, berries) (Bassett and McClure, 2008). This review also noted that climacteric fruit (which can ripen after removal from the plant) would be more susceptible to microbial infection and spoilage as such ripening is associated with a rise in pH. Kiwifruit is a high acid but climacteric fruit.

While low pH might prevent growth, some pathogens are tolerant of these conditions and can survive. For example, *E. coli* O157:H7 was able to survive in a variety of different fruit pulps (pH 2.65-3.24) for up to 30 days at 4°C (Marques *et al.*, 2001). The skin or rind of fruit might help to prevent any bacteria on the surface from accessing the nutrients in the flesh, but pathogens that may have been introduced to raw fruits during growth or harvest may survive for some time depending on the pathogen and the fruit (Hudson and Turner, 2002). This is important with some organisms, such as *Salmonella* spp., that survive well in the environment. Studies have also shown that bacteria are able to grow on the surfaces of fruits with naturally higher pH. For example, *E. coli* O157:H7 grew on the rind of both cantaloupe and watermelon at 25°C (Del Rosario and Beuchat, 1995). Tomatoes have a lower pH (pH 4.1 – 4.2 at the green stage, rising to 4.4 at full ripeness, and then to 4.6 after approximately 3 weeks later (Anthon *et al.*, 2011; Gautier *et al.*, 2008)) so growth on this product would be unexpected, at least until late ripening stages. However, *S.* Montevideo grew well on the surfaces of tomatoes stored at 20 or 30°C, and it has been proposed that many salmonella serotypes are able to colonise and survive on tomatoes but only some are able to multiply (Hanning *et al.*, 2009; Zhuang *et al.*, 1995).

The pH of vegetables varies between 5 and 7 and nutrients are more readily available for any microbial growth (Hudson and Turner, 2002). Where produce is stored at temperatures <7°C the growth of most pathogens would be inhibited (with the exception of *L. monocytogenes* and *Aeromonas* spp.), but many pathogens can survive cool storage. Most fresh ready-to-eat (RTE) vegetables are stored under cool conditions or for short periods of time to prevent spoilage. At higher temperatures the likelihood of growth will be dependent on the organism and the food, making it difficult to generalise (Hudson and Turner, 2002). Vegetables are more likely to be exposed to higher temperatures prior to harvest, particularly if the vegetables are grown indoors. Sprouts, for example, are produced under warm, humid conditions and this promotes growth of any bacteria present in the seeds (*S.* Enteritidis and *S.* Newport inoculated onto mung bean seeds increased by 2.5 logs in 48 h, and persisted for 4 days) (Mohle-Boetani *et al.*, 2009).

Once a vegetable or fruit is cut, the nutrients in the juice or tissue are available to bacteria and careful handling and storage is needed to prevent multiplication of pathogens to hazardous levels (Lynch *et al.*, 2009). An outbreak of shigellosis in 1986 was linked to shredded lettuce that was distributed across a number of restaurants from a single processing plant. Laboratory tests showed that the outbreak strain of *Shigella sonnei* could multiply rapidly on shredded lettuce at 22°C and was able to survive on the lettuce for at least seven days under refrigeration (Davis *et al.*, 1988). Both *L. monocytogenes* and *S.* Enteritidis were shown to grow on the pulp of melon, watermelon and papaya held at 10, 20 or 30°C (Penteado and Leitao, 2004a, 2004b). At 20°C, the generation times observed for *L. monocytogenes* ranged from 1.7 h (melon) to 6.4 h (papaya). At the same temperature the generation time for *S.* Enteritidis was between 1.6 and 1.7 h for all three fruits. Both pathogens also grew at 10°C on all fruits (generation times between 7 and 17 h). Even fruits with higher acidity have been shown to support the growth of pathogens once they are cut: *E. coli* O157:H7 grew on cut apple surfaces in air at 15-20°C (Gunes and Hotchkiss, 2002), and a four-serotype cocktail of *Salmonella enterica* was used to successfully model the growth of *Salmonella* spp. on cut tomatoes between 10 and 35°C (Pan and Schaffner, 2010).

Traditionally, microbial pathogens are thought to attach to the surfaces of plants, including the roots, leaves, fruits and flowers. Biofilms are complex structures composed of bacteria, filamentous fungi and yeasts, and incorporation of pathogenic bacteria into biofilms on the surface of leaves (called the phylloplane) could enhance their survival (Heaton and Jones, 2008). However, this is a growing field of research and some studies have shown that naturally occurring plant microflora might out-compete these pathogens (Critzer and Doyle, 2010; Heaton and Jones, 2008).

There is also a possibility that particular pathogens are associated with particular produce types, through as yet unknown adaptation mechanisms (e.g. *Salmonella* with tomatoes, cantaloupes, sprouted seeds and lettuce, *E. coli* O157 with sprouted seeds, lettuce, apples (juice) and spinach) (Warriner *et al.*, 2009).

3.1.1 Internalisation of microbial pathogens

There are a number of studies that demonstrate the passive movement of bacterial pathogens to the interior of plants. The bacteria can become internalised through a variety of routes (Lynch *et al.*, 2009):

- Movement with water by capillary action. *E. coli* O157:H7 infiltrated the core of intact apples placed in a suspension of the pathogen for 30 min (Burnett *et al.*, 2000). Liquid ingress carried the bacteria through the blossom end of the calyx and up the floral tube into the core region. Lettuces planted in pots were either fertilised with water or a manure slurry containing *E. coli* O157:H7 (taking care to keep the leaves free from the soil, water and slurry) (Solomon *et al.*, 2002). The pathogen was subsequently detected in the leaves of plants, having been carried up through the roots (NB: later studies have failed to demonstrate this effect, suggesting it is a rare event in leafy vegetables under field conditions (Erickson *et al.*, 2010; Johannessen *et al.*, 2005; Pu *et al.*, 2009; Zhang *et al.*, 2009)).

- Entry through wounds, bruises or openings in the surface of a fruit or leaf. *E. coli* O157:H7 preferentially attached to damaged tissue surrounding puncture wounds in apples and was detected at depths up to 70 µm below the tissue surface (Burnett *et al.*, 2000). In another experiment, *E. coli* O157:H7 attached to the stomata of lettuce leaves, and was also entrapped 20-100 µm below the surface in stomata (Seo and Frank, 1999). The presence of spoilage microorganisms (e.g. fungi) at wound sites may increase penetration and growth of pathogenic bacteria by breaking down tissues and releasing nutrients (Heaton and Jones, 2008).

- Transfer from seed to plant. This is particularly evident in sprout production, e.g. mung beans were submersed in a suspension of *E. coli* or *Salmonella* Montevideo then germinated; both pathogens multiplied and became the dominant flora during sprouting, and had colonised the interior of the sprouts (Warriner *et al.*, 2003).

- Transfer from flower to fruit. *Salmonella* serotypes were inoculated onto the flowers or into the stem below the flowers (before or after fruit setting) of tomato plants, and the tomatoes harvested once ripe (21 days or more after inoculation) (Guo *et al.*, 2001). Salmonellae were detected on the surface after ethanol treatment, and also in the stem scar tissue and pulp of tomatoes, irrespective of inoculation site or time.

- Pulled inside by temperature differences between the produce and a waterbath. Using wash water at a temperature cooler than that of produce (a negative temperature differential) causes air inside the fruit or vegetable to contract and the internal pressure of the product to lower, so water outside the product, and any microbes in that water, are drawn into the tissues by the resulting vacuum. For example, after mangoes were immersed in water at 47°C for 90 min (a fruit fly decontamination step), followed by immersion in water at 22°C for 10 min that had been seeded with *S.* Enteritidis, salmonellae were detected in flesh taken from the stem end of 5/6 melons (Penteado *et al.*, 2004).

Once pathogenic bacteria have colonised the internal parts of plants, the native competitive microflora and defence mechanisms of the plant might inhibit long-term colonisation (Critzer and Doyle, 2010). For example, *E. coli* O157:H7 and *Salmonella* Typhimurium were internalised in a variety of leafy vegetable seedlings, but the pathogens were not recovered in mature plants (Jablasone *et al.*, 2005).

The extent to which viruses or protozoa can move into plants has not been well studied. An inactivated hepatitis A vaccine virus inoculated into the soil or hydroponic solution of green onions, or directly to the stem, was detected inside the plant tissues after one week using reverse transcription PCR to identify the virus' RNA (Chancellor *et al.*, 2006). Murine norovirus 1 has been used as a surrogate for norovirus to demonstrate that viruses could enter lettuce leaves through stomata or cuts in the leaves (Wei *et al.*, 2010).

Once pathogens are inside the plant they cannot be removed by surface washing or disinfection (Lynch *et al.*, 2009).

3.2 New Zealand reviews and Risk Profiles

The following material provides more detail on previous reviews for New Zealand.

3.2.1 Ready to eat fruits and vegetables (2008)

The most recent review is a discussion document in 2008 intended to provide a preliminary guide as to possible risks in New Zealand associated with RTE intact and fresh cut vegetables and fruits, fresh (unpasteurised) juices and sprouts (McIntyre *et al.*, 2008).

From the summary:

"Despite the obvious potential for produce-related food safety issues, only one confirmed outbreak – Hepatitis A in raw blueberries – has been documented in New Zealand. However, an additional outbreak of *Salmonella* Saintpaul was tentatively linked to the use of contaminated wash water, and a further VTEC outbreak investigation revealed the presence of *E. coli* O157 in stream water being used as a source of farm-level wash water. These outbreaks suggest failures in good agricultural practices, either as a consequence of poor hygiene or the possible use of contaminated wash water. While both these aspects are addressed by the New Zealand GAP programme, they are acknowledged to be difficult to control and therefore areas of concern. In light of the information above, irrigation and processing water would therefore appear to be an area where additional risk management strategies may be particularly useful. Current underreporting, in combination with an anticipated increase in production and consumption of convenient RTE produce, may see additional incidents, perhaps outbreaks, in this country in the future. The contributions of organic production practices and the use of migrant workers to food safety risks from produce are unknown.

……

Given the breadth of this subject area, numerous data gaps need to be filled before a sensible assessment of the risk posed by pathogens in fruits and vegetables can be undertaken. A better description of the grower, processor and retail sectors in New Zealand needs to be assembled first in order to locate practices or specific products for further risk assessment."

The need to create an overview of the horticultural production sector in New Zealand, as well as to identify data gaps, are addressed as part of the current project.

3.2.2 Risks associated with bacterial pathogens in exported fruit and vegetables (2002)

In 2002 MAF commissioned a study of the risks associated with bacterial pathogens in exported fruits and vegetables (Hudson and Turner, 2002). Parasites, viruses and *Yersinia enterocolitica* were not, however, considered in this report.

A number of potential biological hazards were identified (Table 7), based on literature identifying the potential for growth and survival, disease severity, dose response and prevalence data from overseas. It was noted that (up to 2002) prevalence information specific to New Zealand produce could not be located.

Table 7: Key microbial pathogens of concern in exported vegetables and fruits

Pathogen	Rationale for ranking of pathogens	Concern?
Aeromonas	Equivocal* pathogen	No
B. cereus	Lack of association between pathogen and produce-related outbreaks	No
Campylobacter	Low dose; mainly cross-contamination; rarely detected	No
C. botulinum	Lack of association between pathogen and produce-related outbreaks	No
E. coli O157:H7	Low prevalence in New Zealand but low dose	Yes
L. monocytogenes	Low probability of infection	No
Salmonella	Dominant aetiological agent	Yes
Shigella	Low dose; related to poor hygiene	No
S. aureus	Lack of association between pathogen and produce-related outbreaks; related to poor hygiene	No

*Pathogenicity of this bacterium remains to be confirmed.

Overseas data indicated that the highest risk export foods were likely to be lettuces (mainly due to *E. coli* O157), and melons and tomatoes (due to *Salmonella*). However, New Zealand-grown melons were considered to be low risk and tomatoes, although associated with several outbreaks internationally, were considered to be lower risk due to the growth of export tomatoes in hothouses in New Zealand, and while there was the potential for *Salmonella* to be introduced via the irrigation system, but there had been no documented cases of this occurring for this production method.

Overall, three food-hazard combinations (lettuce & *E. coli*; apples & *Salmonella*; and tomatoes & *Salmonella*) were recommended for further investigation based on international data and export values.

3.2.3 Risk profile: *Listeria monocytogenes* in ready-to-eat salads (2005)

A risk profile commissioned by the NZFSA was conducted to assess the risks associated with *Listeria monocytogenes* in ready-to-eat (RTE) salads (Lake *et al.*, 2005). These salads included lettuce and cabbage-based salads without dressings, and excluded coleslaws and salads with additional non-vegetable ingredients.

The risk profile indicated that invasive listeriosis rates (all cases) in New Zealand for 1999 – 2003 were similar to other countries (at 0.5 – 0.6 per 100,000), and that no evidence currently exists to link RTE salads to *L. monocytogenes* infections. Due to the limited and dated domestic prevalence data available, overseas data were used suggesting a prevalence of up to 10% in RTE salads but at levels of less than 100 CFU/g. Under normal conditions of storage (4°C for 7 days), only a 1 to 2 log increase would be expected given the known behaviour of the pathogen at refrigeration temperatures. It was therefore concluded that RTE salads would be unlikely vehicles for infection in New Zealand, and that good agricultural practices and good manufacturing practices, in conjunction with microbiological testing already being done by the industry, are the best means of managing this risk.

It was noted that data on current prevalence, quantitative contamination levels, market size and structure, and consumption levels of RTE salads in New Zealand were lacking.

The finding of *Listeria* contamination in baby leaf spinach salads during routine testing that resulted in a recall in January 2011 (see Volume 1 Section 3.6.2) supports the conclusion of this earlier Risk Profile.

3.2.4 Risk Profile: Shiga-toxin producing *Escherichia coli* in leafy vegetables (2006)

This risk profile (Gilbert *et al.*, 2006) noted that 91.5% of confirmed STEC infections in New Zealand in 2004 were due to *E. coli* O157:H7. Rates of infection in New Zealand were comparable to those of England and Scotland, lower than in Canada but higher than Australian data. Infections tend to be sporadic and no common source outbreaks had been detected. There are low shedding rates of *E. coli* O157 in cattle in New Zealand, although rates for other STECs are higher. Green leafy vegetables have not to date been linked to any domestic outbreaks and the importation of green leafy vegetables is a reportedly small component of the domestic market.

Based on a 1998 FAO/WHO review (FAO/WHO, 1998), which suggested that microbial loadings are due to environmental factors rather than the type of vegetable, it was concluded that preventing contamination from animal faeces is a priority. This is particularly important given the limitations of chlorine washing and the internalisation of pathogens within plant tissues, rendering the organisms immune to the disinfection process.

Based on the information gleaned above, and the fact that *E. coli* O157:H7 has not been detected in surveys of domestic vegetables, it was concluded that green leafy vegetables are not an important risk for foodborne transmission of STECs in New Zealand. It was however noted that New Zealand data were limited in terms of prevalence and levels of STEC in green leafy vegetables, market size/structure and population levels of consumption.

The rate of STEC infection in New Zealand has risen in recent years, and in 2010 was 3.2 per 100,000 population. This rate is higher than in the United Kingdom, where the most recent data shows a rate of 1.9 per 100,000 population in 2008[6].

3.3 New Zealand surveys of horticultural produce for microbiological hazards

3.3.1 A survey of hydroponically grown vegetables in New Zealand (1999)

In 1999 the New Zealand Ministry of Health (MoH) commissioned a survey to examine the microbiological safety and quality of hydroponically grown vegetables (Graham, 1999; Graham & Dawson, 2002). Sampling was conducted between October 1998 and May 1999. A total of 291 samples comprising 117 sprout samples (46 samples from producers and 71

[6] http://ecdc.europa.eu/en/publications/Publications/1011_SUR_Annual_Epidemiological_Report_on_Communicable_Diseases_in_Europe.pdf accessed 9 January 2012

from retail sources), 114 leafy vegetables (producers) and 60 herb samples (producers) were tested for counts of *E. coli*, coagulase-positive staphylococci and *L. monocytogenes*, and the presence of *Campylobacter*, *E. coli* O157 and *Salmonella*. Sprouts were also tested for *B. cereus*. Results were then compared with MoH Microbiological Reference Criteria for Food (1995) for cultured seeds and grains (section 5.5) and salads – vegetables or fruit – excluding meat (section 5.25).

Salmonella, *Campylobacter*, *E. coli* O157 and *L. monocytogenes* were not found in any samples. All sprout samples were compliant for *B. cereus* (<1000 CFU/g), and all but one of the leafy vegetables complied with the coagulase-positive staphylococci criterion (<1000/g). However, *E. coli* was detected in 34 (11.7%) samples – 15 sprouts (13%), 16 leafy vegetables (14%) and 3 herbs (5%) – suggesting faecal contamination and the potential for pathogens to be present in such products.

Eight sprout producers were also asked a series of questions based on HACCP implementation during sprout production. Five or more of the producers did not implement the following control points: Sanitising the seeds prior to germination, washing the sprouts prior to harvest and keeping the sprouts chilled during distribution.

3.3.2 *Escherichia coli* O157 in lettuces and *Salmonella* in apples (2003)

Based on the recommendations regarding risks from exported produce (Hudson and Turner, 2002), a quantitative study was subsequently initiated to investigate the prevalence of *E. coli* O157:H7 on lettuce and *Salmonella* on apples (Wong, 2003). This study considered both conventionally and organically grown produce from a number of growers as summarised in Table 8.

Table 8: Summary of results for the examination of lettuces and apples for the presence of *E. coli* O157 and *Salmonella* respectively

Food/Hazard	Number of samples	Production	Number of varieties	Findings
Lettuce/*E. coli*	240 (48x5)	Conventional (22 growers)	7	No *E. coli* O157:H7
Lettuce/*E. coli*	234 (46x5)+(1x4)	Organic (9 growers)	13	*E. coli* O157:H16 isolated from 1 sample
Apples/ *Salmonella*	239	Conventional	8	No salmonellae isolated
Apples/ *Salmonella*	230	Organic	5	1 batch positive for *S.* Typhimurium DT12a

E. coli O157:H7 and salmonellae were not detected in 240 conventionally grown lettuces and 239 conventionally grown apples respectively. One organic lettuce sample (of 234 tested) was found to be positive for *E.coli* O157:H16, but the isolate was later identified as non-verotoxigenic *E. coli* (non-VTEC) due to the absence of *stx*1, *stx*2 and *hly*A virulence genes. One batch of organic apples (from 230) was positive for *S.* Typhimurium DT12a (based on a pooled sample).

These survey results are in agreement with two similar organic lettuce surveys conducted in Northern Ireland (McMahon and Wilson, 2001) and the U.S. (Mukherjee *et al.*, 2004), although the sample numbers tested in both studies were much smaller than the New Zealand survey. Neither survey isolated *E. coli* O157:H7, although the U.S. survey demonstrated *E. coli* prevalence on organic lettuce at 24.4% (n=49) while prevalence on conventional lettuce was 16.7% (n=6). Prevalence was higher (30.8%) on uncertified organic farms using manure or compost less than 12 months old.

3.3.3 *Listeria monocytogenes* in deli RTE salads (2006-07)

A survey of RTE salads (with dressings) from retail outlets in New Zealand was conducted from February 2006 to February 2007 to determine the prevalence of *Listeria monocytogenes* and other *Listeria* species (Wong, 2008).

The prevalence of *Listeria* spp. in retail salads containing dressing was 7% (22 out of a total of 302 samples). Of these 22 samples of salads positive for *Listeria* spp., fourteen samples were contaminated with *L. monocytogenes* representing a prevalence of 4.6%. Coleslaw (12.9%) and pasta salad (9.1%) were more frequently contaminated with *L. monocytogenes*, followed by seafood salad (6.7%) where 2/3 *Listeria* isolates were *L. monocytogenes*.

Counts of *L. monocytogenes* in positive samples showed that one coleslaw sample contained 100 CFU g^{-1}, the highest count recorded in this survey while another counted 30 CFU g^{-1}. All other samples contained < 10 CFU g^{-1}.

Out of the 14 samples containing *L. monocytogenes*, four were contaminated with another species of *Listeria*; three of these were *L. welshimeri* and the other *L. innocua*. One bean salad sample contained a mixture of *L. innocua* and *L. welshimeri*. All the samples positive for *Listeria* spp. other than *L. monocytogenes* had a count of <10 CFU g^{-1}, indicating that contamination levels were very low. Bean and pulse salads were the only variety where *L. monocytogenes* was not isolated (N=54).

These data are very similar to *L. monocytogenes* prevalence data of 4.8% and 3.8% respectively reported in a British survey of mixed raw vegetable salads containing cooked meat (76/1268) or cooked seafood (54/1418) (Little *et al.*, 2005). Two salads containing chicken were found to have levels of ≥100 CFU/g *L. monocytogenes*, while all of the positive seafood salads were at levels <100 CFU/g. One salad in each category had between 10 and 99 CFU/g. As with the New Zealand RTE salads survey, a variety of other food ingredients (pasta, rice, mayonnaise, eggs, etc.) were included in these salads, therefore the actual source of *L. monocytogenes* contamination is impossible to speculate on.

3.3.4 Pathogens in fresh fruits and vegetables (2008-09)

A survey of fresh fruits and vegetables for pathogens was conducted during 2008 and 2009 (McIntyre and Cornelius, 2009). A total of 891 imported conventional (n=226) and domestically grown conventional (n=349) and organic (n=316) fresh fruits and vegetables were purchased from a variety of retail outlets in Auckland and Christchurch over a 15 month period. The produce sampled included melons, tomatoes, strawberries, apples, table grapes, capsicums, carrots, sprouts and leafy greens (lettuce, baby (salad) spinach, kale).

For each sample, concentrations of faecal coliforms and generic *E. coli*, and the prevalence of shiga-toxin producing *E. coli* (STEC) O157, *Salmonella* spp. and *Campylobacter* spp. were determined. Testing was conducted using most probable number (MPN) and enrichment-based standard methods on 250 g samples (excluding melon where one whole fruit was analysed per test). Results were assessed as satisfactory, marginal or unsatisfactory using relevant microbiological reference criteria for salads, sprouted seeds and RTE foods.

Campylobacter spp. and *E. coli* O157 were not detected in any sample. However, *Salmonella* Typhimurium phage type RDNC-May06 was detected in two domestic organic lettuces from the same grower, both of which were deemed satisfactory/marginal in terms of limits for faecal coliforms and *E. coli*. A site visit identified bird faeces on hail netting located directly above growing produce, which was particularly concentrated in areas where birds were able to land on metal hoops holding the netting up. It is likely that contamination occurred either through direct defecation onto plants below or indirectly via overhead irrigation and/or precipitation.

In terms of microbiological quality, 95.4% and 96.6% of produce items sampled were satisfactory, based on microbiological limits for faecal coliforms (Ministry of Health) or *E. coli* (FSANZ) respectively. All imported samples (apples, capsicums, grapes, melons and strawberries) were of a satisfactory nature, while at least 54% of marginal and unsatisfactory samples were attributed to domestic conventional and organically grown leafy greens.

The number of leafy green samples taken was (108/891) was a similar proportion to the other produce types. Between 72% (21/29) and 82% (18/22) of the marginal and unsatisfactory results obtained for leafy greens were due to organically grown spinach, lettuce and kale. However, it was noted that 15 samples of organic kale, of uniformly poor microbiological quality, were purchased from the same premises on a single sampling day which increased the number of marginal/unsatisfactory samples obtained overall. Excluding these results reduced the percentage of marginal and unsatisfactory results attributed to organic leafy greens to 43%, but leafy greens as a whole were still responsible for the highest proportion (54%; 14/26) of marginal and unsatisfactory results obtained overall. The next highest category was strawberries with 31% (8/26).

McIntyre & Cornelius (2009) suggested a review of current domestic practices for leafy greens in light of these results. The dominance of *E. coli* as a proportion of the faecal coliform population on leafy greens suggests that the current Ministry of Health guidelines are scientifically no longer appropriate. A guideline based on *E. coli* rather than faecal coliforms might be more robust. The inclusion of testing for additional pathogens such as non-O157 STECs, *Listeria monocytogenes*, viruses and protozoa would allow future produce surveys to more comprehensively assess the risks associated with the production, processing and consumption of fresh fruits and vegetables.

3.4 New Zealand surveys of horticultural produce for chemical hazards

The New Zealand Total Diet Study (NZTDS) is a regular survey of agricultural compound residues, contaminants and nutrients in New Zealand foods so that dietary exposure to these chemicals can be estimated. Horticultural produce is sampled as part of this survey, but it is important to note that these foods are a mixture of imported and domestically-grown produce.

The foods are analysed as they would normally be consumed, e.g. apples are rinsed and cored but tested with the skin on, potatoes are cooked, only the edible flesh of oranges is tested. Eight composite samples of each food type are tested over a period of one year (samples are collected from four New Zealand cities twice during the year).

Arsenic, cadmium, lead and mercury were detected in at least one horticultural produce sample during 2009 (Table 9). Dietary intake analyses from the 2009 NZTDS found that intakes of arsenic and lead from all foods were "as low as reasonably achievable" (ALARA) and unlikely to represent a significant risk to public health (MAF, 2011a). Although potatoes and carrots are significant contributors to total cadmium intake, total cadmium intake from all foods in the 2009 TDS was less than half of the provisional tolerable monthly intake from all age groups. The only produce sample in which mercury was detected was silverbeet. Intakes of mercury and methyl mercury are dominated by fish and shellfish, and intake estimates for New Zealand from the 2009 TDS were all less than half the provisional tolerable weekly intake.

The 1990/91 NZTDS included analyses for tin (Vannoort *et al.*, 1995). Tin is usually associated with canned products, and was only detected in the following non-canned horticultural products:

- Beans (sliced, frozen; n=12), mean 1,750 µg/kg;
- Potato (with skin, baked; n=15), mean 750 µg/kg;
- Potato (peeled, boiled; n=15), mean 750 µg/kg; and
- Apricots (dried; n=12), mean 5,750 µg/kg.

Estimated intakes of tin (from all foods) calculated from data in the 1990/91 NZTDS were less than 10% of the provisional tolerable daily intake (Vannoort *et al.*, 1995).

The 2009 NZTDS included testing for several organochlorine pesticides. The following organochlorine pesticides were not detected in any foods: Aldrin, benhexachlors (alpha(α)-BHC, beta(β)-BHC, delta(γ)-BHC, gamma(δ)-BHC/lindane), chlordanes (*cis*-chlordane, oxychlordane, *trans*-chlordane), dichlorodiphenyltrichloroethane (DDT) and its derivatives (2,4'-DDD, 2,4'-DDE, 2,4'-DDT, 4,4'-DDD, 4,4'-DDT), endrin, endrin aldehyde, endrin ketone, heptachlor, heptachlor epoxide and hexachlorobenzene (HCB).

The organochlorine 4,4'-DDE was detected in animal products (meat, dairy), but not horticultural products. The NZTDS did not test for pentachlorophenol (PCP) or toxaphene. The following organochlorines were detected in horticultural products:

Dieldrin:

- 1/8 courgette samples (0.0092 mg/kg)

Endosulfan I:

- 1/8 tomato samples (0.009 mg/kg)

Endosulfan II:

- 2/8 tomato samples (0.038 and 0.0025 mg/kg)
- 1/8 courgette samples (0.0019 mg/kg)
- 1/8 pear samples (0.0012 mg/kg)

- 1/8 strawberry samples (0.0028 mg/kg)

Endosulfan sulphate:
- 4/8 courgette samples (0.006, 0.006, 0.013 and 0.023 mg/kg)
- 2/8 tomato samples (0.007 and 0.003 mg/kg)
- 1/8 cucumber samples (0.007 mg/kg).

Dieldrin and endosulfan were deregistered from use in New Zealand in 1989 and 2009, respectively. The residues of dieldrin and endosulfan detected in the 2009 NZTDS were all less than the default maximum residue limit (MRL) of 0.1 mg/kg permitted for agricultural compounds in New Zealand (MAF, 2011b)

Between 1996 and 2001 New Zealand's Ministry for the Environment investigated the levels of organochlorines in foods, people and the environment.[7] Fifty-three foods were purchased, and combined into 22 food type composites for ther purposes of analysis. Most of the foods analysed for polychlorinated biphenyls (PCBs) and dioxins (polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs)) were animal products (Buckland *et al.*, 1998). Some cereals were tested, but most of these were processed (e.g. cornflakes, biscuits). Potatoes were also tested, but the organochlorines (OCs) were only detected in potato samples where these were combined with samples of hot potato chips. The levels in potatoes were low and not of a health concern, but nonetheless unexpected, given OCs are generally not considered to bioaccumulate in vegetables. The authors attributed this to the use of animal fats used for deep frying the hot potato chips.

[7] Information on the Organochlorines Programme is available from http://www.mfe.govt.nz/issues/hazardous/contaminated/organochlorines.html (accessed 23 March 2011).

Table 9: Detection of heavy metals in New Zealand produce (NZTDS, 2009)

Food tested	Analysed raw/cooked[1]	Total arsenic		Cadmium		Lead		Mercury	
		Prevalence[2]	Maximum concentration (mg/kg)[3]	Prevalence	Maximum concentration (mg/kg)	Prevalence	Maximum concentration (mg/kg)	Prevalence	Maximum concentration (mg/kg)
Apple	Raw	1/8	0.003	4/8	0.0006	0/8	<0.002	0/8	<0.002
Avocado	Raw	2/8	0.006	8/8	0.0286	0/8	<0.002	0/8	<0.002
Bananas	Raw	0/8	<0.002	5/8	0.0015	2/8	0.003	0/8	<0.002
Beans, frozen	Cooked	0/8	<0.002	8/8	0.0022	5/8	0.010	0/8	<0.002
Broccoli/cauliflower	Cooked	0/8	<0.002	8/8	0.0103	7/8	0.010	0/8	<0.002
Cabbage	Raw	0/8	<0.002	8/8	0.0048	1/8	0.002	0/8	<0.002
Capsicum	Raw	0/8	<0.002	7/8	0.0049	4/8	0.009	0/8	<0.002
Carrot	Raw	0/8	<0.002	8/8	0.0387	5/8	0.012	0/8	<0.002
Celery	Raw	0/8	<0.002	8/8	0.0336	3/8	0.004	0/8	<0.002
Courgette	Raw	1/8	0.004	7/8	0.0046	4/8	0.014	0/8	<0.002
Cucumber	Raw	8/8	0.009	0/8	<0.0004	1/8	0.002	0/8	<0.002
Grapes	Raw	4/8	0.004	6/8	0.0097	5/8	0.004	0/8	<0.002
Kiwifruit	Raw	0/8	<0.002	6/8	0.0009	4/8	0.004	0/8	<0.002
Kumara	Cooked	0/8	<0.002	8/8	0.0042	5/8	0.004	0/8	<0.002
Lettuce	Raw	0/8	<0.002	8/8	0.0399	1/8	0.006	0/8	<0.002
Melons	Raw	0/8	<0.002	8/8	0.0185	0/8	<0.002	0/8	<0.002
Mushrooms	Raw	8/8	0.389	8/8	0.0083	3/8	0.008	0/8	<0.002
Nectarine	Raw	3/8	0.009	8/8	0.0029	1/8	0.003	0/8	<0.002
Onion	Cooked	0/8	<0.002	8/8	0.0314	6/8	0.006	0/8	<0.002
Orange	Raw	2/8	0.005	1/8	0.0004	2/8	0.005	0/8	<0.002
Pear	Raw	7/8	0.006	8/8	0.0060	4/8	0.003	0/8	<0.002
Peas, frozen	Cooked	0/8	<0.002	8/8	0.0051	7/8	0.011	0/8	<0.002

Table 9 (continued)

Food tested	Analysed raw/cooked[1]	Total arsenic		Cadmium		Lead		Mercury	
		Prevalence[2]	Maximum concentration (mg/kg)[3]	Prevalence	Maximum concentration (mg/kg)	Prevalence	Maximum concentration (mg/kg)	Prevalence	Maximum concentration (mg/kg)
Potatoes, peeled	Cooked	0/8	<0.002	8/8	0.0463	1/8	0.003	0/8	<0.002
Potatoes, with skin	Cooked	0/8	<0.002	8/8	0.0722	6/8	0.005	0/8	<0.002
Prunes, pitless	Raw	4/8	0.012	5/8	0.0026	5/8	0.093	0/8	<0.002
Pumpkin	Cooked	1/8	0.005	8/8	0.0168	4/8	0.012	0/8	<0.002
Raisins/sultanas	Raw	8/8	0.032	5/8	0.0027	8/8	0.041	0/8	<0.002
Silverbeet	Cooked	3/8	0.006	8/8	0.0366	8/8	0.012	1/8	0.0026
Strawberries	Raw	5/8	0.005	8/8	0.0146	6/8	0.014	0/8	<0.002
Taro	Cooked	1/8	0.003	8/8	0.0492	2/8	0.007	0/8	<0.002
Tomato	Raw	1/8	0.003	4/8	0.0029	2/8	0.002	0/8	<0.002

1. Full food preparation details are available in Appendix 1 of (NZFSA, 2005).
2. Prevalence = number of samples in which chemical was detected/total number of samples analysed (one sample is a composite of 2-16 samples from two retail outlets collected at the same point in time from the same New Zealand city).
3. The maximum concentration of the chemical detected in the positive samples. A "less than" value (e.g. <0.002) indicates the level of detection for that test.

3.5 Outbreaks in other countries

Table 10: Outbreaks in other countries from contaminated fruit or vegetables where natural fertiliser or water was the suspected cause of contamination after environmental investigations

Year(s)	Country	Pathogen causing illness	Product	Number of cases	Suspected cause(s) of contamination	Reference
1990, 1993	USA	*Salmonella* Javiana (1990) *Salmonella* Montevideo (1993)	Tomatoes	176 (1990) 100 (1993)	Inadequate monitoring of chlorine levels in packhouse water bath (the same grower/packhouse operation was identified as the likely source of contaminated tomatoes in both outbreaks)	Hedberg *et al.*, 1999
1996	USA	*Cyclospora cayetanensis*	Raspberries	1,465	Contaminated water used for sprays	Herwaldt *et al.*, 1997
1996	USA	*E. coli* O157:H7	Mesclun lettuce[1]	61	Contaminated post-harvest wash water (most likely), composted chicken manure, poor worker hygiene, faecal contamination from chickens	Hilborn *et al.*, 1999
1998	Finland	*Yersinia* pseudotuberculosis O:3	Iceberg lettuces	47	Irrigation water contaminated with animal faeces, direct contamination by animal faeces, surface water runoff	Nuorti *et al.*, 2004
1998	USA, Canada	*Shigella sonnei*	Parsley	478 (8 outbreaks)	Unchlorinated municipal water used for cooling parsley after harvest (recirculating hydrocooler) and making ice to transport parsley, poor worker hygiene[2]	Crowe *et al.*, 1999
1999	USA	*Salmonella* Newport	Mangoes	78	Contaminated water used for post-harvest dipping	Sivapalasingam *et al.*, 2003
1999	USA	*Cyclospora cayetanensis*	Basil	62 (2 clusters)	Contaminated water used for sprays	Lopez *et al.*, 2001

Table 10 (continued)

Year(s)	Country	Pathogen causing illness	Product	Number of cases	Suspected cause(s) of contamination	Reference
2001-02	USA	*Salmonella* Poona	Cantaloupes[3]	47 (2001) 50 (2002)	Irrigation of fields with water contaminated with sewage, cleaning and cooling produce with contaminated water, poor hygienic practices of workers, pests in packing facilities, inadequate cleaning of equipment	Anderson *et al.*, 2002
2002	USA	*Salmonella* Newport	Tomatoes	510	Contaminated pond water used for irrigation	Greene *et al.*, 2008
2005	USA	*Salmonella* Newport	Tomatoes	72	Water used for irrigation and sprays contaminated by geese and duck faeces	Greene *et al.*, 2008
2006	Australia	*Salmonella* Saintpaul	Cantaloupes	115	Untreated or inadequately treated irrigation and wash water, processors not using disinfectants according to manufacturers' instructions, temperature differentials between the fruit and wash water, processing of bruised or damaged fruits	Munnoch *et al.*, 2009
2006-07	USA	*E. coli* O157:H7	Pre-packed spinach	205	Faeces from wild pigs, contamination of irrigation wells from faecally-contaminated surface water	California Emergency Response Team, 2007; Jay *et al.*, 2007
2006-07	Australia	*Salmonella* Litchfield	Papaya	26	Untreated river water used to wash the fruit with fungicide prior to packaging	Gibbs *et al.*, 2009
2007	Australia, Denmark	*Shigella sonnei*	Raw baby corn	12 (Australia) 215 (Denmark)	Insufficient chlorination of wash water in packing shed, poor hygiene of workers	Lewis *et al.*, 2009

Table 10 (continued)

Year(s)	Country	Pathogen causing illness	Product	Number of cases	Suspected cause(s) of contamination	Reference
2008	USA	*Salmonella* Saintpaul	Jalapeño and serrano peppers	1,500	Contaminated agricultural water	Behravesh *et al.*, 2011
2010	USA	*E. coli* O145	Romaine lettuce	33	Contamination of irrigation water with septic tank waste	CDC, 2010; Crawford *et al.*, 2010

1. Mix of small red and green leaf lettuces.
2. Contaminated parsley from the same grower was also the possible cause of two outbreaks of enterotoxigenic *E. coli* infection during the same time period (Naimi *et al.*, 2003).
3. Also known as rock melon.

4 APPENDIX 4: HORTICULTURAL INPUTS AND CONTROLS

4.1 Production of natural fertilisers

4.1.1 Mulches

Mulch is coarsely broken plant waste that is usually applied to soils to retain moisture and suppress weeds. The material is broken and homogenised using machines. Mulches add fertility to soils, but their coarse nature means that nutrients are released slowly.

Mulches may be composted before application. The New Zealand Standard for composts, soil conditioners and mulches (NZS 4454, 2005) defines mulches and coarse mulches:

Mulch: Any pasteurised or composted organic product (excluding polymers which do not degrade, such as plastics, rubber and coatings) that is suitable for placing on soil surfaces. Mulch has at least 20% by mass of material that has passed through a 20 mm sieve.

Coarse mulch: Any pasteurised or composted organic product (excluding polymers which do not degrade, such as plastics, rubber and coatings) that is suitable for placing on soil surfaces. Coarse mulch has less than 20% by mass of material that has passed through a 20 mm sieve.

4.1.2 Composts

Compost is the product of a managed aerobic process involving the biological decomposition of plant and animal materials to form a stable product suitable for soil improvement (NZS 8410:2003). A wide variety of microorganisms are involved in the composting process, but there are generally two sequential phases; phase 1 (decomposition, high-rate, thermophilic) and phase 2 (maturation, mesophilic, stabilisation) (Compost New Zealand, 2007). Finished compost has very little coarse material left; The New Zealand Standard for composts, soil conditioners and mulches (NZS 4454, 2005) requires a consistency whereby at least 95% by mass of material has passed a 20 mm sieve.

The materials used to produce compost can range from manures and animal by-products to greenwaste and domestic kitchen waste, so compost production systems vary. Bulking material such as straw or woodchip is usually added prior to composting. The bulking materials increase porosity so that oxygen can circulate, soak up moisture and add carbon, and are particularly important for composting animal wastes. A recommended carbon:nitrogen (C:N) ratio for a starting mix is between 25:1 and 40:1 (NZS 8410, 2003).

There are several systems that can be used for the first phase of composting (Compost New Zealand, 2007; NZWWA, 2003):

Windrow systems The composting material is placed in long rows that are periodically turned to introduce air, reduce moisture levels and maintain even temperatures. In a passively aerated windrow, the composting material is laid over perforated pipes and the windrows are not turned. In an

	aerated covered windrow, the windrows are covered and air is blown into them.
Aerated static piles	The composting material is laid over perforated pipes through which air is blown or sucked to introduce oxygen and reduce moisture.
Rotating drum	The composting material is continuously mixed and aerated inside rotating drums.
Agitated bed	Agitating beds are housed in a building or protected by a roof and the aeration of the compost is controlled.
In-vessel systems	These are contained aerobic systems that can operate continuously and in which the composting process is controlled by regulating the rate of mechanical aeration. The vertical system at Tirohia is one example of an in-vessel system currently in operation in New Zealand.[8]

Turned windrows are most commonly used in New Zealand. If not used for phase one, windrows are usually used for compost maturation (stage two).

The decomposition process generates heat and this reduces the concentration of any bacterial pathogens and plant propagules (plant or part of a plant that could generate a new plant, e.g. a seed) (NZS 4454, 2005). The temperature achieved and the time over which this is sustained depends on the inputs and how the system is managed. Ideally, composting should include a pasteurisation step, whereby organic materials are heat-treated to significantly reduce the numbers of plant and animal pathogens and plant propagules. The standard pasteurisation regime for compost is 55 °C for three consecutive days (or equivalent), though longer periods are recommended for compost materials that are likely to carry pathogens (Compost New Zealand, 2007; NZS 4454, 2005).

The New Zealand standard for organic production (NZS 8410, 2003) recommends that producers using an in-vessel or static aerated pile system should maintain the composting materials at a temperature between 55°C and 76°C for at least 3 days. Producers using a windrow system should maintain the composting materials at a temperature between 55°C and 76°C for at least 15 days, during which time the materials should be turned a minimum of three times.

The initial hot composting may be followed by a period of maturation, where temperatures remain steady below 45°C. Compost is matured in small, covered piles (or larger, covered piles that are aerated) for up to six months. During this time mesophilic microorganisms continue the composting process and reduce phytotoxic organic acids that are formed during the hot composting stage, which makes the compost safer to use with plants (Compost New Zealand, 2007; NZS 4454, 2005).

[8] See http://www.hgleach.co.nz/Tirohia_compost_solutions.html (accessed September 2010).

4.1.3 Vermicasts

Vermicast is a solid organic product produced by composting worms that have processed organic materials such as plant and food waste (these might be composted first). The process, called vermiculture, produces a fine substrate. Under the New Zealand Standard for composts, soil conditioners and mulches, 90% or more of the vermicast should pass through a 1.18 mm sieve (NZS 4454, 2005).

4.1.4 Biosolids

Biosolids are sewage sludges, or sewage sludges mixed with other materials, that have been treated and/or stabilised to the extent that they are able to be safely and beneficially applied to land (NZWWA, 2003). Biosolids do not include untreated raw sewage sludges or sludges solely from industrial processes (though they may include material delivered from industrial inputs to sewers that are diluted by organic material in domestic sewage inputs), animal manures, or food processing and abattoir wastes.

Sewage sludge is the organic solid material removed from wastewater during the treatment process. It contains pathogens, organic material, nutrients, metals and other chemicals from residential (human waste) and commercial properties, and tradewaste discharges (NZWWA, 2003). There are several options that can be combined to produce biosolids from sewage sludge (see NZWWA (2003) for further detail):

Pasteurisation	Heating the sludge to a temperature of 70–80°C for approximately 30 minutes using heat exchangers or steam injection.
Lime stabilisation	Adding lime to the sludge to raise the pH to 12 or more, which has the effect of destroying or inhibiting the pathogens present.
Composting	Mixing treated sludge with plant waste such as sawdust, greenwaste or wood chips and composting using windrows, aerated static piles or in-vessel systems.
Anaerobic digestion	Digestion by microorganisms under anaerobic conditions in closed tanks. High-rate anaerobic digestion involves mechanical mixing and heating of the sludge. The system can be operated in either a mesophilic mode (~35°C) or a combination of a thermophilic mode (> 50°C) followed by a mesophilic mode. Standard-rate anaerobic digestion uses ambient temperatures and no mechanical mixing.
Aerobic digestion	Digestion by bacteria in either open or closed vessels with oxygen delivered through agitation or air injection. The bacteria break down organic matter to carbon dioxide, nitrate, nitrogen and water, and generate heat in the process (the system can operate in either the mesophilic or thermophilic temperature ranges). Aerobic digestion can be continuous or done in batches.

Air drying	The sludge is applied to a sand or gravel bed and allowed to dry naturally over a period of months. During drying, biological processes take place, such as decomposition of organic matter, formation of ammonia and reduction in moisture, which in turn reduce bacteria, protozoa and viruses.
Thermal drying	Sludge is dried by direct or indirect contact with heat. There are four main types of thermal driers: Flash, spray, rotary and steam. All operate at different temperatures.

Treated biosolids may be stored long-term, which results in further reduction of bacteria and viruses.

4.2 Treatments and withholding periods in the United States

The US FDA has published guidance for industry entitled "Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables".[9] These refer to requirements from the US EPA for pathogen reductions in biosolids ("sewage sludge") to be used as fertilisers, that describe pathogen reduction processes and targets in terms of bacteria, viruses, and helminths.[10]

The USDA National Organics Standards Board (NOSB) has published Recommendations for Guidance for use of compost, vermicompost, processed manure, and compost teas (13 September 2006).[11] This document provides specifications for compost treatments, including:

> "1. Compost, …..is acceptable if: (i) made from only allowed feedstock materials (incidental residues are allowed only if they will not lead to contamination); (ii) the compost pile is mixed or managed to ensure that all of the feedstock heats to the minimum of 131 o F (55°C) for the minimum time (3 days). …."

The USDA NOSB has also published requirements for the use of raw animal manure for organic production, which specify that raw animal manure must be incorporated into the soil not less than 120 days prior to harvest of a product whose edible portion has direct contact with the soil surface or soil particles, or 90 days if there is no direct contact.[12]

[9] Available at: http://www.fda.gov/downloads/Food/GuidanceComplianceRegulatoryInformation/GuidanceDocuments/ProduceandPlanProducts/UCM169112.pdf
[10] Available at: http://www.epa.gov/nrmrl/pubs/625r92013/625R92013.pdf
[11] Available at: http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5057305
[12] Available at: http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5086966&acct=nopgeninfo

5 APPENDIX 5: WATER FOR HORTICULTURAL USE

5.1 Irrigation water in New Zealand

The Ministry for the Environment (MfE) has published a "Snapshot of water allocation in New Zealand" (MfE, 2006). This report provides an analysis, by Regional Council/Unitary Authority, of consents for irrigation water categorised by a number of criteria of interest to this project. The data were collected by a survey conducted in 2006. Data on water source and water use are shown in Tables 11 and 12.

Table 11: Consented irrigated area (hectares) by water source

Regional council/unitary authority	Area (ha)	From groundwater (%)	From surface water (%)	From storage (%)
Northland	8,205	6	61	33
Auckland	3,732	63	18	19
Waikato	8,832	19	75	6
Bay of Plenty	20,310	39	59	2
Gisborne	4,366	31	69	0
Hawkes Bay	39,978	77	23	0
Manawatu-Wanganui	12,149	58	42	0
Taranaki	2,590	4	86	10
Wellington	21,200	52	35	13
Marlborough	36,590	43	57	0
Nelson City	87	6	61	33
Tasman	18,271	42	20	38
Canterbury	647,006	53	46	1
West Coast	1,011	31	69	0
Otago	141,275*	6	89	5
Southland	7,053	86	14	0
Total	**972,653**	**46**	**51**	**3**

* Includes area supplied from mining water rights estimated to be approximately 80,000 hectares.

Table 12: Consented irrigated area by water use

Regional council/unitary authority	Area (ha)	Arable (%)	Horticulture (%) (hectares)	Other (%)[2]	Pasture (%)	Viticulture (%)
Northland	8,205	5	30 (2,460)	0	65	0
Auckland	3,732	40	28 (1,040)	0	32	0
Waikato	8,832	0	1 (90)	92	7	0
Bay of Plenty	20,310	0	33 (6,700)	37	30	0
Gisborne	4,366	10	67 (2,920)	2	21	0
Hawkes Bay	39,978	45	20 (8,000)	0	21	14
Manawatu-Wanganui	12,149	73	7 (850)	0	20	0
Taranaki	2,590	0	2 (50)	0	98	0
Wellington	21,200	0	2 (420)	60	35	3
Marlborough	36,590	0	0 (0)	17	16	66
Nelson City	87	0	24 (20)	74	2	0
Tasman	18,271	0	0 (0)	100	0	0
Canterbury	647,006	59	1 (6,470)	6	34	1
West Coast	1,011	0	0 (0)	0	100	0
Otago	141,275[2]	0	16 (22,604)	56	27	1
Southland	7,053	0	8 (560)	3	90	0
Total	**972,653**	**42**	**5 (48,630)**	**20**	**31**	**1**

1. For some councils crop type was not specified for all consents and such records have been assigned to the "other" category. It is therefore likely that a substantial proportion of crop use currently assigned in the "other" category actually relates to pasture
2. Includes area supplied from mining water rights estimated to be approximately 80,000 hectares.

The mining water rights in Otago represent historical permits for water to be used for mining, which are also allowed to be used for land irrigation. The information on land irrigated by these particular permits is very limited.

The MfE report acknowledges the difference between the total irrigated area as collated by the 2002 Statistics New Zealand agricultural census (463,239 hectares) and the 972,653 hectares identified from consents. The difference is suggested to be caused by requested consent areas representing an upper gross area for a property and includes a safety factor for future development. Consequently the absolute values in Table 2 should be treated cautiously. In particular, these data suggest that Otago has the most irrigated horticultural land area in New Zealand by a factor of three. This is unlikely to be the case; the horticultural consent data for Otago may well include land used for growing wine grapes (Sarah Ibbotson, Otago Regional Council, personal communication, 23 September 2010).

6 REFERENCES

Anderson S, Verchick L, Sowadsky R, Sun B, Civen R, Mohle-Boetani J, Werner S, Starr M, Abbott S, Gutierrez M, Palumbo M, Farrar J, Shillam P, Umland E, Tanuz M, Sewell M, Cato J, Keene W, Goldoft M, Hofmann J, Kobayashi J, Waller P, Braden C, Djomand G, Reller M and Chege W (2002) Multistate outbreaks of *Salmonella* serotype Poona infections associated with eating cantaloupe from Mexico - United States and Canada, 2000-2002. Morbidity and Mortality Weekly Report; 51:1044-1047.

Anthon GE, LeStrange M, Barrett DM. (2011) Changes in pH, acids, sugars and other quality parameters during extended vine holding of ripe processing tomatoes. Journal fo the Science of Food and Agriculture; 91: 1175-1181.

Bassett J, McClure P. (2008) A risk assessment approach for fresh fruits. Journal of Applied Microbiology; 104: 925-943.

Behravesh C, Mody R, Jungk J, Gaul L, Redd J, Chen S, Cosgrove S, Hedican E, Sweat D, Chávez-Hauser L, Snow S, Hanson H, Nguyen T-N, Sodha S, Boore A, Russo E, Mikoleit M, Theobald L, Gerner-Smidt P, Hoekstra R, Angulo F, Swerdlow D, Tauxe R, Griffin P and Williams I (2011) 2008 outbreak of *Salmonella* Saintpaul infections associated with raw produce. The New England Journal of Medicine; 364:918-927.

Buckland S, Scobie S and Heslop V (1998) Organochlorines in New Zealand: Concentrations of PCDDS, PDCFs and PCBs in retail foods and an assessment of dietary intake for New Zealanders. Ministry for the Environment.

Burnett S L, Chen J and Beuchat L R (2000) Attachment of *Escherichia coli* O157:H7 to the surfaces and internal structures of apples as detected by confocal scanning laser microscopy. Applied and Environmental Microbiology; 66:4679-4687.

California Emergency Response Team (2007) Investigation of an *Escherichia coli* O157:H7 outbreak associated with Dole pre-packaged spinach. California Department of Health Services, U.S. Food and Drug Administration. Available at: http://www.cdph.ca.gov/pubsforms/Documents/fdb%20eru%20Spnch%20EC%20Dole032007wph.PDF. Accessed 14 March 2011.

CDC (2010). Investigation update: Multistate outbreak of human *E. coli* O145 infections linked to shredded romaine lettuce from a single processing facility. Centers for Disease Control and Prevention, Atlanta. Available at: http://www.cdc.gov/ecoli/2010/ecoli_o145/index.html. Accessed 14 March 2011.

Chancellor D D, Tyagi S, Bazaco M C, Bacvinskas S, Chancellor M B, Dato V M and de Miguel F (2006) Green onions: potential mechanism for hepatitis A contamination. Journal of Food Protection; 69:1468-1472.

Compost New Zealand (2007) Introduction to composting science and management for industry training: An overview of the scientific principles of the composting process. Compost New Zealand.

Crawford W, Baloch M and Gerrity K (2010) Environmental Assessment Report FDA Foods Program. Non-O157 shiga toxin-producing *E. coli* (STEC). Environmental assessment findings and potential preventative control strategies. US Food and Drug Administration. Available at:

http://www.fda.gov/downloads/Food/FoodSafety/FoodborneIllness/UCM235923.pdf. Accessed 14 March 2011.

Critzer F J and Doyle M P (2010) Microbial ecology of foodborne pathogens associated with produce. Current Opinion in Biotechnology; 21:125-130.

Crowe L, Lau W, McLeod L, Anand C, Ciebin B, LeBer C, McCartney S, Easy R, Clark C, Rodgers F, Ellis A, Thomas A, Shields L, Tate B, Klappholz B, LaBerge I, Reporter R, Sato H, Lehnkering E, Mascola L, Waddell J, Waterman S, Suarez J, Hammond R, Hopkins R, Neves P, Horine M, Kludt P, DeMaria Jr. A, Hedberg C, Wicklund J, Besser J, Boxrud D, Hubner B, Osterholm M, Wu F and Beuchat L (1999) Outbreaks of *Shigella sonnei* infection associated with eating fresh parsley - United States and Canada, July-August 1998. Morbidity and Mortality Weekly Report; 48:285-289.

Davis H, Taylor J P, Perdue J N, Stelma G N, Jr., Humphreys J M, Jr., Rowntree R, 3rd and Greene K D (1988) A shigellosis outbreak traced to commercially distributed shredded lettuce. American Journal of Epidemiology; 128:1312-1321.

Del Rosario B and Beuchat L (1995) Survival and growth of enterohemorrhagic *Escherichia coli* 0157:H7 in cantaloupe and watermelon. Journal of Food Protection; 58:105-107.

Erickson M, Webb C, Diaz-Perez J, Phatak S, Silvoy J, Davey L, Payton A, Liao J, Ma L and MP D (2010) Infrequent internalization of *Escherichia coli* O157:H7 into field-grown leafy greens. Journal of Food Protection; 73:500-506.

FAO/WHO (1998) Surface decontamination of fruits and vegetables eaten raw: a review. World Health Organisation WHO/FSF/FOS/98.2. Prepared by L. Beuchat.

http://www.who.int/foodsafety/publications/fs_management/surfac_decon/en/

Gautier H, Diakou-Verdin V, Bénard C, Reich M, Buret M, Bourgard F, Poëssel J-L, Caris_Veyrat C, Génard M. (2008) How does tomato quality (sugar, acid and nutritional quality) vary with ripening stage, temperature, and irradiance? Journal of Agricultural and Food Chemistry; 56: 1241-1250.

Gibbs R, Pingault N, Mazzucchelli T, O'Reilly L, MacKenzie B, Green J, Mogyorosy R, Stafford R, Bell R, Hiley L, Fullerton K and van Buynder P (2009) An outbreak of *Salmonella enterica* serotype Litchfield infection in Australia linked to consumption of contaminated papaya. Journal of Food Protection; 72:1094-1098.

Gilbert S, Lake R, Hudson A and Cressey P (2006) Risk Profile: Shiga-toxin producing *Escherichia coli* in leafy vegetables. Client Report FW00456 for the New Zealand Food Safety Authority. Institute of Environmental Science and Research (ESR) Limited.

Greene S, Daly E, Talbot E, Demma L, Holzbauer S, Patel N, Hill T, Walderhaug M, Hoekstra R, Lynch M and Painter J (2008) Recurrent multistate outbreak of *Salmonella* Newport associated with tomatoes from contaminated fields, 2005. Epidemiology and Infection; 136:157-165.

Gunes G and Hotchkiss J (2002) Growth and survival of *Escherichia coli* O157:H7 on fresh-cut apples in modified atmospheres at abusive temperatures. Journal of Food Protection; 65:1641-1645.

Guo X, Chen J, Brackett R E and Beuchat L R (2001) Survival of salmonellae on and in tomato plants from the time of inoculation at flowering and early stages of fruit development through fruit ripening. Applied and Environmental Microbiology; 67:4760-4764.

Hanning I, Nutt J and Ricke S (2009) Salmonellosis outbreaks in the United States due to fresh produce: sources and potential intervention measures. Foodborne Pathogens and Disease; 6:635-648.

Heaton J C and Jones K (2008) Microbial contamination of fruit and vegetables and the behaviour of enteropathogens in the phyllosphere: A review. Journal of Applied Microbiology; 104:613-626.

Hedberg C W, Angulo F J, White K E, Langkop C W, Schell W L, Stobierski M G, Schuchat A, Besser J M, Dietrich S, Helsel L, Griffin P M, McFarland J W and Osterholm M T (1999) Outbreaks of salmonellosis associated with eating uncooked tomatoes: implications for public health. Epidemiology and Infection; 122:385-393.

Herwaldt B L, Ackers M L and the cyclospora working group (1997) An outbreak in 1996 of cyclosporiasis associated with imported raspberries. The New England Journal of Medicine; 336:1548-1556.

Hilborn E, Mermin J, Mshar P, Hadler J, Voetsch A, Wojtkunski C, Swartz M, Mshar R, Lambert-Fair M-A, Farrar J, Glynn M and Slutsker L (1999) A multistate outbreak of *Escherichia coli* O157:H7 infections associated with consumption of mesclun lettuce. Archives of Internal Medicine; 159:1758-1764.

Hudson A and Turner N (2002) Risks associated with bacterial pathogens in exported fruit and vegetables. Client Report FW0280 for the New Zealand Food Safety Authority. Institute of Environmental Science and Research (ESR) Limited.

Hutchison M L, Walters L D, Moore A, Crookes K M and Avery S M (2004) Effect of length of time before incorporation on survival of pathogenic bacteria present in livestock wastes applied to agricultural soil. Applied and Environmental Microbiology; 70:5111-51118.

Jablasone J, Warriner K and Griffiths M (2005) Interactions of *Escherichia coli* O157:H7, *Salmonella typhimurium* and *Listeria monocytogenes* plants cultivated in a gnotobiotic system. International Journal of Food Microbiology; 99:7-18.

Jay M T, Cooley M, Carychao D, Wiscomb G W, Sweitzer R A, Crawford-Miksza L, Farrar J A, Lau D K, O'Connell J, Millington A, Asmundson R V, Atwill E R and Mandrell R E (2007) *Escherichia coli* O157:H7 in feral swine near spinach fields and cattle, central California coast. Emerging Infectious Diseases; 13:1908-1911.

Johannessen G, Bengtsson G, Heier B, Bredholt S, Wasteson Y and Rørvik L (2005) Potential uptake of *Escherichia coli* O157:H7 from organic manure into crisphead lettuce. Applied and Environmental Microbiology; 71:2221-2225.

Lake R, Hudson A, Cressey P and Gilbert S (2005) Risk profile: *Listeria monocytogenes* in ready-to-eat salads. Client Report FW0446 for the New Zealand Food Safety Authority. Institute of Environmental Science and Research (ESR) Limited.

Lewis H, Ethelberg S, Olsen K, Nielsen E, Lisby M, Madsen S, Boel J, Stafford R, Kirk M, Smith H, Tikumrum S, Wisetrojana A, Bangtrakulnonth A, Vithayarungruangsri J, Siriarayaporn P, Ungchusak K, Bishop J and Mølbak K (2009) Outbreaks of *Shigella sonnei* infections in Denmark and Australia linked to consumption of imported raw baby corn. Epidemiology and Infection; 137:326-334.

Lopez A, Dodson D, Arrowood M, Orlandi Jr. P, da Silva A, Bier J, Hanauer S, Kuster R, Oltman S, Baldwin M, Won K, Nace E, Eberhard M and Herwaldt B (2001) Outbreak of cyclosporiasis associated with basil in Missouri in 1999. Clinical Infectious Diseases; 32:1010-1017.

Lynch M F, Tauxe R V and Hedberg C W (2009) The growing burden of foodborne outbreaks due to contaminated fresh produce: risks and opportunities. Epidemiology and Infection; 137:307-315.

MAF (New Zealand Ministry of Agriculture) (2011a) 2009 New Zealand Total Diet Study. Agricultural compound residues, selected contaminant and nutrient elements. Wellington: Ministry of Agriculture and Forestry.

MAF (New Zealand Ministry of Agriculture) (2011b) New Zealand (Maximum Residue Limits of Agricultural Compounds) Food Standards 2011. http://www.foodsafety.govt.nz/policy-law/legislation/food-standards/index.htm#mrl (accessed September 2011)

Marques P, Worcman-Barninka D, Lannes S and Landgraf M (2001) Acid tolerance and survival of *Escherichia coli* O157:H7 inoculated in fruit pulps stored under refrigeration. Journal of Food Protection; 64:1674-1678.

McIntyre L and Cornelius A (2009) Microbiological survey of retail fresh product of imported, domestic conventional and domestic organic origin. Client Report FW09064 for the New Zealand Food Safety Authority. Institute of Environmental Science and Research (ESR) Limited.

McIntyre L, Cressey P and Lake R (2008) Discussion document on pathogens in fruits and vegetables in New Zealand. Client Report FW0737 for the New Zealand Food Safety Authority. Institute of Environmental Science and Research (ESR) Limited.

McMahon M A and Wilson I G (2001) The occurrence of enteric pathogens and Aeromonas species in organic vegetables. International Journal of Food Microbiology; 70:155-62.

MfE (2006) Snapshot of water allocation in New Zealand. Prepared for Ministry for the Environment by Aqualinc Research Limited. Ministry for the Environment. Available at: http://www.mfe.govt.nz/publications/ser/snapshot-water-allocation-nov06/snapshot-water-allocation-nov06.pdf. Accessed 20 May 2011.

Mohle-Boetani J C, Farrar J, Bradley P, Barak J D, Miller M, Mandrell R, Mead P, Keene W E, Cummings K, Abbott S and Werner S B (2009) *Salmonella* infections associated with mung bean sprouts: epidemiological and environmental investigations. Epidemiology and Infection; 137:357-366.

Mukherjee A, Speh D, Dyck E and Diez-Gonzalez F (2004) Preharvest evaluation of coliforms, Escherichia coli, Salmonella, and Escherichia coli O157:H7 in organic and conventional produce grown by Minnesota farmers. Journal of Food Protection; 67:894-900.

Munnoch S, Ward K, Sheridan S, Fitzsimmons G, Shadbolt C, Piispanen J, Wang Q, Ward T, Worgan T, Oxenford C, Musto J, McAnulty J and Durrheim D (2009) A multi-state outbreak of *Salmonella* Saintpaul in Australia associated with cantaloupe consumption. Epidemiology and Infection; 137:367-374.

Naimi T, Wicklund J, Olsen S, Krause G, Wells J G, Bartkus J, Boxrud D, Sullivan M, Kassenborg H, Besser J, Mintz E D, Osterholm M and Hedberg C (2003) Concurrent outbreaks of *Shigella sonnei* and enterotoxigenic *Escherichia coli* infections associated with parsley: Implications for surveillance and control of foodborne illness. Journal of Food Protection; 66:535-541.

Nicholson F A, Groves S J and Chambers B J (2005) Pathogen survival during livestock manure storage and following land application. Bioresource Technology; 96:135-143.

Nuorti P, Niskanen T, Hallanvuo S, Mikkola J, Kela E, Hatakka M, Fredriksson-Ahomaa M, Lyytikäinen O, Siitonen A, Korkeala H and Ruutu P (2004) A widespread outbreak of *Yersinia pseudotuberculosis* O:3 infection from iceberg lettuce. Journal of Infectious Diseases; 189:766-774.

NZFSA (2005) 2003/04 New Zealand Total Diet Survey. Agricultural compound residues, selected contaminants and nutrients. Auxiliary data. New Zealand Food Safety Authority.

NZFSA (2009a) 2009 New Zealand Total Diet Study: Analytical results Q2. NZFSA information report. New Zealand Food Safety Authority. Available at: http://www.foodsafety.govt.nz/science/research-projects/total-diet-survey/2009.htm. Accessed 22 March 2011.

NZFSA (2009b) 2009 New Zealand Total Diet Study: Analytical results Q3. NZFSA information report. New Zealand Food Safety Authority. Available at: http://www.foodsafety.govt.nz/science/research-projects/total-diet-survey/2009.htm. Accessed 22 March 2011.

NZFSA (2010) 2009 New Zealand Total Diet Study: Analytical results Q4. NZFSA information report. New Zealand Food Safety Authority. Available at: http://www.foodsafety.govt.nz/science/research-projects/total-diet-survey/2009.htm. Accessed 22 March 2011.

NZS 4454 (2005) New Zealand Standard: Composts, Soil Conditioners and Mulches (NZS 4454:2005). Standards New Zealand.

NZS 8410 (2003) New Zealand Standard: Organic production (NZS 8410:2003). Standards New Zealand.

NZWWA (2003) Guidelines for the safe application of biosolids to land in New Zealand. New Zealand Water and Wastes Association.

Pan W and Schaffner D (2010) Modeling the growth of *Salmonella* in cut red round tomatoes as a function of temperature. Journal of Food Protection; 73:1502-1505.

Penteado A L, Eblen B S and Miller A J (2004) Evidence of *Salmonella* internalization into fresh mangos during simulated postharvest insect disinfestation procedures. Journal of Food Protection; 67:181-184.

Penteado A L and Leitao M F (2004a) Growth of *Salmonella* Enteritidis in melon, watermelon and papaya pulp stored at different times and temperatures Food Control; 15:369-373.

Penteado A L and Leitao M F (2004b) Growth of *Listeria monocytogenes* in melon, watermelon and papaya pulps. International Journal of Food Microbiology; 92:89-94.

Pu S, Beaulieu J C, Prinyawiwatkul W and Ge B (2009) Effects of plant maturity and growth media bacterial inoculum level on the surface contamination and internalization of

Escherichia coli O157:H7 in growing spinach leaves. Journal of Food Protection; 72:2313-2320.

Seo K and Frank J (1999) Attachment of *Escherichia coli* O157:H7 to lettuce leaf surface and bacterial viability in response to chlorine treatment as demonstrated by using confocal scanning laser microscopy. Journal of Food Protection; 62:3-9.

Sivapalasingam S, Barrett E, Kimura A, van Duyne S, de Witt W, Ying W, Frisch A, Phan Q, Gould E, Shillam P, Reddy V, Cooper T, Hoekstra M, Higgins C, Sanders J, Tauxe R and Slutsker L (2003) A multistate outbreak of *Salmonella enterica* serotype Newport infection linked to mango consumption: Impact of water-dip disinfestation technology. Clinical Infectious Diseases; 37:1585-1590.

Solomon E B, Yaron S and Matthews K R (2002) Transmission of *Escherichia coli* O157:H7 from contaminated manure and irrigation water to lettuce plant tissue and its subsequent internalization. Applied and Environmental Microbiology; 68:397-400.

Vannoort R (2009) 2009 New Zealand Total Diet Study. Analytical results - Q1. Client Report FW0977 for the New Zealand Food Safety Authority. Institute of Environmental Science & Research (ESR) Limited. Available at: http://www.foodsafety.govt.nz/science/research-projects/total-diet-survey/2009.htm. Accessed 22 March 2011.

Vannoort R, Hannah M and Pickston L (1995) 1990/1991 New Zealand Total Diet Survey. Part 2: Contaminant elements. Client Report FW95/7 for the Ministry of Health. Institute of Environmental Science & Research (ESR) Limited.

Warriner K, Huber A, Namvar A, Fan W and Dunfield K (2009) Recent advances in the microbial safety of fresh fruits and vegetables. Advances in Food and Nutrition Research; 57:155-208.

Warriner K, Spaniolas S, Dickinson M, Wright C and Waites W M (2003) Internalization of bioluminescent *Escherichia coli* and *Salmonella* Montevideo in growing bean sprouts. Journal of Applied Microbiology; 95:719-727.

Wei J, Jin Y, Sims T and Kniel K E (2010) Manure- and biosolids-resident murine norovirus 1 attachment to and internalization by Romaine lettuce. Applied and Environmental Microbiology; 76:578-83.

Wong T (2003) Levels of *Escherichia coli* O157 in lettuces and *Salmonella* in apples. Client Report FW0338 for the New Zealand Food Safety Authority. Institute of Environmental Science and Research (ESR) Limited.

Wong T (2008) Prevalence of Listeria monocytogenes and other Listeria species in ready-to-eat salads (with dressings) from retail outlets in New Zealand. Client Report FW0749 for the New Zealand Food Safety Authority. Institute of Environmental Science and Research (ESR) Limited.

Zhang G, Ma L, Beuchat L, Erickson M, Phelan V and Doyle M (2009) Lack of internalization of *Escherichia coli* O157:H7 in lettuce (*Lactuca sativa* L.) after leaf surface and soil inoculation. Journal of Food Protection; 72:2028-2037.

Zhuang R-Y, Beuchat L and Angulo F J (1995) Fate of *Salmonella montevideo* on and in raw tomatoes as affected by temperature and treatment with chlorine. Applied and Environmental Microbiology; 61:2127-2131.

Client report FW11024

A REVIEW OF THE USE OF WATER AND NATURAL FERTILISERS DURING THE GROWING, HARVESTING AND PACKING OF HORTICULTURAL PRODUCE

VOLUME 3: GROWER SURVEY

Prepared for the Ministry of Agriculture and Forestry
under Agreement 11875

Dr Stephen On
Food Safety Programme Leader

Dr Rob Lake
Project Leader

Wendy Williamson
Peer Reviewer

Institute of Environmental Science & Research Limited
Christchurch Science Centre
Location address: 27 Creyke Road, Ilam, Christchurch
Postal address: P O Box 29 181, Christchurch, New Zealand
Website: www.esr.cri.nz

A CROWN RESEARCH INSTITUTE

REVIEW OF THE USE OF WATER AND NATURAL FERTILISERS DURING THE GROWING, HARVESTING AND PACKING OF HORTICULTURAL PRODUCE

VOLUME 3: GROWER SURVEY

Prepared for the Ministry of Agriculture and Forestry
under Agreement 11875

by

Nicola King (ESR),
Wymond Symes (Catalyst® R&D Ltd),
Jane Lancaster (Catalyst® R&D Ltd)
and Rob Lake (ESR)

September 2011

DISCLAIMER

ACKNOWLEDGEMENTS

The authors wish to thank the growers who generously participated in this study.

The authors would also like to thank the following people and organisations for their contribution to this volume:

Malcolm Garnham (Catalyst R&D)

Matthew Dolan, John Seymour and Peter Silcock (Horticulture New Zealand)

Dr Michael Hutchison (Hutchison Scientific Ltd, United Kingdom)

Rod Klarwill (Managing Director, Rural Research Ltd.)

REFERENCES TO WEBSITES

All of the websites referred to in this document were available for access in April 2011, unless specified.

PRINTING THIS DOCUMENT

Note that some of the images in this document require colour printing for clear interpretation.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

The overall aim of this study was to identify the risks with respect to the current control measures and management practices from chemical and microbiological hazards that may be present on horticultural products as a result of:

.

- The application of natural fertilisers during horticultural production;
- The application of water during horticultural production; and
- The use of water during harvesting and post-harvesting activities.

The study has investigated these risks by conducting a survey of horticultural growers to discover how growers are using natural fertilisers and water, and also what controls are currently in place to minimise the risks. This report describes the findings from the grower survey and provides detailed information to support the overarching summary (Volume 1). Another part of the study (Volume 4) has reviewed existing assurance programmes to examine the controls they include, for those growers who are registered for such programmes.[1]

2 METHOD

2.1 Development of questionnaire

The questions included in the questionnaire were developed according to the information sought, and were partly based on a survey conducted in the United Kingdom to collate information about horticultural crops that are likely to be consumed without cooking.[2] Only parts of the UK survey were applicable to this study, and permission was granted by the UK authors to adapt these sections of their questionnaire.

The Ministry of Agriculture and Forestry (MAF) and Horticulture New Zealand (HortNZ) were consulted during questionnaire preparation. The questionnaire was piloted with a large-scale grower of multiple crops. MAF granted approval of the final questionnaire before growers were contacted to request their participation.

A key part of the questionnaire was a consent form that set out ESR and Catalyst's responsibilities in terms of protecting grower anonymity and providing feedback, and formalised the grower's agreement to participate. The finalised questionnaire is shown in Appendix 1.

2.2 Source of grower contact details

We obtained grower contact details from the following sources:

[1] All volumes are available from http://www.foodsafety.govt.nz/index.htm

[2] The survey was conducted in 2007 by J.M. Monaghan and H. Cunningham of Harper Adams University College as part of a wider study for the Food Standards Agency. The survey and study report are available from http://www.food.gov.uk/science/research/foodborneillness/organicwasteresearch/b17programme/b17projlist/b17007/

- Horticulture New Zealand fresh vegetable product group;
- AsureQuality list of NZGAP-registered growers;[3] and
- BioGro and AsureQuality lists for organic growers.[4]

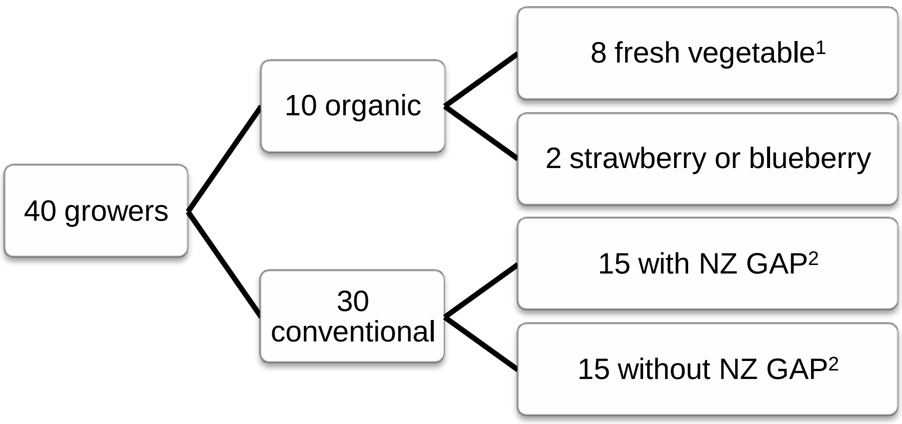
We updated the information received from these sources as required by using New Zealand telephone directories and the internet.

2.3 Criteria for grower selection

We used the following criteria to select the growers to approach:

1. Growers of fresh vegetables that are grown outside, close to the ground and likely to be eaten raw, i.e. Growers of cabbages, lettuces, spinach, spring onions, radishes, courgettes, mesclun, salad leaves, watercress, snow peas, carrots, celery, parsley and herbs.
2. Growers of fruits that are not peeled, grow close to the ground and receive significant applied water compared to natural rain, i.e. growers of strawberries and blueberries.
3. Growers located in regions with the most outdoor vegetable farms, i.e. growers in Canterbury, Manawatu-Wanganui and South Auckland.
4. A small number of growers located in other regions to ensure wider representation (particularly to ensure that information on water use is not biased because of regional differences).
5. Ensure growers include those using organic or "conventional" (i.e. non-organic) methods, those operating with or without the assurance programme New Zealand GAP (and/or New Zealand GAP (GLOBALG.A.P. Equivalent)), and those who sell through wholesalers, retailers and directly to the public (e.g. farmers markets, farm shop).

Based on these criteria we aimed to engage a minimum of 40 growers to participate in the study, distributed as follows:



1. Likely to be eaten raw (see criteria)
2. NZ GAP = New Zealand GAP and/or New Zealand GAP (GLOBALG.A.P. Equivalent).

[3] Available from http://approvedsuppliersearch.asurequality.com/
[4] Available from http://www.organiccertification.co.nz/organic-registrants.cfm

Additionally, we aimed to engage:

- A minimum of three conventional growers in each of the Canterbury, Manawatu-Wanganui, South Auckland and “other” regions; and
- A minimum of two conventional growers that supplied farmers markets.

We expected to obtain information from every grower on their use of water, but information on the use of natural fertilisers would only be obtained from a proportion of the growers since it was anticipated that the use of these inputs would not be widespread (other than among organic growers).

2.4 Information collection

We aimed to complete the questionnaire with each grower either through a visit to their premises (preferred method) or by telephone. If growers wanted to participate but refused a visit and telephone interview, then completed questionnaires were accepted upon the understanding that we might ring the grower for clarification of any information.

The standard process for each grower was as follows:

1. E-mail outlining the project and asking for participation.
2. Telephone follow-up.

If agreement was given by the grower to participate:

3. Send a copy of the questionnaire by post or e-mail and arrange how the grower can return their signed consent.
4. Telephone follow-up to confirm consent and either:
    a. Arrange a site visit (interview then carried out with grower in person);
    b. Arrange a telephone interview;
    c. Conduct the telephone interview; or
    d. Arrange for the grower to complete the questionnaire without interview.
5. Final telephone call to follow-up on any responses (if necessary).

Most questionnaires were completed during February - March 2011. In early February an email was sent to the relevant local authority officers to inform them of the survey activity in their region.

3 RESULTS

Note: Unless otherwise specified, the abbreviation NZ GAP is used in this section to indicate certification to New Zealand GAP or New Zealand GAP (GLOBALG.A.P. Equivalent).

3.1 Grower participation

Findings

i. 65% of the growers were interviewed in person or over the telephone.
ii. 58% of the growers were in the three target growing regions.
iii. Most of the targets set for the grower distribution were met or exceeded.

From an initial list of 128 potential growers, 75 growers were identified using the grower selection criteria. The participation of these 75 growers was as follows:

Shortlist of 75 growers

↓

23/75 (31%) of growers declined, could not be contacted or were too busy to participate

↓

Surveys sent out to 52 growers who agreed to participate

↓

Questionnaires completed with 40/52 (77%) growers (the remainder declined)

18 conventional, NZ GAP[1]	11 conventional, no assurance programme certification	11 organic[2]

1. One of these growers was later found to be certified under the international assurance programme GLOBALG.A.P., and not New Zealand GAP or New Zealand GAP (GLOBALG.A.P. Equivalent). For simplicity, this grower has been kept in the NZ GAP grower group.
2. Organic growers may or may not be certified under NZ GAP.

Fourteen of the growers wanted to participate but declined the site visit and telephone interview in preference to returning their completed questionnaire and accepting any follow-up telephone calls to clarify information, as needed.

Table 1 summarises the methods by which the questionnaires were completed, Table 2 presents the regional distribution of the growers and Table 3 compares the target grower distribution (Section 2.3) with that achieved.

Table 1: How the information was collected from the 40 growers who participated in the survey

Grower type	Questionnaire completed by:			Total
	Site visit	Telephone interview	Post/fax/ e-mail*	
Conventional, NZ GAP	6	6	6	18
Conventional, no certification	8	0	3	11
Organic	6	0	5	11
Total (n=40)	20 (50%)	6 (15%)	14 (35%)	40 (100%)

* Followed by a telephone call to clarify any of the information, if necessary.

Table 2: Regional distribution of the 40 growers who participated in the survey

Grower type	Region*				
	South Auckland	Manawatu-Wanganui	Canterbury	Rest of NZ	Total
Conventional, NZ GAP	5 (12.5%)	2 (5.0%)	1 (2.5%)	10 (25.0%)	18 (45.0%)
Conventional, no certification	0 (0%)	3 (7.5%)	3 (7.5%)	5 (12.5%)	11 (27.5%)
Organic	2 (5.0%)	2 (5.0%)	5 (12.5%)	2 (5.0%)	11 (27.5%)
Total (n=40)	7 (17.5%)	7 (17.5%)	9 (22.5%)	17 (42.5%)	40 (100%)

* All percentage values are out of the total of 40 growers.

Table 3: How the distribution of the 40 growers matched the target distribution

Divisor	Target	Achieved
Total growers	40 (minimum)	40
Organic growers - Fresh vegetable - Strawberry/blueberry	10 - 8 - 2	11 - 7* - 4*
Conventional growers - With NZ GAP - No certification - South Auckland - Manawatu-Wanganui - Canterbury - "other" regions - Supplies farmers markets	30 - 15 - 15 - 3 - 3 - 3 - 3 - 2	29 - 18 - 11 - 5 - 5 - 4 - 15 - 7

* One is a grower of fresh vegetables and blueberries (i.e. the values 7 and 4 are comprised of 10 growers; the 11th organic grower produced blackcurrants and vegetables likely to be consumed cooked).

3.2 Certifications and memberships

Findings

i. 45% (18/40) of the participants were conventional growers who were certified under New Zealand GAP, New Zealand GAP (GLOBALG.A.P. Equivalent) or GLOBALG.A.P.
ii. 28% (11/40) of the participants were certified under an organic assurance programme (BioGro or AsureQuality).
iii. 28% (11/40) of the participants were not certified under any assurance programme.
iv. 28% (11/40) of the growers were certified under more than one assurance programme (one grower was certified under five assurance programmes).
v. 53% (21/40) of the growers were certified under New Zealand GAP, New Zealand GAP (GLOBALG.A.P. Equivalent) or GLOBALG.A.P., including three organic growers. Six growers were certified under Woolworths Quality Assurance.
i. 70% (28/40) of the growers were members of one or more industry groups (most growers were members of HortNZ).

The certifications held by the 29 growers certified under NZ GAP or an organic programme are illustrated in Figure 1 and Figure 2. One grower not certified under any assurance programme reported they had Growsafe certification.[5]

Twenty-eight (70%) growers were members of one or more industry groups. Twenty-three (58%) growers reported they belonged to HortNZ or VegFed.[6] Some of these growers also reported they belonged to one of the 22 product groups affiliated to HortNZ:

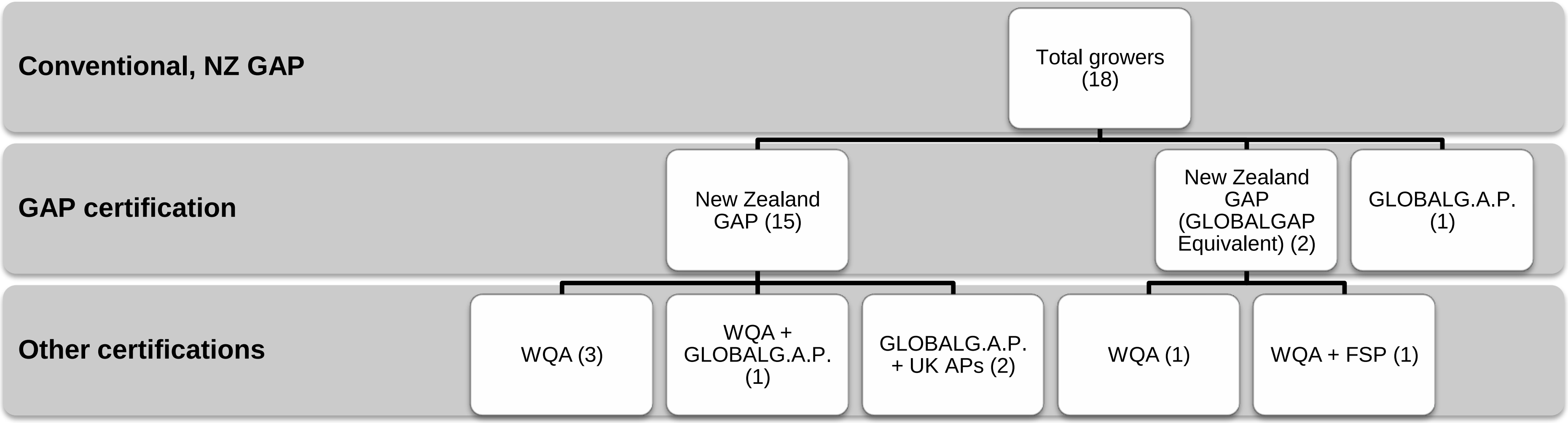
- Strawberry Growers New Zealand (5 growers).
- Fresh Vegetable Product Group (4 growers).
- Potatoes New Zealand (2 growers).
- Pipfruit New Zealand (1 grower).

Six growers reported they belonged to a regional growers association and two reported membership of a produce marketing/promotional association. Growers also belonged to the following industry bodies:

- Biodynamic Association (1 grower).
- Blueberries New Zealand (2 growers).
- Landwise (1 grower).
- New Zealand Buttercup Squash Council (1 grower).
- Onions New Zealand (1 grower).
- Organics Aotearoa New Zealand (1 grower).
- Soil and Health Association of New Zealand (1 grower).

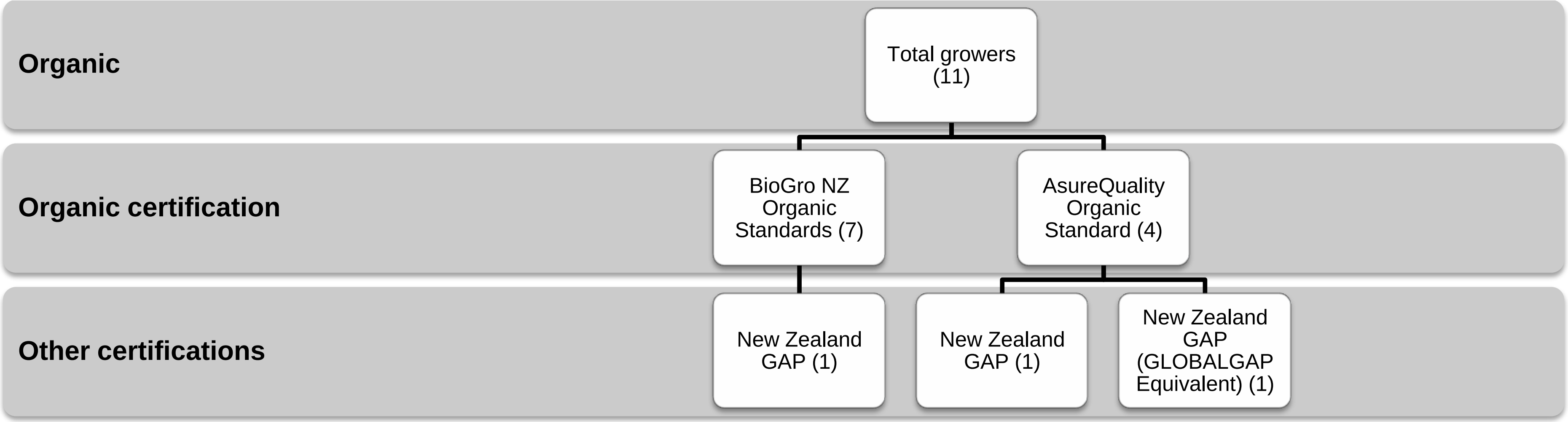
[5] Growsafe is a certification programme for the safe management of agrichemicals for the control of pests and diseases. Growsafe is administered by the New Zealand Agrichemical Education Trust.
[6] VegFed (the New Zealand Vegetable and Potato Growers' Federation) amalgamated with the New Zealand Fruit Growers' Federation in 2005 to become Horticulture New Zealand.

Figure 1: Assurance programmes that the conventional growers are certified under



WQA = Woolworths Quality Assurance; UK APs = United Kingdom assurance programmes (Linking Environment and Farming (LEAF) Marque, British Retail Consortium (BRG) Global Standards or Tesco Nurture Scheme); FSP = Food Safety Programme according to the Food Act 1981.

Figure 2: Assurance programmes that that organic growers are certified under



3.3 Crop production

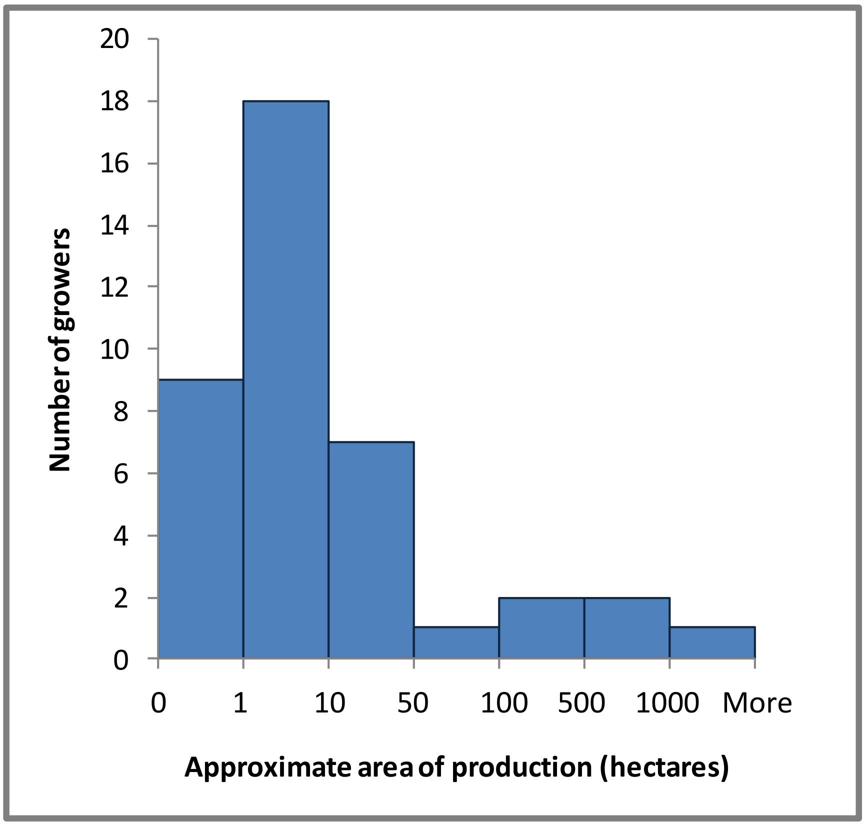
Findings

i. 25% of the growers operated hydroponic systems.
ii. 68% of the growers had 10 hectares or less in production.
iii. The growers have produced a wide variety of vegetables, fruit, nuts and herbs since January 2010, but most (93%) produced 10 or less different crop types.
iv. 25% of the growers produced one or more minimally-processed products.

All 40 participants were growers of horticultural produce, and 25 of these growers classified themselves as a grower/packhouse (including those who produced minimally-processed products). Ten of the growers operated a hydroponic system as all or part of their operation (seven grew hydroponic lettuces, two grew hydroponic lettuces and herbs, and one grew hydroponic strawberries).

The area in production varied between growers, from <1 to 3,000 hectares (Figure 3).

Figure 3: Distribution of growers according to their area of horticultural production



Growers were asked which crops they produced and to estimate the amount produced since January 2010. The number of crop types produced per grower ranged from 1 (12 growers) to 33 (1 grower); 37 growers produced 10 crop types or less. Table 4 shows the wide variety of crops the growers produced.

Table 4: Number of growers producing each crop

Crop		Number of growers	Number processing[1]	Processed products
Vegetables	artichokes	2	0	
	Asian greens[2]	2	0	
	asparagus	2	0	
	beans	5	0	
	beetroot	4	0	
	broccoli	12	2	Pieces
	cabbages	13	1	Shredded
	capsicums	2	0	
	carrots	4	0	
	cauliflowers	10	0	
	celeriac	1	0	
	celery	3	0	
	chillies	1	0	
	choggia[3]	1	0	
	chokos	1	0	
	courgettes/zucchini	6	0	
	cucumbers	2	0	
	eggplants/aubergine	1	0	
	fennel	2	0	
	garlic	2	0	
	kale[4]	3	0	
	leeks	8	0	
	lettuces[5]	27	6	Shredded, salad mix, bagged
	melons	1	0	
	onions	11	0	
	peas	1	0	
	pulses	1	1	Mixed with sprouts
	potatoes	10	1	Cut for fries
	pumpkins	7	0	
	radishes	3	0	
	rhubarb	1	0	
	silverbeet[6]	10	0	
	snow peas	1	0	
	spinach	7	0	
	spring onions	2	0	
	sprouts[7]	1	1	Mixed
	squash	2	1	Powdered
	swede	1	0	
	sweetcorn	4	0	
	watercress	1	0	

Table 4 (continued)

Crop		Number of growers	Number processing[1]	Processed products
Fruit	apples	2	0	
	blackcurrants	1	0	
	blueberries	2	0	
	grapefruit	1	0	
	lemons	2	0	
	peaches	1	0	
	pears	2	0	
	plums	3	0	
	quinces	1	0	
	raspberries	1	1	Frozen whole
	redcurrants	1	0	
	strawberries	8	2	Frozen whole
	tomatoes	5	0	
	watermelon	2	0	
Nuts	almonds	1	0	
	walnuts	1	0	
Herbs	(any)	9	1	Bagged mixes

1. Number of growers producing minimally processed products, i.e. products that are dried, semi-dried or pre-prepared in some way such as shredded lettuce or sliced fruit.
2. E.g. bok choi.
3. A type of beet.
4. Including growers of cavelo nero.
5. Including growers of fancy lettuce, mesclun lettuce and salad leaves.
6. Including growers of chard.
7. Beans, peas, radish, broccoli, onion and alfalfa.

None of the growers produced any fungi (mushrooms, truffles). Ten growers minimally-processed one or more of their products, producing cut, frozen or mixed products.

Many growers were not able to estimate the amount of each crop produced as tonnage, as this was not how they kept their records. Instead, these data were reported in a number of different ways (e.g. number of plants, number of seeds planted, number of crates, acres/week) so it was not possible to consolidate this information.

3.4 Path to the consumer

Findings

i. The pathways to the consumer were highly variable between growers and between crops, irrespective of whether the growers were certified under an assurance programme.
ii. 18% of the growers exported one or more products.
iii. The most common retail outlets (by numbers of growers) were supermarkets and independent retailers/chain stores.

Growers were asked how each of their products reached the consumer, with their responses recorded as the estimated proportion that goes:

- To export;
- Through a wholesaler and then on to various retail outlets;
- Directly to retail outlets; or
- Directly to the consumer.

Six growers sent all of their crops, or 100% of some crop types (e.g. all of their lettuces), to a wholesaler and were not always aware of where the products were sent after this. Seven growers sold all or nearly all (>90%) of a crop directly to the public through farmers markets or their own shop (two of these growers sold >95% of all crops directly to the public). Most of the growers used a variety of pathways for different crops, irrespective of whether they were conventional or organic growers, or whether they were certified under an assurance programme.

Figure 4 illustrates the pathways for lettuces. Most growers sold the entire crop to a wholesaler or directly to retailers, but the final destination (supermarket, independent retailer or food service) was highly variable. Supermarkets appeared to be an important destination for the lettuces of growers accredited to NZ GAP, while independent retailers, farmers markets and farm shops were important for growers without certification to an assurance programme. Anecdotal information provided by the growers indicated that the market pathway for each crop often depended on factors like how competitive the market was, the prices offered for their products, or how quickly a particular crop needed to get to market. For example, a grower who usually sold lettuces directly to independent retailers and food service companies might opt to sell a portion of their stock at lower prices to a wholesaler if they had excess stock that required shifting.

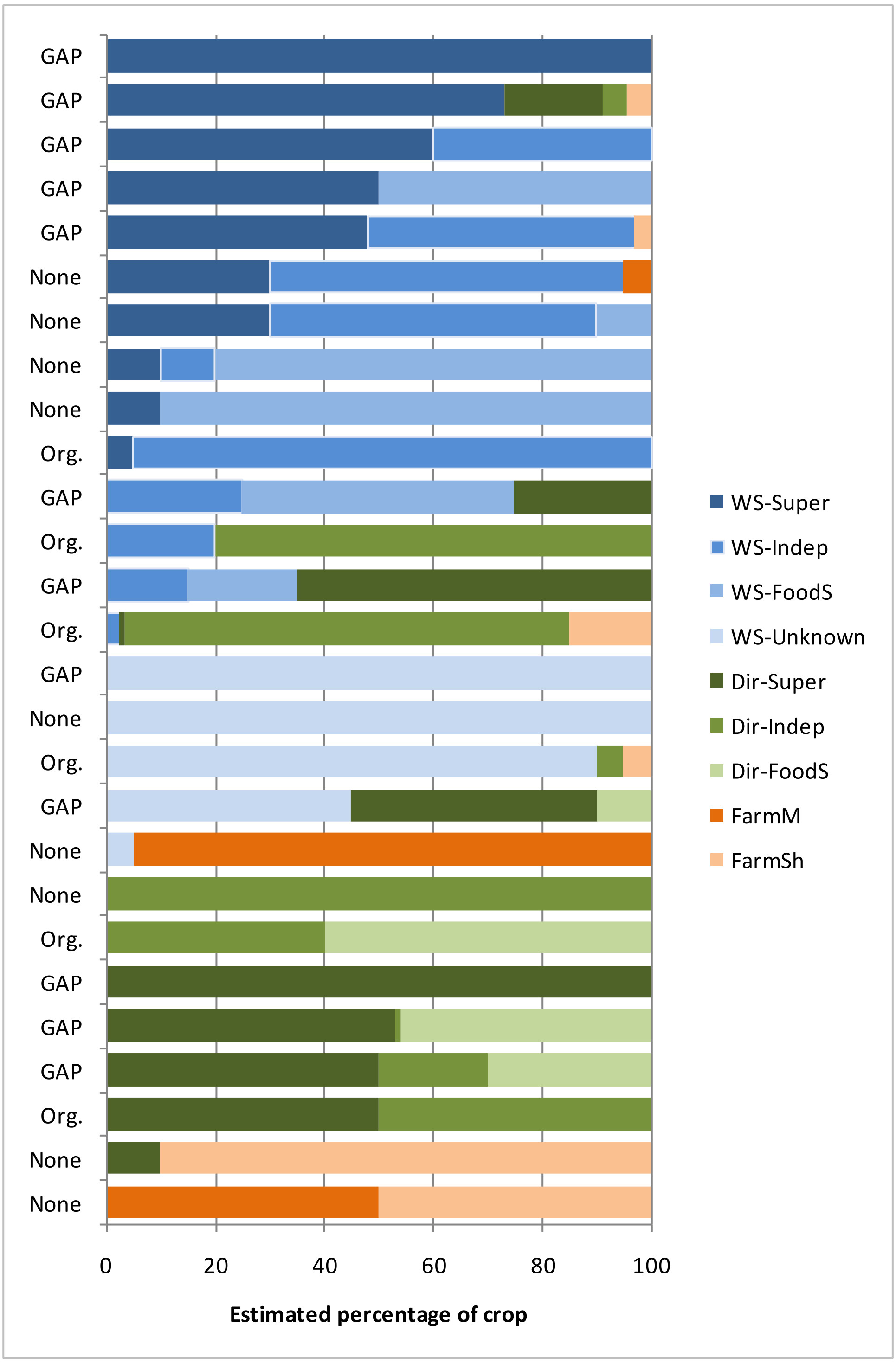
Only seven of the growers exported some of their crops. The crops exported were onions (3 growers exported 90-100% of their onion crop), blueberries (2 growers, exporting 30% or 80% of their crop), apples (50% of crop) and squash (96% of crop). All of the five conventional growers exporting crops held either New Zealand GAP (GLOBALG.A.P. Equivalent) or GLOBALG.A.P. certification. One of the two organic growers exporting crops was certified under New Zealand GAP (GLOBALG.A.P. Equivalent) and AsureQuality, and the other held BioGro certification (organic growers can be certified for domestic or export supply).

The majority of the crops sold to wholesalers appear to be retailed through supermarkets or independent retailers/chain stores. For example, one grower of cabbages sold 95% of the crop to a wholesaler, and estimated that 75% went to independent retailers and 20% to supermarkets. The grower sold the remaining 5% of the crop through farmers markets. The next most common destination was the food service industry, and the proportions sent to this market via a wholesaler were notably higher for lettuces and herbs.

There were six growers who sold all of their crops directly to retail, most of which went to supermarkets or independent retailers/chains. An additional grower sold all of their products either directly to retail outlets or through their own farm shop (the proportions going through each outlet were crop-dependant, e.g. 100% of their potatoes were sold through the farm shop, but only 20% of their red onions).

The variability of the market pathways is further illustrated by three examples in Figure 5.

Figure 4: Percentage of lettuce crop reaching the consumer through different market pathways, as reported by 30 growers



Y-axis:

Org. = organic grower

None = grower is not certified under an assurance programme

GAP = grower is NZ GAP certified.

Legend:

WS = wholesale

Dir = direct to retail

Super = supermarket

Indep = independent retailer

FoodS = food service

FarmM = farmers market

FarmSh = farm shop

Figure 5: Examples of market pathways – lettuces, silverbeet and cabbages

Grower A is a conventional grower certified under NZ GAP, and grows nine different crops. Most of the products that are marketed through wholesalers or sold directly to retailers are sold through supermarkets. The grower has a farm shop for public sales.

Pathway	Lettuces	Silverbeet	Cabbages
via wholesalers	72%	67%	5%
direct to retailers	23%	27%	60%
direct to the public	5%	6%	35%

Grower B is a conventional grower of eight crops and is not certified under any assurance programmes. For the three products illustrated below, most sold to wholesalers is destined for independent retailers (i.e. not supermarkets). The grower sells produce directly to the public through a farmers market.

Pathway	Lettuces	Silverbeet	Cabbages
via wholesalers	95%	95%	95%
direct to retailers	0%	0%	0%
direct to the public	5%	5%	5%

Grower C is an organic grower certified under the BioGro organic standard and grows nine different crops. The retailers buying the products directly or via a wholesaler are all independent retailers.

Pathway	Lettuces	Siverbeet	Cabbages
via wholesalers	20%	20%	20%
direct to retailers	80%	80%	80%
direct to the public	0%	0%	0%

3.5 Natural fertilisers used by growers

Findings

i. 50% of the growers used one or more natural fertilisers.
ii. The most commonly used natural fertilisers were poultry litter, composted plant waste and foliar sprays made from fish or seaweed.
iii. Except for foliar sprays, most natural fertilisers were applied to the soil prior to crop planting.

Twenty (50%) growers reported that they had used one or more natural fertilisers for growing their crops since January 2010:

- 4/18 (22%) NZ GAP growers;
- 6/11 (55%) growers not certified under any assurance programme; and
- 10/11 (91%) organic growers.

None of the 10 hydroponic growers used any natural fertilisers.

The 20 growers applied a variety of natural fertilisers (Table 5). Growers were not specifically asked about the use of green crops (e.g. lupins), but several growers reported that they grew and ploughed these into fields between crops.

Four the natural fertilisers were sprayed directly on the plants:

- Liquid fish extract;
- Liquid blood and bone (sprayed onto seedlings);
- Liquid seaweed extract; and
- Compost tea.

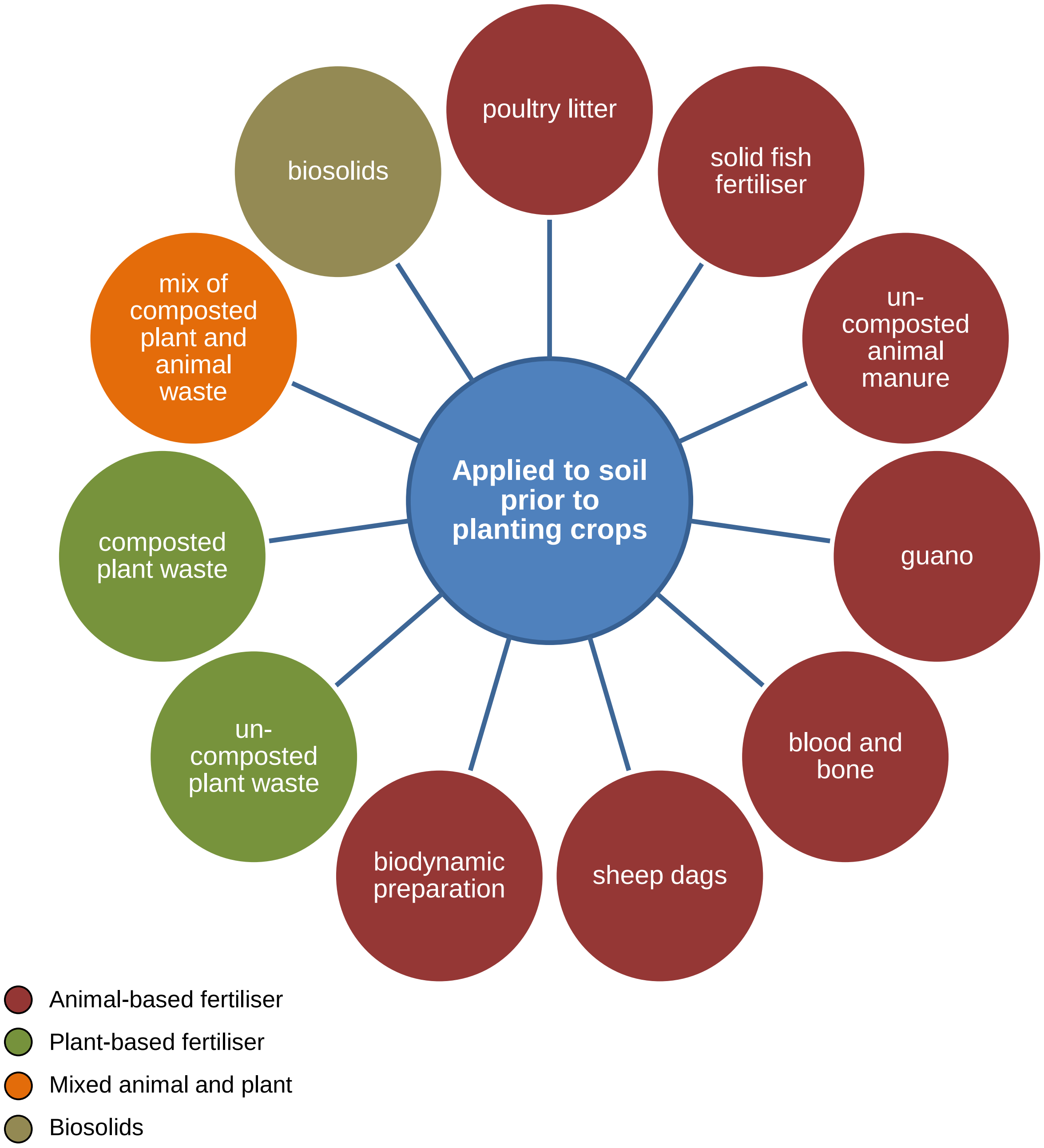
Most growers applied the other natural fertilisers to the soil prior to planting the crops (Figure 6). One grower applied bone meal to the soil under the crops after they were planted, and three berry growers applied compost to their plants before fruiting (see Section 3.6.2).

Table 5: Number of growers reporting the use of different types of natural fertiliser

Natural fertiliser	Number of growers			
	NZ GAP	Not certified	Organic	Total
Uncomposted livestock manure[1]	0	1	0	1
Composted animal waste	0	0	2	2
Poultry litter[2]	2	0	4	6
Fish by-products	0	0	8	8
Vermicast[3]	0	0	1	1
Guano[4]	0	0	2	2
Uncomposted plant waste[5]	0	0	3	3
Composted plant waste[4]	0	0	5	5
Other plant-based fertiliser[6]	2	1	6	9
Biosolids[7]	0	1	0	1
Other types				
- blood and bone	0	3	2	5
- mixed compost[8]	1	0	2	3
- other[9]	0	1	1	2

1. Grazed livestock on leftover crops after harvesting and ploughed the manure into the fields.
2. From a commercial supplier or a local egg producer.
3. This grower was trialling vermicast on a small area of land at the time of the survey.
4. Also used as a compost or potting mix for nursery plants.
5. Offcuts and waste from harvested crop turned into soil before planting next crop; mulch of bark fines used for weed control under crops; sawdust and shavings applied prior to planting crops.
6. Liquid seaweed extract or compost tea (extract of microorganisms from plant-based compost) applied as a foliar spray.
7. The product used by this grower is Bioboost®. This is a sterilised and dried product made from microorganisms extracted from wastewater aeration basins (i.e. not made from sewage sludge), see http://www.newplymouthnz.com/AtoZOfCouncilServices/Wastewater/Bioboost.htm.
8. Produced from mix of plant and animal products (e.g. manures, poultry litter, waste from food production, kitchen waste, prunings from orchards). Some growers used commercially produced products and some produced their own.
9. Sheep dags (mix of sheep manure and wool); Biodynamic preparation 500 (made from cow manure buried in a cow horn for a year, which is then diluted to a very low concentration in water and applied to soil as a spray).

Figure 6: The types of natural fertilisers that growers applied to the soil prior to planting the crops



3.6 How growers used natural fertilisers on specific crops

We asked the 20 growers who reported using one or more natural fertilisers for more detail on how they used these fertilisers. To collect this information, we asked about natural fertiliser use for up to three crops that the grower produced and that were most likely to be eaten without cooking. Seventeen of the growers used natural fertilisers during the production of lettuces or berry fruits and their use of natural fertilisers on these crops is described below (Sections 3.6.1 and 3.6.2). Nine of the ten lettuce growers used natural fertilisers the same way or to a lesser extent (e.g. fewer fertilisers) for their other crops. There were three growers that did not produce lettuces or berry fruits, and their use of natural fertilisers on their crops is described in Section 3.6.3, along with one lettuce-grower who reported a different natural fertiliser regime for their tomato crops.

Findings

i. Most natural fertilisers were applied to the soil prior to planting, although the time period between final application and planting was not always clearly specified.
ii. Sprays made from commercially produced fish or seaweed extracts are commonly applied to the edible parts of plants right up to harvest.
iii. Some growers increase the possibility of introducing pathogens onto the edible parts of the plants by applying untreated animal-based natural fertilisers close to (or at) planting (e.g. poultry litter[7]).
iv. Almost all of the growers knew what raw materials went into the products they were using but did now know whether any of the products were tested for pathogenic bacteria.
v. Growers often relied on their experience to know if a natural fertiliser was safe to use on a particular crop.
vi. The organic assurance programmes appeared to have more influence than other assurance programmes over what natural fertilisers a grower used and how they used them.

3.6.1 Lettuces

Of the 27 growers whose crops included lettuce, 10 (37%) used natural fertilisers during lettuce production: One NZ GAP grower, five organic growers and four growers not certified under any assurance programmes.

Six growers applied one or more of the following fertilisers to the soil, or incorporated them into the soil, prior to planting lettuces:

- Sawdust/shavings from untreated wood (1 organic grower);
- Poultry manure/litter (1 organic grower, 1 NZ GAP grower);
- Solid fish fertiliser (1 organic grower);
- Blood and bone (1 organic grower, 1 grower not certified under an assurance programme);

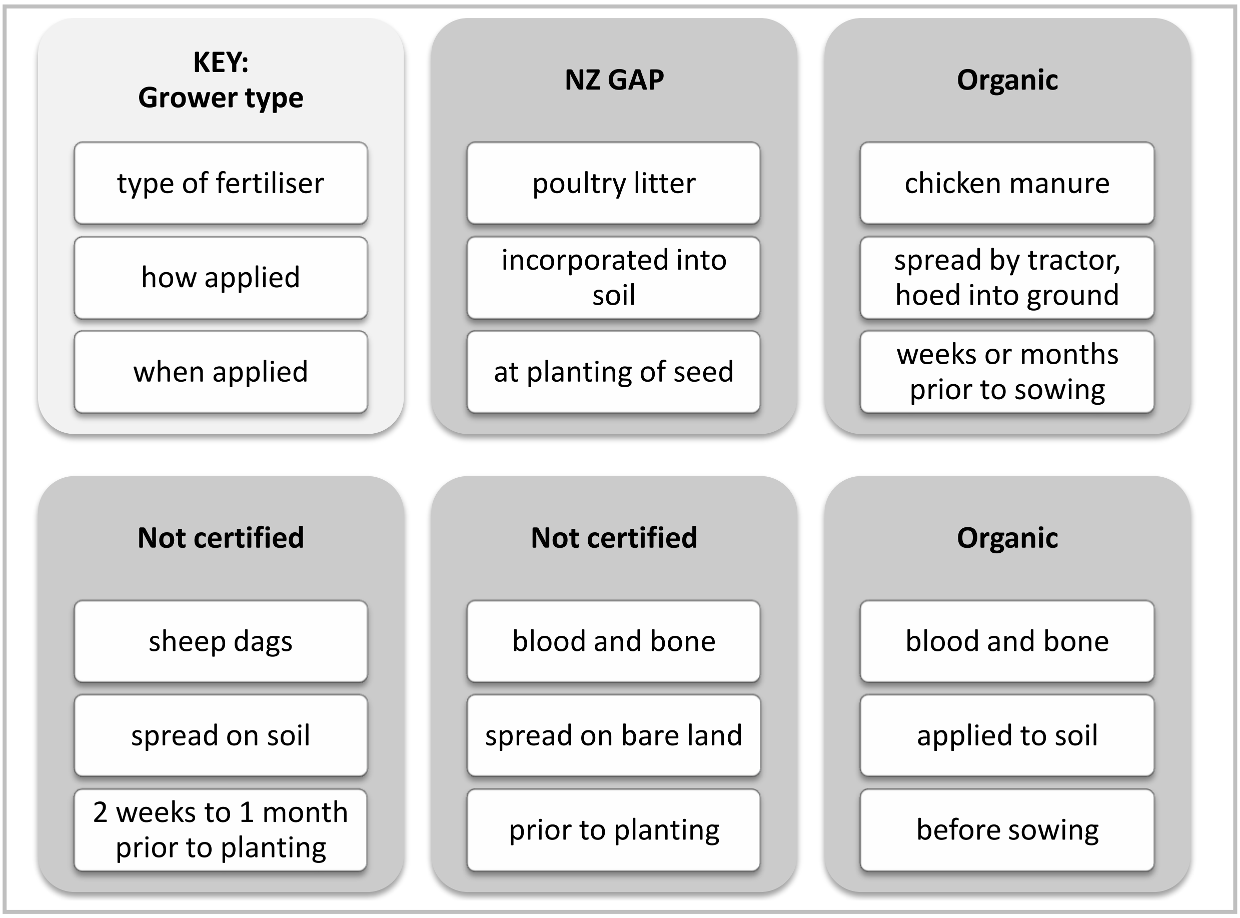
[7] Poultry litter is faecal material (chicken manure) mixed with the wood shavings etc., used on the floor of poultry sheds. Growers reported that they hoed the litter into the soil before planting.

- Biosolids (Bioboost®) (1 grower not certified under an assurance programme);
- Guano (1 organic grower);
- Composted plant waste (1 organic grower); and/or
- Sheep dags (manure/wool mix) (1 grower not certified under an assurance programme).

The time periods between applying these fertilisers and planting out was often vague varied from weeks to months. The sawdust/shavings, poultry manure/litter and sheep dags were not treated (e.g. composted, heat treated) before application; most growers applied these to the soil at least two weeks prior to planting, but one grower applied poultry litter to the soil at the same time as seed planting. The growers applying the fish fertiliser or blood and bone were unsure about the treatment these products received, but given that these were all commercial dried products it is likely their production included heat-drying or rendering. No information was available on whether the guano was treated.

Figure 7 illustrates how growers used poultry litter, sheep dags and blood and bone to fertilise the soil before planting their lettuce crops.

Figure 7: How six different growers use poultry litter, sheep dags and blood and bone to fertilise their lettuce crops



Seven growers sprayed a commercially produced liquid fertiliser directly to the foliage of the lettuces:

- One grower (not accredited to an assurance programme) sprayed liquid blood and bone on lettuce seedlings and made this liquid from a product that is dry and sterile when unopened.[8]
- One organic grower sprayed a compost tea made from plant-based compost onto young plants.
- Four organic growers used a fish-based liquid fertiliser sprayed onto the plants. Three of these growers did not apply a withholding period between application of the fish fertiliser and harvest (although one grower commented that they would allow at least one day for plant uptake, and another specified that the fertiliser was applied to seedlings); the fourth grower applied a withholding period of a minimum of one week. One of the growers reported that manufacture of the fish fertiliser involved a cold mulching process.
- Four growers (3 organic, 1 not certified to an assurance programme) used a seaweed-based fertiliser (two of the organic growers also used the fish-based liquid fertiliser, above). None of the growers applied a withholding period for the seaweed fertiliser, but one grower specified that they only sprayed seedlings and the other reported that they only sprayed young plants because they were unable to get the spraying equipment into the fields once the plants had grown. Two of these growers reported that manufacture of the seaweed fertiliser involved washing and drying of the seaweed.

Five (50%) of the growers using commercial products reported that they received information on the recommended application rates and element concentrations. One grower commented that they based their application rates on soil testing, and another grower based their application rates on long-term knowledge and experience. Two growers commented that they did not receive information on recommended withholding periods.

All but one of the growers knew what raw materials went into the products they were using, and six growers did not know whether any of the products were tested for bacteria. The grower using the commerciallyproduced compost tea sends samples of the fertiliser to be tested for pathogenic bacteria, and beneficial bacteria and fungi, twice a year. Three of the growers assumed that the manufacturers of the commercial products tested them for quality standards (e.g. nutrients, particle size), since these manufacturers provided elemental breakdowns on the packaging and also produced a consistent product (e.g. a standard granule size or a liquid able to be sprayed through application equipment).

The growers were asked how they knew that the natural fertilisers they used on the lettuces were safe and suitable for use. Four growers said that they had been using the products for a long time (10-20 years) and had not observed any problems, and two growers commented that these were natural products. Other sources of information included discussions with other growers or those selling the products. One grower applying poultry litter commented that chicken factories were rigorous with their feeding programmes and maintained a controlled environment.

[8] Rod Klarwill (Managing Director, Rural Research Ltd), pers. comm.

Growers that were certified under assurance programmes were also asked whether the requirements of the assurance programme influenced what natural fertilisers were used on the crop and how they were used. All five organic growers referred to the requirements specified in the relevant assurance programme manual (BioGro or AsureQuality) and three growers further commented that all inputs must be certified under these assurance programmes. One NZ GAP grower did not think this assurance programme influenced these activities.

3.6.2 Berries

Ten berry growers participated in this study (six strawberry growers, one blackcurrant grower, one blueberry grower, one grower of blueberries and strawberries and one grower of raspberries and strawberries). Four of these growers also produced other fruit and vegetables. Three of the berry growers did not use natural fertilisers on their berry crops (both only grew strawberries). Of the seven berry growers that used natural fertilisers, five were organic operators and two (both strawberry growers) were certified under NZ GAP.

Four berry growers (all organic growers) applied some form of compost:

- A 50:50 blend of poultry litter and compost (commercial product): Applied to strawberry and blueberry plants using a spreader while the plants are not fruiting. Withholding period of two months (minimum).
- A composted mixture of animal manures, fish waste, paunch grass, and waste from food and petfood manufacturers, fruit packhouses and wineries (commercial product): Applied before planting and annually to the ground by machine fertiliser spreader or by hand. Withholding period of 2-3 months.
- An organic compost (commercial product): Applied to strawberry plants two months after planting using a spreader, before the plants begin to flower and fruit (there is approximately six months between application and harvest).
- A compost produced by the grower from manures and plant waste: Incorporated into the soil before planting strawberry plants.

Five growers applied a fish and/or seaweed-based foliar spray directly to the plants, these were:

- Organic grower: Commercially produced seaweed and fish fertilisers applied to blueberry plants. The seaweed is applied up to one month before harvest, and the fish up to two months before harvest.
- Organic grower: A commercially produced liquid fish meal applied to blackcurrant plants in autumn (no flowers or fruit) using a watering can.
- Organic grower: A commercially produced seaweed fertiliser and (sometimes) a fish extract prepared on-site, both applied to strawberry plants throughout the growing season.
- NZ GAP grower: A commercially produced seaweed filtrate applied to strawberry plants every 7-10 days throughout the picking season.
- NZ GAP grower: A liquid seaweed applied to strawberry plants (no withholding period).

One organic grower also sprayed their strawberry plants throughout the growing season with a commercially produced mineral-based biodynamic preparation.[9]

All of the growers reported that they received information on the recommended mixing and application rates for commercial products. One grower commented that they also received information on how and when to apply their seaweed-based spray. All but one of the growers knew what raw materials went into the products they were using, but none of the growers knew whether any of the products were tested for bacteria. Three the growers reported that the manufacturers of the commercial products tested their products for nutrients and particle size.

Three of the growers (all organic growers) agreed that the requirements of their assurance programme influenced what natural fertilisers they used on the crop and how they were used. These growers commented that manufacturers of the products they used had to be certified to the same organic assurance programme, and that animal manures must be hot composted. One of the NZ GAP growers commented that they were not aware of any requirements for the use of natural fertilisers under this assurance programme.

When asked how they knew that the natural fertilisers they used on the berries were safe and suitable for use, the growers relied on their experience, organic certification of the products, or their knowledge of the inputs where a grower produced their own fertilisers.

3.6.3 Other crops

Four growers reported different usage of natural fertilisers that have not been captured above.

A grower of organic tomatoes applies a compost predominantly made from green waste to this crop.[10] The compost is applied by hand before planting so does not come into contact with the fruit. The grower reported that this fertiliser was tested for multiple residues and some bacteria before use, but the grower only receives information on application rates with the product. The grower is assured of the product’s safety because the product has been available for a long time. The organic assurance programme this grower is certified under also influences what fertilisers they use and how these are used.

One grower, who is not certified under an assurance programme, uses cattle manure from their property’s own livestock to fertilise the soil. The grower allows the livestock to graze leftover crops after harvest and ploughs the manure into the soil before any new crops sown. This grower produces nine different crops, including broccoli, cabbage, cauliflower, courgette and silverbeet.

A grower of brassicas (cabbages, broccoli and cauliflower) applies poultry litter from a local egg producer into the soils before planting the crops and uses a withholding period of at least three months. The grower reported that they immediately hoe the poultry litter into the ground after application, and do not apply the litter in the rain to avoid any smell and contamination. The litter is not deliberately treated but is stored in a paddock for 1-3 months

[9] Biodynamic preparation 501: Made from powdered quartz buried in a cow horn for six months, which is then diluted to a very low concentration in water and applied as a spray.

[10] This is a commercially produced product that has green waste as the dominant input, but may also include food waste from kitchens.

before use. This grower reported that the NZ GAP assurance programme influences the way that they use natural fertilisers in that they are careful not to let the dust drift on to other crops. They also reported that they knew this fertiliser was safe and suitable for use as they had been applying it for over 50 years without an incident.

A grower of garlic and herbs only reported use of natural fertilisers on their garlic crops. The grower applies a commercially produced bone meal to the garlic when the crop is almost half-grown.

3.7 Controlling effluent from adjacent properties

Findings

i. Physical barriers were important for minimising any contamination from livestock farming activities adjacent to growing areas.

We asked the growers whether they had a dairy farm, poultry farm or piggery adjacent to their property and if so, how they minimised the risk from potential contamination for their crops or water sources from effluent.

Six growers reported an adjacent livestock farm, all of whom relied on physical barriers to minimise contamination:

- Roads, shelterbelts or buildings;
- Buffer zones required by regional council rules for manure spreading;
- Topography (e.g. the farm is located downhill of the grower's property);
- Underground (bore) water supply;

Two growers kept chickens onsite, and one also kept pigs onsite. The chickens belonging to one of these growers were free range and kept on pasture adjacent to crops, and the grower reported that their processes were approved by BioGro, to whom they were certified. The grower keeping both chickens and pigs reported that the animals were self-contained and kept separate from crop growing areas; this grower also reported that they take their water from a deep spring so they considered the risk of contamination to be minimal.

3.8 Water sources

Findings

i. Most growers used groundwater for irrigation and applying products to the crops.
ii. Some growers used groundwater and water from other sources (roof water, surface water or town supply).

Thirty-eight growers used water for irrigating their crops (this includes the ten growers using hydroponic systems). The other two growers relied on rainfall to irrigate their crops. All forty growers used water to apply products to their crops (e.g. pesticides, seaweed sprays, biodynamic applications, compost teas, etc.).

The majority of growers drew water from underground sources (bores, wells) (Table 6). Of the ten hydroponic growers, seven took water from a bore or well and three from town supply. Seven growers took irrigation water from more than one source, and four growers used multiple sources of water for applying products. All of these growers took water from a bore, but the alternative source varied (e.g. roof water, surface water or town supply).

Table 6: Source of water for irrigation (including hydroponic systems) and the application of products to crops

Source of water	Number of growers (%) using this water source for:[1]	
	Irrigation	Applying products
Town supply	7 (18)	12 (30)
Ground (bore/well)	32 (84)[2]	28 (70)[3]
Roof water	2 (5)	2 (5)
Stream/river	2 (5)	2 (5)
Lake/dam	4 (11)	1 (3)

1. Percentages are calculated from 38 growers who used water for irrigation or the 40 growers who used water for applying plant products. Percentages do not sum to 100% because some growers reported using more than one source of water (see text of preceding paragraph).
2. This includes three growers who specified that they drew water from an artesian spring/well and one who drew water from a well.
3. This includes two growers who specified that they drew water from an artesian spring/well and one who drew water from a well.

3.9 Water quality

Findings

i. Most of the growers did not treat the water they used for growing their crops.
ii. Many of the growers using groundwater, roof water or surface water had these water sources tested for chemicals and/or microbial contaminants, but the testing frequency varied from quarterly to around every 10 years.
iii. Most growers did not assess for any potential sources of contamination to their water sources, but a few growers had taken action to ensure their water was still suitable for use when it was potentially contaminated.
iv. Where growers used water that they did not test or treat (other than town supply), they were assured that the water was appropriate to use because it was a drinking water supply or had been used for a long period without any observable adverse effects, or because there were risk management processes in place such as physical barriers to contamination or avoiding contact between the water and the edible parts of the crop.

Few growers treated the water they used for growing their crops (Table 7), but many of the growers using bore or surface water have had their water tested at some point (Table 8).

Table 7: Treatment of the water used for growing crops

Source of water	No. growers using source	Water treatment?[1] Yes (%)	No (%)	Treatments reported
Town supply	7	7 (100)	0 (0)	Treated by council: Chlorinated, and may also be filtered or pH-adjusted[2]
Bore	32	3 (9)[3]	29 (91)	Ozone treatment, UV filter, reverse osmosis filter[2]
Roof water	2	0 (0)	2 (100)	N/A
Stream/river	2	0 (0)	2 (100)	N/A
Lake/dam	4	1 (25)	3 (75)	Nylate® is added at water intake as needed[4]

N/A, not applicable

1. Percentages are calculated from the number of growers using each source (column 2).
2. One grower reported that they adjust the pH of their water from 7 to 5.8 using nitric or phosphoric acid. The grower uses this water for irrigating lettuces. Another grower reported that the council adjusted the pH of the water.
3. An additional four growers reported that the water was filtered to remove coarse particles. Most bore water uptakes would have such filters in place and their presence cannot be relied upon to reduce any microbial or chemical contamination that might be present in the water.
4. Nylate® is a commercial product available for the control of algae and bacteria in irrigation supply water (and for the control of post-harvest rot causing organisms and human pathogens in fruit and vegetable wash systems). See http://www.elliottchemicals.co.nz/cgi-bin/product.pl?product=902;type=2;printable=1

Table 8: Testing of the water used for growing crops

Source of water	No. growers using source	Water tested?[1] Yes (%)	No (%)	How frequently tested (No. growers)
Town supply	7	2 (29)	5 (71)[2]	annually (1); quarterly (1)
Bore	32	24 (75)[3]	8 (25)	monthly[4] (1); quarterly (1); every 6 months (3); annually (8); less frequently[5] (11)
Roof water	2	1 (50)	1 (50)	every few years (1)
Stream/river	2	2 (100)	0 (0)	at least annually (2)
Lake/dam	4	3 (75)	1 (25)	two months ago[6] (1); annually (2)

1. Percentages are calculated from the number of growers using each source (column 2).
2. One grower reported that the regional council tests the water every six months, and another (a hydroponic grower) reported that they test the pH every day.
3. Two growers reported that the water was tested by the regional council.
4. The grower testing their water monthly only tests for salinity.
5. Less frequently included: 1-2 years, when bore was put in, approximately 8 years ago, every 10 years or so, twice in 4-5 years, every few years, once 5 years ago.
6. This grower had just started using water from a dam.

Overall, 18/32 (56%) growers using bore water did not treat their water or test their water annually or more often and this includes growers certified to NZ GAP, an organic assurance programme, or not certified to any assurance programme (Table 9). For users of the other water types:

- Roof water: Two growers (1 NZ GAP, 1 not certified). Neither treated the water or tested it annually or more often.
- Stream/river water: Two growers (1 NZ GAP, 1 not certified). Neither treated the water but both tested annually or more often.
- Lake/dam water[11]: Four growers (all NZ GAP). One grower treated and tested the water annually. Of the three growers that did not treat the water, two did not test annually or more often.

Table 9: Testing and treatment of the bore water used by 32 growers for growing their crops, separated by certification to assurance programmes

Type of grower	Treat water? (see Table 7)	Test water annually or more often?	
		Yes	No*
NZ GAP (14 growers)	Yes	1	1
	No	7	5
Organic (11 growers)	Yes	0	0
	No	4	7
Not certified (7 growers)	Yes	1	0
	No	0	6
All growers (32 growers)	*Yes*	*2*	*1*
	No	*11*	*18*

* Shading indicates higher risk where water is not treated or tested annually or more often.

Seventeen (43%) growers were able to report at least one specific microbe or chemical their water was tested for (e.g. coliforms, *E. coli*, salinity) and 19 (48%) kept testing records.[12] When growers could recall at least some of the water tests, most indicated that the water was tested for *E. coli* and faecal coliforms or that the water underwent a standard laboratory screen for these bacteria, plus chemicals or minerals. One grower presented the results of such a screen, which included tests for *E. coli*, faecal coliforms and multiple chemicals including nitrates, metals and salts. Two growers also reported that their water was tested for other properties such as pH, cations, anions, hardness and conductivity.

[11] Lakes and dams are more static water supplies and environmental effects on hazards may be different than for other surface waters such as streams and rivers.

[12] The growers were not asked to retrieve these records, but some growers voluntarily provided them to show what their water was tested for.

We asked the growers whether they assessed for any potential sources of contamination to their water sources (e.g. animal access, run-off, storm events, septic tank overflow), and how often they did this. Three growers assessed their bore water sources; one did this 2-3 times per year, another when needed (e.g. after heavy rainfall or when stock have been known to have passed through the area of the bore), and the third reported that they would only ever do this if there had been a serious flood. One user of dam water reported that they visually checked this source on a random basis or as conditions required, and another user of lake water reported that they routinely checked for stock contamination or rain runoff.

We also asked growers whether they have used a potentially contaminated water source for irrigating their crops, and whether this involved them treating the water or changing the way they used it. The majority of the growers reported that they had not been in this situation. One grower used potentially contaminated bore water, but only after it had passed through a UV filter. Another user of bore water reported that they cleaned the pump and filter following contamination of fertigation. One grower's neighbour tested their shared bore water after the Canterbury earthquake. A fourth grower reported that when they first started they used well water, but found that the supply was too unreliable due to fluctuating water levels and run-off from dairy farms so they switched to town supply. Other growers made some general comments:

- "Knowing risks that exist with dam water contamination, use it only in May during planting" (grower uses town, bore and lake water).
- "Hasn't happened yet, but action plan in place to treat the water in the event of contamination – several options identified which would be considered on a case-by-case basis" (as recorded by interviewer; grower uses bore water).
- "Where contamination is observed, water source would be disconnected until contamination addressed" (as recorded by interviewer; grower uses bore and dam water).
- "If contamination likely to occur with lake water (e.g. stock effluent run-off, heavy rain) the lake water will not be used until deemed safe" (grower uses bore and lake water).

Growers were also asked, for any water sources they used that they did not test or treat, how they knew that the water was appropriate to use and whether they put any risk management steps in place. The users of a town water supply assumed that the water was safe because it should meet drinking water standards. Users of bore water provided varied responses:

- The same water is consumed in their home or community, e.g. "Bore water is also household water so assumed safe" (as recorded by interviewer), "the water is from a deep well bore that is used for the entire [name] village".
- Long-term use with no observable effects, e.g. "This bore has been used for 50+ years without any adverse effects to stock or plant growth", "there have been no adverse effects to crops".
- Physical barriers to contamination, e.g. "Bore has own artesian pressure and is sealed off and on high ground" (as recorded by interviewer), "Only use water from constant deep springs - if levels fluctuate or the spring is shallow, water will not be pulled from it" (as recorded by interviewer).

One user of roof water only used this water for seedlings. A grower who uses water from a dam and bore applies this water using trickle irrigation so there is no contact with the fruit or flowers.

3.10 How growers used water to irrigate specific crops

We asked the 38 growers who reported using one or more sources of water to irrigate their crops for more detail on how they did this. To collect this information, we asked about irrigation water use for up to three crops that the grower produced and that were most likely to be eaten without cooking. Some growers used the same methods for all of their crops. In these cases we have included their information where we talk about specific crop groups below, if the grower produced these crops (e.g. information from a grower who produced lettuces is included among other lettuce producers). As part of the questioning, we also asked growers how close to harvest they applied any spray water carrying products. Most of the growers indicated that the application of products to their crops depended on the withholding period of the product being applied, and this might range from days to months.

Findings

i. Most growers took steps to keep their produce free from any potential contamination from irrigation water by testing water sources, by changing the method of irrigation depending on the water source, or by not applying any irrigation water close to harvest.
ii. Some growers increased the possibility of their crops becoming contaminated by using irrigation water of uncertain quality up to the point of harvest.
iii. Growers were assured that their water was safe for irrigation because it was tested, was a drinking water supply or had been used for a long period without observable adverse effects.
iv. The assurance programmes have some influence on what water growers used to irrigate and how they use it.

3.10.1 <u>Lettuces</u>

Of the 27 growers whose crops included lettuce, 22 (81%) irrigated their lettuce crops (Table 10):

- Sixteen (73%) of these growers used groundwater for irrigation, and an additional three growers used a mix of groundwater and either roof-collected rain water or surface water. The two growers applying ground and surface water both used overhead irrigators and tested their dam or lake water annually for chemicals and microbial contaminants (both were certified under NZ GAP).
- Nine growers (41%) grew lettuces using hydroponic systems which meant that the irrigation water was applied up to harvest. Seven of these growers either used town supply or tested their water, and the other two growers (including the user of roof water who was certified under NZ GAP) assumed it was safe as it was their drinking water supply.
- Of the 13 non-hydroponic growers, four applied irrigation water up to harvest if necessary, but over half (54%) reported that they stopped applying water three days or more before harvest.

Table 10: Number of growers irrigating their lettuce crops by type of irrigation, source of the irrigation water and how close to harvest irrigation water is applied

Type of irrigation[1]	Source of water[2]	How close to harvest			
		Up to harvest	1 day	3-7 days	>1 week
Overhead	Ground	3	0	6	0
	Ground+Surface	0	1	1	0
Overhead+Trickle	Ground	1	1	0	0
Hydroponic	Town	3	0	0	0
	Ground	5	0	0	0
	Ground+Roof	1	0	0	0

1. Overhead = boom sprayers, sprinklers, travelling irrigators; Trickle = drip or trickle irrigation at soil level; Hydroponic = hydroponic systems (root level).
2. Town = town (municipal) supply; Ground = bore, well or artesian bore/well/spring; Surface = lake, dam or stream; Roof = rainwater collected from a roof.

When asked how they knew the water was safe to use on this crop, 12 growers referred to the water testing results, four growers reported that they drank the water, two growers trusted the water because it was a town drinking water supply, and four growers reported that they had used the water for long periods of time without problems.

Eleven growers reported that the requirements of the assurance programme they are certified under influences what irrigation water they use and how they use it. Some of these growers reported that their assurance programme required general hazard analysis, or water quality monitoring and testing (the assurance programmes included Woolworths Quality Assurance, BioGro or AsureQuality organic standards).

3.10.2 Berries

Of the ten berry growers that participated in the survey, nine irrigated their berry crops (Table 11) (six strawberry growers, one blackcurrant grower, one blueberry grower and one grower of blueberries and strawberries):

- Seven (78%) of these growers only used groundwater for irrigation, and of these growers, four tested the groundwater for chemicals or microbial contaminants.
- None of the growers using overhead irrigation tested their groundwater for chemicals or microbial contaminants.
- Four of the five growers using a mix of overhead and trickle irrigation specifically reported that they used the overhead irrigation while the plants were being established, and trickle irrigation underneath plastic thereafter. This includes the grower using surface water only (who tests their water source but not annually), and the grower using a mix of three water sources (who only uses town water for overhead irrigation).
- All of the strawberry growers applied irrigation water up to harvest, if needed. The blackcurrant grower reported that they irrigated nine months prior to harvest.

Table 11: Number of growers irrigating their berry crops by type of irrigation, source of the irrigation water and how close to harvest irrigation water is applied

Type of irrigation[1]	Source of water[2]	How close to harvest[3]		
		Up to harvest	1 day	>1 week
Overhead	Ground	1 (S)	0	1 (Bc)
Overhead+Trickle	Ground	2 (S,S+Bb)	1 (Bb)	0
	Surface	1 (S)	0	0
	Ground+Surface+Town	1 (S)	0	0
Trickle	Ground	1 (S)	0	0
Hydroponic	Ground	1 (S)	0	0

1. Overhead = boom sprayers, sprinklers, travelling irrigators; Trickle = drip or trickle irrigation at soil level; Hydroponic = hydroponic systems (root level).
2. Town = town (municipal) supply; Ground = bore, well or artesian bore/well/spring; Surface = lake, dam or stream; Roof = rainwater collected from a roof.
3. S = Strawberry plants; Bb = Blueberry plants; Bc = Blackcurrant plants.

When asked how they knew the water was safe to use on this crop, five growers referred to the water testing results, two growers relied on the attributes of the supply (town water, deep bore), and the remaining two reported that they had used the water for long periods of time without problems.

Five growers reported that the requirements of the assurance programme they are certified under influences what irrigation water they use and how they use it. Three of these growers reported that their assurance programme requires their water source to be approved or tested (the assurance programmes included BioGro organic standard and NZ GAP).

3.10.3 Brassicas

Cabbage, kale, cauliflower and broccoli were common brassicas produced by the growers in this study and 11 growers provided information on irrigation practices for these products (Table 12):

- All of the growers used groundwater as a source of irrigation water.
- All four of the growers that used surface water tested this water for chemicals or microbial contaminants annually or more often.
- The grower who trickle irrigated over a week before harvest specified that they only irrigated at the transplant stage.

When asked how they knew the water was safe to use on this crop, four growers referred to the water testing results, three growers reported they had used the water for a long period of time without problems, two growers thought it was safe because they used bore water and the remaining two growers because they drank the water.

Table 12: Number of growers irrigating their brassica crops by type of irrigation, source of the irrigation water and how close to harvest irrigation water is applied

Type of irrigation[1]	Source of water[2]	How close to harvest			
		Up to harvest	1 day	1 week	>1 week
Overhead	Ground	2	0	2	0
	Ground+Surface	0	1	1	0
	Ground+Surface+Town	0	0	0	1
Overhead+Trickle	Ground	2	0	0	0
	Ground+Surface	0	1	0	0
Trickle	Ground	0	0	0	1

1. Overhead = boom sprayers, sprinklers, travelling irrigators; Trickle = drip or trickle irrigation at soil level.
2. Town = town (municipal) supply; Ground = bore, well or artesian bore/well/spring; Surface = lake, dam or stream.

Seven growers reported that the requirements of the assurance programme they are certified under influences what irrigation water they use and how they use it. Three of these growers reported that their assurance programme requires their water source to be monitored, tested or of good quality, and one grower was required to consider their water as part of a general hazard analysis (the assurance programmes included NZ GAP, GLOBALG.A.P., Woolworths Quality Assurance, and the BioGro or AsureQuality organic standards).

3.10.4 Herbs and sprouts

Nine growers participating in this study grew herbs, of which five provided information on irrigation practices for these products (Table 13):

- Two growers used hydroponic systems and another grew both hydroponic and soil crops.
- All of the growers used groundwater or town supply for irrigation.
- All but one of the growers using groundwater tested their water; the remaining grower used trickle tape irrigation.
- The grower applying town water by overhead irrigation reported that they only irrigated to get the plants established.

Only one sprout grower participated in this survey. This grower produced a variety of sprouts and used water from a town supply to soak, sanitise and grow their products.

Table 13: Number of growers irrigating their herb crops by type of irrigation, source of the irrigation water and how close to harvest irrigation water is applied

Type of irrigation[1]	Source of water[2]	How close to harvest		
		Up to harvest	1 day	>1 week
Overhead	Ground	0	1[3]	0
	Town	0	0	1
Trickle	Ground	1	0	0
Hydroponic	Ground	2[3]	0	0
	Town	1	0	0

1. Overhead = boom sprayers, sprinklers, travelling irrigators; Trickle = drip or trickle irrigation at soil level; Hydroponic = hydroponic systems (root level).
2. Town = town (municipal) supply; Ground = bore, well or artesian bore/well/spring.
3. One grower produces separate hydroponic crops and soil crops, which have different irrigation systems.

3.10.5 Other crops

Six growers provided information on how they irrigate other crops that are likely to be eaten without cooking (Table 14). Other than the tomato crop irrigated by a trickle system, the irrigation water is likely to come into contact with all of the vegetables and the watermelon (although these products are likely to be washed and/or peeled prior to sale or consumption since they will carry soil remnants after harvest).

Table 14: The irrigation practices of seven growers producing crops that are likely to be eaten without cooking

Crop	Type of irrigation[1]	Source of water[2]	How close to harvest[3]	Test water every 1-2 years?
Carrots	Overhead	Ground+surface	1 week	yes
Carrots	Overhead	Ground	1 week	no
Celery	Overhead	Ground	Up to harvest	yes
Cucumbers, tomatoes	Trickle	Ground	Up to harvest	no
Radishes	Overhead	Ground	>1 week	yes
Watermelons	Trickle	Ground+town+surface	1 day	yes

1. Overhead = boom sprayers, sprinklers, travelling irrigators; Trickle = drip or trickle irrigation at soil level.
2. Town = town (municipal) supply; Ground = bore, well or artesian bore/well/spring; Surface = lake, dam or stream.
3. How close to harvest the irrigation water is applied (if required).

3.11 How growers used water during and after harvest

Findings

i. 20% of growers used water to wash or moisten produce in the field during harvest, and 63% used water to transport, wash, cool and/or moisten produce after harvest.
ii. Most growers using water on produce during or after harvest reduced the possibility of contamination by using groundwater or water from a roof or town supply, but these water sources were not always treated or tested regularly.
iii. Several growers took additional action to reduce the possibility of contamination by monitoring or adding antimicrobial chemicals to water used for immersing produce (tub/sink) and changing this water regularly, by using two wash steps, or by washing the plant roots separately.
iv. One grower increased the possibility of contaminating their produce by applying water from a stream to their produce during harvest.
v. Most growers used a hose or spray to apply water so the contact time was less than a minute.
vi. Most products were stored under cool conditions after packing.
vii. Growers were assured that their water was safe for use during and after harvest because it was tested, was a drinking water supply or had been used for a long period without observable adverse effects.
viii. The assurance programmes have some influence on what water growers used during and after harvest and how they use it.

We asked growers whether they used any water during the harvest or packing of any of their crops, and if so, what water source was used and how. Thirty-one (78%) growers reported using water during or after harvest for one or more of their crops.

Eight growers reported using water in the field during harvest (Table 15):

- Seven of these growers used bore or town supply water to wash the produce in the field, e.g. washing the produce on the back of the tractor, immersing it in a tub or washing the produce once it was in transportation crates.
- One grower used stream water to moisten the produce (the grower was not accredited to an assurance programme and tested this water once a year).

Table 15: Use of water on produce during harvest

Number of growers	Crops water used on	Purpose	Source of water*
6	Artichokes, cabbages, lettuces, leeks, pumpkins, radishes, silverbeet	Wash produce	Ground
1	Lettuces, herbs	Wash produce	Town
1	Lettuces, celery, silverbeet, brassicas	Moisten produce	Surface

* Town = town (municipal) supply; Ground = bore, well or artesian bore/well/spring; Surface = lake, dam or stream.

Twenty-five growers reported using water to transport, wash, cool and/or moisten one or more crops in the grading and packing area (Table 16). A few growers commented that the wash step also helps to cool the produce, particularly if a waterbath is used (e.g. carrots). All 25 growers used water from a town, ground or roof supply for these post-harvest processes. The two growers using roof water (1 NZ GAP grower, 1 grower not accredited to an assurance programme) did not treat this water or test it annually or more often.

We asked these growers for more detail on how they used water during or after harvest on crops that were most likely to be eaten without cooking. Some growers used the same methods for all of their crops. In these cases we have included their information where we talk about specific crop groups below, if the grower produced these crops (e.g. information from a grower who produced lettuces is included among other lettuce producers). The growers were also asked how they knew the water was safe to use on this crop, and whether the requirements of an assurance programme influenced what water was used and how it was used. The responses were similar to that provided when the growers were asked these questions about their irrigation water. None of the growers reported instances where potentially contaminated water was used during harvesting or post-harvest processes.

Table 16: Use of water on produce after harvesting

Number of growers	Crops water used on	Purpose	Source of water[1]
7	Beetroot, brassicas, carrots, coriander, courgettes, garlic, herbs, leeks, lettuces, sprouts, strawberries[2]	Wash/rinse produce	Town
1	Brassicas, courgettes, lettuces, mesclun, squash, sweetcorn, tomatoes, watermelons	Transport, cool and wash produce	Town
14	Asian greens, beetroot, brassicas, carrots, cucumbers, fennel, kale, leeks, lettuces, mesclun, parsley, potatoes, radishes, rocket, salad mix, silverbeet, spinach, spring onions, strawberries[2], tomatoes	Wash/rinse produce	Ground
2	Lettuces, onions, spinach	Wash/rinse produce	Ground+roof
1	Lettuces	Moisten produce[3]	Ground

1. Town = town (municipal) supply; Ground = bore, well or artesian bore/well/spring; Roof = rainwater collected from a roof.
2. Only fruit intended for freezing or processing.
3. Mist spray.

3.11.1 Lettuces

Of the 27 growers whose crops included lettuce, 19 (70%) used water during or after harvest of their lettuce crops, including three mesclun growers and five hydroponic growers (Table 17):

- Eighteen growers used water from town, ground or roof supplies to wash, rinse or spray the lettuces or loose leaves (six of these growers, including those using roof water, used water that was not treated or regularly tested).
- One grower used stream water to moisten the produce.[13]
- None of the growers carried out any tests for microbial contaminants or water quality above that already carried out on the source water, however four growers reported that they monitored and/or added antimicrobial chemicals to the wash water if required (all of these growers used a tub or sink to wash the produce).

Table 17: The quality of the water applied to lettuces or lettuce products during or after harvest

Source of water[1]	Is source water treated?	Is source water tested annually or more often for microbial contaminants?	Number of lettuce growers	Additional testing or treatment of wash water?[2]
Town	Yes	Yes[3]	4	2 growers: Monitor and add chlorine
Ground	Yes	Yes	2	None specified
	Yes	No	1	1 grower: Treat with antimicrobial product
	No	Yes	4	None specified
	No	No	5	1 grower: Treat with antimicrobial product
Ground+roof	No	No	2	None specified
Surface	No	Yes	1	None specified

1. Town = town (municipal) supply; Ground = bore, well or artesian bore/well/spring; Roof = rainwater collected from a roof; Surface = lake, dam or stream.
2. Four growers reported additional treatment of their wash water. The antimicrobial products used were Tsunami® (see http://www.ecolab.com/initiatives/foodsafety/fst/Tsunami.asp) and Geosil® (see http://www.geosil.co.nz/).
3. Town supplies are monitored and tested by local authorities.

13 The grower was not a member of an assurance programme and tested the stream water once a year.

There was some variability in the way that water was used:

- One of the hydroponic growers reported that they only rinsed the roots of the lettuces using bore water, and another reported that they used bore water for a post-harvest mist spray rather than washing.
- Four non-hydroponic growers reported that they used water in the field during harvest to remove dirt before or after packing the lettuces into crates.
- Five growers specifically reported they used a tub or sink to wash their lettuce product; all but one of these growers monitored and/or added antimicrobial product.

Ten of the growers estimated or knew the temperature of the wash water; the remainder were unable to say or reported that the water was at “ambient” temperature or cold/ground temperature. Five growers reported that the temperature was 10°C or less (one grower reported that the water comes from a tank in the chiller and is 2°C). The temperatures reported by the other five growers were: 8-16°C, 10-15°C, 12°C (2 growers) and 13°C. Because most of the growers used hoses or sprays to wash the produce, in most cases the contact time with the water was less than one minute. Of the five growers using a tub or sink, two reported that the produce was in contact with the water for about five minutes.

None of the growers specifically used water for cooling the lettuce products, although some cooling will be achieved with chilled wash water.

Fifteen growers stored their lettuce products in a chiller or coolstore before it was transported elsewhere, usually only for a day or less, but sometimes up to two weeks. Most of these growers stored the lettuce products in crates (either unbagged or in individual plastic bags); those providing loose leaf products stored them in plastic bags. The reported temperatures were: 1°C, 2-4°C, 2-7°C, 4°C (2 growers), 5-7°C and 8°C. Four growers transported their lettuces on the day of harvest to a wholesaler’s coolstore, supermarket or retailer, farmers market or their farm shop.

3.11.2 Berries

Of the ten berry growers that participated in the survey, only two growers used water after harvesting their strawberries. Other berry growers reported that applying water to berries after harvesting encourages the growth of spoilage microorganisms. The two growers only used water on the portion of their strawberry crops that was destined for further processing – either freezing or sending on to a jam manufacturer. One of these growers used a town supply of water to rinse the berries for 2-3 minutes before storing them in a coolstore and transporting them to a jam manufacturer. The other grower used a bore water supply (tested quarterly) to feed a partial recirculating wash system, where fresh water was mixed with older water in a constant process of replacement (the grower estimated that the water was around 12°C). After passing through the system (<1 minute) the strawberries were packaged in boxes and kept in a coolstore until transportation offsite for freezing.

3.11.3 Brassicas

Six growers provided information on the use of water during and after harvest for cabbages, broccoli and cauliflower. One of these growers only used water in the field to moisten their broccoli and cauliflower to keep it fresh prior to storage or transportation. This grower used stream water that was not treated, but was tested annually.

All of the five remaining growers used water for washing the produce:

- Two growers used bore water or a mix of bore and roof water to wash the produce for a few seconds. One of these growers reported that they did this in the field during harvest. Neither grower treated the water, or tested the water annually or more often.
- Two growers used town supply water. One rinsed the produce for less than a minute. The other washed the produce in a tub at 2-8°C for up to 3 minutes, monitoring the level of chlorine in the water every 30 minutes and changing the water at least every two hours. This grower also used town water for their hydrocooling system (renewed daily) or to make ice to cool broccoli.
- One grower used UV-treated water from an artesian spring to fill two sinks for washing the produce (dipped in one, then the other). The water temperature was estimated as 10°C and is changed after every harvested batch of produce.

Of these five growers, two growers shifted the products to market on the day of harvesting, and the other three stored the products in crates in a chiller for up to two weeks.

3.11.4 Herbs and sprouts

Nine herb growers and one sprout grower participated in this study. Four herb growers (two of which grew herbs hydroponically) and the sprout grower provided information on the use of water during and after harvest of these crops. One of these growers only uses bore water to soak parsley for up to one hour after harvest, but only does this if the parsley has wilted at picking. The bore water is from a deep well and is not tested or treated. The remaining four growers all use a town supply for their water but use this water in different ways:

- A grower adds hydrogen peroxide to the wash water in a tub. The water is approximately 16°C and is in contact with the herbs for less than 1 minute. The grower changes the water daily or before each harvest batch if more than one batch is harvested in a day.
- A grower washes soil from the roots of the herbs in one bath of water (only the roots are submerged for about 10 minutes), then the whole plant is briefly immersed in a second bath of water. The water in both baths is changed daily.
- A grower passes the herbs through two wash tubs for 2-3 minutes each. The grower adds chlorine to the water as needed and refreshes the water periodically.
- The grower uses water for rinsing and sorting sprouts, and may add additional chlorine to the supply. The water temperature is about 18°C and is in contact with the sprouts for up to an hour, after which the sprouts are spin dried.

All of the growers stored their products in a chiller after washing.

3.11.5 Other crops

Thirteen growers provided information on how they use water during or after harvest on other crops that are likely to be eaten without cooking. Three of these growers used water from a town supply to:

- Transport watermelon by flume and wash using a spray;
- Wash courgettes in a tub for 2-3 minutes (water changed every 2-3 crates);
- Wash beetroot with a hose; or
- Wash and clean carrots in a rotating drum with spray, following by soaking them in a bath (water changed about every 30 minutes) and a final spray wash.

Nine growers used groundwater for product washing. Only one of these growers used treated water; this grower used UV-treated water from an artesian spring for washing tomatoes. Four of the growers used untreated groundwater, but tested this water annually or more often for microbiological contamination:

- Two growers washed carrots after harvesting. One used a tub of water that was replaced daily, and topped up as required during the day. The other grower rinsed carrots on a conveyer before these were put through a spray tumbler. The spray tumbler used fresh water, and this water was then recycled to the pre-rinse step before being discharged out of the system.[14]
- One grower washed radishes in tubs in the field, changing the water between harvests.
- One grower rinsed spinach in the packing shed.

The remaining four growers using groundwater did not treat this water, or test it annually or more often for microbial contaminants (one grower also used roof water). These growers used the water to wash cucumbers, radishes, silverbeet and spinach.

Only one of the thirteen growers of "other crops" used surface water. This grower used stream water to moisten celery in the field before transportation. The stream water is not treated, but is tested annually.

All of the produce is kept in a coolstore or chiller until transportation to market, except for the watermelon (kept in dry, ambient conditions) and the tomatoes (transported straight to market).

[14] Prior to these washing steps, this grower rinsed the carrots and cooled them in a high humidity coolstore (0.5°C) for 24 hours, then stored them at ambient temperatures for up to one hour.

3.12 Testing produce for microbial contaminants

Findings

i. The produce from 18% of growers was regularly tested for microbial contaminants.

We asked growers whether they, or their customers, tested their horticultural produce for microbial contaminants. Seven growers (18%) (all NZ GAP) reported that regular testing takes place as a requirement of an assurance programme (e.g. Woolworths Quality Assurance, MAF Quality Assurance), customer (e.g. supermarket, takeaway chain), or because the grower chooses to test their produce as part of their own quality control processes. Another seven growers reported that their produce was randomly tested by customers or as part of their assurance programme requirements (two of these knew that residue testing was undertaken, but were unsure if microbial testing was also included). Four growers (10%) reported that their produce was tested once as part of a research project or by a customer. Finally, one grower reported that their products were not tested, but their packhouse was swab-tested during the packing season.

3.13 Enhancing food safety in the horticultural industry

We asked growers whether they had identified anything that could enhance food safety in the horticultural industry. This was an open question that allowed growers to share their views and 20 (50%) growers provided one or more answers. These have been summarised under some general themes in Table 18 (note that these are not direct quotes as many of these views were recorded by the interviewer rather than being written by the grower).

Table 18: Summary of grower views on things that could enhance food safety in the horticultural industry

Theme	Views
General regulations/standards	• In three years of production observed little regulation which is surprising • Rather than standards have heavy fines for contamination detected by random testing • If standards are brought in there will need to be incentive to comply
Assurance programmes, food safety programmes, labelling	• Supportive of NZ GAP and WQA, despite costs and added administration • Concerned over growers supplying independent retailers where assurance programmes do not exist • No 'penalty' for not being certified under NZ GAP • Make assurance programmes mandatory for supply to retail, wholesale and farmers markets • Implementation of HACCP programme is a good way of identifying any potential hazards and threats • Our premises are also licensed and inspected by Health Inspectors under Food Safety Regulations by District Council; I know that others in the industry are only covered by NZGAP that has different agendas • Tag system: Three tiers of tags to indicate grading of produce (top quality, average, poor) – grower should put on tags but this is not useful as grower can put on any tag; also supposed to put a tag on to indicate product has been sprayed; don't think these systems are in use anymore
Contamination concerns at primary production	• Spray drift is an issue for organic growers • Concerns over the impact of smoke from steel mill • Concerns over lack of information on bacterial contamination of natural fertilisers • Concerns over acceptable pesticide residue levels and the cumulative affect these continue to have on our lives
Addressing contamination at primary production	• Would value a treatment policy for lake water • Random/spot checks on produce by regulatory bodies • Reduce chemical residues; ban use of "off label" agrichemicals • Ban use of raw manure • More chemical residue testing of produce delivered to markets (publish results)

Table 18 (continued)

Theme	Views
Addressing contamination at primary production (continued)	• NZFSA together with industry could do more to help organise/advertise advisors (not auditors) to visit farms and pack houses; education rather than regulation would be a good way to continue; growers will want to do learn more if they see it as improving the sales value of their produce, but not if regulation is forced on them, they will then see it as increased compliance costs • Implementation of in house safety systems (e.g. a risk management programme) with staff education (through notices, notice boards)
Responsibility for controlling contamination and quality along the foodchain	• Contamination can occur at any point through the supply chain (e.g. the wholesaler). Grower would encourage analysis downstream of the grower • At point of sale fruit and produce is handled, squeezed, etc. by customers whose hygiene could easily be in question and then picked up by the next customer • Food safety is the end of a line of problems; if food has pathogens on it something has gone wrong (e.g. handling, transport); there are lots of steps between the grower and the consumer • Plastic wrap is not the answer - consumers also need to take some responsibility (e.g. wash produce) • Farmers markets are good - direct from grower to consumer • New regulations - growers are regulated enough; if there are to be new regulations these should be applied at supermarkets, transporters, distributers, retailers, etc., as contamination can often appear at this level • What happens in the market in the supply chain post grower; grower has incentive to get product to market as quickly as possible for freshness • Would like to see retailers move stock faster rather than having it sitting in crates
Traceability	• There is a lack of traceability in NZ (gate to plate, domestically and export) • All produce (and products) should indicate city/country of origin clearly as well as km travelled to store so we can elect to buy local
NZ reputation	• Generally NZ produce is safe compared with other countries; there are good standards in place and the grower has never heard of an instance where someone has been poisoned by vegetables
Imported products	• Imported goods need greater scrutiny

4 SUMMARY

The results of this survey are based on the responses of 40 growers of horticulture produce. The sample of growers was principally from the three target geographical regions of New Zealand, and included growers of single or multiple crops, growers who produced minimally-processed products, growers of export and domestic produce, growers who farmed small and large areas, and growers who produced food under different systems (e.g. hydroponic, organic, outdoors).

The majority of growers were certified under an assurance programme, but the survey also captured the practices of 11 growers who were not certified under an assurance programme. Many (but not all) of the growers that were certified to an assurance programme reported that the programme influenced how they used natural fertilisers and water, in particular the organic assurance programmes. However, growers appeared more likely to rely on their experience and their knowledge of the source of natural fertiliser or water inputs for deciding if these inputs are safe and appropriate for use.

Most of the growers had some understanding of the quality of the water and natural fertiliser inputs they used, and applied these inputs in ways that would reduce the risk of chemical or microbial contamination. In most cases, natural fertilisers considered to be of higher contamination risk (i.e. those produced from animal products) were applied to the soil prior to crop planting. Growers took steps to protect their produce from contaminated water by testing or treating the water, by using potable water, or by taking care over how the water was applied (e.g. overhead versus trickle irrigation, not applying irrigation too close to harvest (where possible), using multiple wash steps).

We recorded some potentially unsafe practices where there was a possibility of produce becoming contaminated, or the potential for water or fertiliser contamination had not been assessed:

- Short (i.e. <1 month) or undefined periods of time between application of untreated natural fertilisers to the soil and planting of the crop (emerging seeds or the young leaves of seedlings are likely to come into contact with the soil and if pathogens are still viable these could be transferred to the plant). The scientific literature (see Volume 2) indicates that pathogens from natural fertilisers may be viable in soil for several weeks;
- Fish and seaweed sprays are commonly applied to plants right up to harvest (this study has not investigated the microbiological and chemical quality of these solutions);
- Water sources used for irrigation, application of sprays and washing could not always be guaranteed to be free from contamination where these were not regularly tested or treated (particularly if the water is roof or surface water, which are susceptible to contamination events). Contamination of surface water with pathogens, particularly *Campylobacter*, has been shown to be common (see Volume 1 Section 5.3).

The potentially unsafe practices identified above were not associated with specific grower groups; in particular, such practices were not reported more often by growers that were not certified under an assurance programme compared to those who were certified. For example, some of the NZ GAP or organic certified growers in this study applied poultry litter close to planting lettuce crops, or used surface water for irrigating or washing crops. However, this observation must be treated with caution as the sample was only a small proportion of the total grower population, and may not representative of New Zealand growers as a whole.

Given the small sample size relative to the number horticultural growers in New Zealand, this survey has revealed considerable variability of practices between growers, irrespective of assurance programme certification.

APPENDIX 1: GROWER QUESTIONNAIRE

Horticultural Produce - water and natural fertiliser use (PWNF Project)

Top Sheet

Name	
Business name	
Location/address	

Source/criteria

office use only – please leave blank

Type	Canterbury	Manawatu	South Auckland	Rest of NZ
NZGAP				
Not certified				
Organic				
Farmers Markets				
Total				

Horticultural Produce - water and natural fertiliser use (PWNF Project)

Questions for producers

The New Zealand Food Safety Authority has commissioned the Institute of Environmental Science & Research (ESR) and Catalyst® R&D Ltd to review how water and natural fertilisers are used during the growing, harvesting and packing of horticultural products, and how this might affect the safety of these products. The driver for the project is the new Food Bill and the possible food safety controls that might form part of its implementation.

Our reporting for this project will be anonymous i.e. individuals and properties will not be identified. To manage this aspect of the project we have put together a confidentiality agreement (see Appendix 1). If you are happy with how we will handle your information, please sign to give your consent.

What do we mean by natural fertiliser?
Any fertiliser produced from animal, plant and human waste products or by-products (e.g. biosolids, manure, farm effluent, compost, chicken litter, vermicast, mulch, seaweed, blood and bone meal). This material may or may not be treated by pasteurisation, composting, fermentation, etc. This study does not cover crushed mineral deposits (e.g. limestone), biological activators (e.g. biodynamic preparations) or foliar applied growth regulators.

What water are we interested in?
Any water that is used for irrigating produce, applying products to the crop, and any water that comes into contact with the produce after harvesting (e.g. wash water, cooling water). Non-potable water means water that does not meet the New Zealand Drinking Water Standards or does not need to meet these standards (e.g. water used for agricultural purposes but not for drinking).

What produce are we interested in?
The project scope includes fruit, vegetables, nuts, seeds, herbs, spices, cereal grains, fungi and grasses consumed raw (whole or as pieces) or minimally processed (in a way that is not intended to kill micro-organisms) as a raw dried or semi-dried product.

For the purpose of these interviews we are interested in fresh fruits and vegetables consumed raw, and which are likely to have come into contact with natural fertilisers and/or water for irrigation and sprays.

The project is expected to finish in mid-2011. For any enquiries please contact Jane Lancaster at: PWNFstudy@gmail.com or 03 3296888.

Q1. Production information

Q1.1 Are you a:

☐ Grower

☐ Grower and packhouse

☐ Packhouse only

☐ Other, please tell us what:

Q1.2 How large is your production area? (in hectares):

Q2. Are you a member of any industry body?

☐ No

☐ Yes – Please tell us which body(s):

Q3. Do you operate under any assurance programmes or quality systems?

(Include programmes for export and domestic market).

☐ No

☐ Yes – Please specify which programmes/systems:

☐	**Growing**	
☐	**Harvesting**	
☐	**Packhouse**	

Q4. What horticultural products have you produced since January 2010?

Please use the table below to tell us:

4.1 The products you have produced since January 2010

4.2 The total tonnes you produced since January 2010. Where tonnage is unknown please provide data in other units and specify what those are in your answers.

4.3 Of the total tonnes you produced since January 2010, how many tonnes were grown to make minimally processed products? (these are products that are dried, semi-dried or pre-prepared in some way, such as dried apricots, shredded lettuce, sliced fruit).

4.4 What were these minimally processed products?

4.1 Product	4.2 Tonnes produced	4.3 Tonnes of minimally processed product	4.4 Type of minimally processed product

Q5. How do your products reach the consumer?

Please estimate the relative percentage by volume (not $), where known to you.

	e.g.	Products:									
Percent (%) of product that is:	Lettuces										
Exported	50										
Sold on the domestic market *Wholesaler and then:*											
Supermarket	25										
Independent retailer/chain											
Food service											
Farmer's market											
Farm shop											
Other, please specify:											
Direct to retail or public:											
Supermarket											
Independent retailer/chain	25										
Food service											
Farmer's market											
Farm shop											
"Pick-your-own"											
Other, please specify:											

The use of natural fertilisers

Q6. Have you used any natural fertilisers for growing your crops since January 2010?

☐ No

☐ Yes: Please tell us which natural fertilisers you have used on which crops, below.

Type of natural fertiliser applied		Crop(s)
Uncomposted livestock manure	Specify animal source:	
Composted animal waste	Specify type (e.g. manure, offal) and animal source:	
Poultry litter		
Fish by-products		
Vermicast		
Guano		
Composted plant waste		
Uncomposted plant waste	Specify type (e.g. tree mulch, bark):	
Plant-based fertiliser (e.g. compost tea, seaweed)		
Biosolids		
Other	Please specify:	
	Please specify:	
	Please specify:	
	Please specify:	

By natural fertilisers we mean products that may include any of the following:

Animal products: livestock manures, compost from manures, mulch of animal origin, poultry litter, fish by-products (e.g. fishmeal), worm by-products (vermicast), marine bird manure (guano).

Plant products: compost from plant material, mulch from plant material, peat, food plant by-products (e.g. kitchen waste, cocoa husks, oilseed cake), wood by-products (e.g. sawdust, bark, ash, charcoal), seaweed, seaweed meal or algae preparations, stillage (by-product of distillation, straw).

Human waste: biosolids, sewage effluent from wastewater treatment facilities.

Q7. We would like to collect some more detailed information on how these natural fertilisers were used for some of your crops.

Please choose up to three crops where you used natural fertilisers, including any natural fertilisers you produced yourself. Please choose the crops that are most likely to be eaten without cooking.

Q7.1 Crop 1: [ ]

Type(s) of natural fertiliser applied	
Source/supplier	
For each fertiliser:	
Does the supplier of the fertiliser provide information about usage? e.g. recommended application method, withholding periods. *If yes, what?*	
Do you know what raw materials went into this fertiliser? *If yes, what?*	
Do you know how the fertiliser was treated before you used it? e.g. composted. *If yes, how?*	
Do you know if the fertiliser was tested for bacteria before you used it? *If yes, do you know which bacteria?* *(do you keep records of this?)*	
Do you know if any other quality tests were carried out on the fertiliser before you used it? e.g. chemicals, nutrients, particle size. *If yes, what tests?* *(do you keep records of this?)*	
At what stage of year/site preparation/crop growth is the fertiliser applied?	
How is it applied? *(Does it come into contact with the edible parts of the plant?)*	
Is there a withholding period between application and crop harvest? *If yes, how long?*	

If this crop is accredited to an assurance programme: Do the requirements of the assurance programme for this crop influence what natural fertilisers you use and how you use them? In what ways?	
How do you know that the natural fertiliser is safe and suitable for use?	
Any other comments?	

Q7.2 Crop 2:

Type(s) of natural fertiliser applied	
Source/supplier	
For each fertiliser:	
Does the supplier of the fertiliser provide information about usage? e.g. recommended application method, withholding periods. *If yes, what?*	
Do you know what raw materials went into this fertiliser? *If yes, what?*	
Do you know how the fertiliser was treated before you used it? e.g. composted. *If yes, how?*	
Do you know if the fertiliser was tested for bacteria before you used it? *If yes, do you know which bacteria?* *(do you keep records of this?)*	
Do you know if any other quality tests were carried out on the fertiliser before you used it? e.g. chemicals, nutrients, particle size. *If yes, what tests?* *(do you keep records of this?)*	

At what stage of year/site preparation/crop growth is the fertiliser applied?	
How is it applied? *(Does it come into contact with the edible parts of the plant?)*	
Is there a withholding period between application and crop harvest? *If yes, how long?*	
If this crop is accredited to an assurance programme: Do the requirements of the assurance programme for this crop influence what natural fertilisers you use and how you use them? In what ways?	
How do you know that the natural fertiliser is safe and suitable for use?	
Any other comments?	

Q7.3 Crop 3:

Type(s) of natural fertiliser applied	
Source/supplier	
For each fertiliser:	
Does the supplier of the fertiliser provide information about usage? e.g. recommended application method, withholding periods. *If yes, what?*	
Do you know what raw materials went into this fertiliser? *If yes, what?*	
Do you know how the fertiliser was treated before you used it? e.g. composted. *If yes, how?*	

Do you know if the fertiliser was tested for bacteria before you used it? *(do you keep records of this?)* *If yes, do you know which bacteria?*	
Do you know if any other quality tests were carried out on the fertiliser before you used it? e.g. chemicals, nutrients, particle size. *(do you keep records of this?)* *If yes, what tests?*	
At what stage of year/site preparation/crop growth is the fertiliser applied?	
How is it applied? *(Does it come into contact with the edible parts of the plant?)*	
Is there a withholding period between application and crop harvest? *If yes, how long?*	
If this crop is accredited to an assurance programme: Do the requirements of the assurance programme for this crop influence what natural fertilisers you use and how you use them? In what ways?	
How do you know that the natural fertiliser is safe and suitable for use?	
Any other comments?	

Q8. Do you have a dairy farm, poultry farm or piggery adjacent to your property?

☐ No

☐ Yes: How do you minimise the risk from potential contamination of your crops or water sources from effluent?

Water usage for irrigation and any spray application of agrichemicals (chemicals and products) to the crop

Note to interviewer: We are trying to assess how the grower knows the water is appropriate to use. We also want to know whether growers use the same source of waters for irrigation and any agrichemical application. If the water for agrichemical application is different, please note it.

Q9. Where do you get your irrigation and agrichemical application water from?

Irrigation water		**Water used for agrichemical application**	
Source of water	**Applied to which crops?**	**Source of water**	**Applied to which crops?**
☐ Town supply		☐ Town supply	
☐ Bore		☐ Bore	
☐ Roof water		☐ Roof water	
☐ Stream/river		☐ Stream/rive r	
☐ Lake		☐ Lake	
☐ Other source (eg. grey water) Please specify:		☐ Other source Please specify:	

Q9. Some questions on irrigation water quality

Using the table below, please tell us about the water sources you use for irrigation:

Q9.1 Is it treated in any way? (e.g. filtered, chlorinated, UV, storage lagoons, bio-remediation)

Q9.2 Do you test the irrigation water for any microbial contaminants or water quality?

Q9.3 Do you assess potential sources of contamination to your water sources? (e.g. animal access, run-off, storm events, septic tank overflow). If so, how often?

Q9.4 Where a water source is potentially contaminated, do you still use it? (You might take extra steps to treat it, or change the way you use it)

Source of water	Q9.1 Treatment? (specify how)	Q9.2 Tested? > if yes, see Q9.5		Q9.3 Contamination assessment? (how often)	Q9.4 Use contaminated water? > If yes, see Q9.6	
		Yes	No		Yes	No
Town supply		☐	☐		☐	☐
Bore		☐	☐		☐	☐
Roof water		☐	☐		☐	☐
Stream/river		☐	☐		☐	☐
Lake		☐	☐		☐	☐
Other source		☐	☐		☐	☐

Q9.5 For each irrigation water source where you test the water:

How often do you test?
What do you test for?
What limits make it unacceptable for use?
Do you keep records of this?

Source water	How often	Test for	Limits	Records?

Q9.6 In instances where potentially contaminated water has been used, have you treated it or changed the way you use it?

Q10. If there are any water sources you do not test or treat, how do you know that the water is appropriate to use? Are there any risk management steps you put in place?

Q11. We would like to collect some more detailed information on how water was used to irrigate some of your crops. These crops may also have had agrichemicals applied using water.

Please choose up to three crops which were irrigated. Please choose the crops that are most likely to be eaten without cooking.

Q11.1 Crop 1:

How is the irrigation water applied?* (Does the water come into contact with the edible parts of the plant?)	
How close to harvest is the irrigation water applied?	
If agrichemical sprays are also applied using water: How close to harvest is any spray water applied?	
How do you know this water is safe to use on this crop?	
If this crop is accredited to an assurance programme: Do the requirements of the assurance programme for this crop influence what irrigation water you use and how you use it? In what ways?	
Any other comment?	

* e.g. overhead, trickle, hydroponic, sub surface

Q11.2 Crop 2:

How is the irrigation water applied?* (Does the water come into contact with the edible parts of the plant?)	
How close to harvest is the irrigation water applied?	
If agrichemical sprays are also applied using water: How close to harvest is any spray water applied?	
How do you know this water is safe to use on this crop?	
If this crop is accredited to an assurance programme: Do the requirements of the assurance programme for this crop influence what irrigation water you use and how you use it? In what ways?	
Any other comment?	

Q11.3 Crop 3:

How is the irrigation water applied?* (Does the water come into contact with the edible parts of the plant?)	
How close to harvest is the irrigation water applied?	
If agrichemical sprays are also applied using water: How close to harvest is any spray water applied?	
How do you know this water is safe to use on this crop?	
If this crop is accredited to an assurance programme: Do the requirements of the assurance programme for this crop influence what irrigation water you use and how you use it? In what ways?	
Any other comment?	

Water usage during harvesting or post-harvesting

Q12. Do you use any water during the harvest or packing of any of your crops?

Crop	In the field during harvest		In the grading and packing area	
	How water used*	Source of water**	How water used*	Source of water**

* e.g. cooling, transportation, washing.
** There may be additional sources to those used for irrigation.

Q13. We would like to collect some more detailed information on how water was used during and after harvest of some of your crops.

Please choose up to three crops where water is used during and/or after harvest. Please choose the crops that are most likely to be eaten without cooking.

Q13.1 Crop 1: [ ]

During harvesting and post-harvesting, when does water come into contact with the produce? *Collect any additional detail to the information given in Q12.*	
Washing: Where produce is washed (either during harvest or in the packhouse), where does the water come from for the final wash step?	
Washing: If there are circulation systems, how often is water renewed? (is the water treated or monitored? If so, how?)	
Washing: What is the temperature of the wash water? How long is the product in contact with the wash water?	
Washing: Do you test the wash water for any microbial contaminants or water quality? *(How often? What analyses? What limits make it unacceptable for use? Do you have to keep records of this?)*	
Cooling (if water comes into contact, including ice): where does the water come from for the cooling? (Is it potable or treated? e.g. chlorinated)	
Cooling: If these are circulation systems, how often is water renewed? (is the water treated or monitored? If so, how?)	
Cooling: Do you test the cooling water for any microbial contaminants or water quality? *(How often? What analyses? What limits make it unacceptable for use? Do you have to keep records of this?)*	
How do you know this water is safe to use on this crop?	

If this crop is accredited to an assurance programme: Do the requirements of the assurance programme for this crop influence what water you use and how you use it? In what ways?	
How is the product stored before it is transported to wholesalers, retailers, distributers, etc.? Please describe *(temperature, time, how kept, e.g. in boxes, crates, plastic bags)*	
Any other comments?	

Q13.2 Crop 2:

During harvesting and post-harvesting, when does water come into contact with the produce? *Collect any additional detail to the information given in Q12.*	
Washing: Where produce is washed (either during harvest or in the packhouse), where does the water come from for the final wash step?	
Washing: If there are circulation systems, how often is water renewed? (is the water treated or monitored? If so, how?)	
Washing: What is the temperature of the wash water? How long is the product in contact with the wash water?	
Washing: Do you test the wash water for any microbial contaminants or water quality? *(How often? What analyses? What limits make it unacceptable for use? Do you have to keep records of this?)*	
Cooling (if water comes into contact, including ice): where does the water come from for the cooling? (Is it potable or treated? e.g. chlorinated)	

Cooling: If these are circulation systems, how often is water renewed? (is the water treated or monitored? If so, how?)	
Cooling: Do you test the cooling water for any microbial contaminants or water quality? *(How often? What analyses? What limits make it unacceptable for use? Do you have to keep records of this?)*	
How do you know this water is safe to use on this crop?	
If this crop is accredited to an assurance programme: Do the requirements of the assurance programme for this crop influence what water you use and how you use it? In what ways?	
How is the product stored before it is transported to wholesalers, retailers, distributers, etc.? Please describe *(temperature, time, how kept, e.g. in boxes, crates, plastic bags)*	
Any other comments?	

Q13.3 Crop 3:

During harvesting and post-harvesting, when does water come into contact with the produce? *Collect any additional detail to the information given in Q12.*	
Washing: Where produce is washed (either during harvest or in the packhouse), where does the water come from for the final wash step?	
Washing: If there are circulation systems, how often is water renewed? (is the water treated or monitored? If so, how?)	

Washing: What is the temperature of the wash water? How long is the product in contact with the wash water?	
Washing: Do you test the wash water for any microbial contaminants or water quality? *(How often? What analyses? What limits make it unacceptable for use? Do you have to keep records of this?)*	
Cooling (if water comes into contact, including ice): where does the water come from for the cooling? (Is it potable or treated? e.g. chlorinated)	
Cooling: If these are circulation systems, how often is water renewed? (is the water treated or monitored? If so, how?)	
Cooling: Do you test the cooling water for any microbial contaminants or water quality? *(How often? What analyses? What limits make it unacceptable for use? Do you have to keep records of this?)*	
How do you know this water is safe to use on this crop?	
If this crop is accredited to an assurance programme: Do the requirements of the assurance programme for this crop influence what water you use and how you use it? In what ways?	
How is the product stored before it is transported to wholesalers, retailers, distributers, etc.? Please describe *(temperature, time, how kept, e.g. in boxes, crates, plastic bags)*	
Any other comments?	

Q14. Have there been any instances where potentially contaminated water has been used during harvesting or post-harvest processes? If so, have you treated it or changed the way you use it?

Q15. If there are any water sources you use for washing or cooling that you do not test or treat, how do you know that the water is appropriate to use? Are there any risk management steps you put in place?

Q16: Do you, or your customers, test horticultural produce for microbial contaminants? If so what micro-organisms are tested for and how often?

Q17. Is there anything else you can identify that could enhance food safety in the horticultural industry?

The project is expected to finish in mid-2011. For any enquiries please contact: PWNFstudy@gmail.com

Appendix 1 Confidentiality

Your contribution will be combined with information from other growers for reporting to the NZFSA. A final report is expected in autumn, 2011 and this will be publicly available on the NZFSA website (www.nzfsa.govt.nz). We might contact you before the report is published to check our understanding of your information.

Please take a moment to read about your rights and how we (ESR and Catalyst) will manage your information.

YOUR RIGHTS AND OUR OBLIGATIONS TO YOU

By signing below you give us permission to use the information you have provided to us in this study. We will not use this information for any other studies. We will not release your name, business name or contact details to the NZFSA or any third party unless you give us permission to do so (we will ask in writing).

We aim to present the results so that you are not personally identifiable. However, once the results are analysed it may be possible by inference to identify you or your business. If this is the case we will contact you first to explain the situation and you have the choice to refuse or allow publication of the results in this way.

You can withdraw your consent to participate at any time, up until Friday 28 January, 2011. You will need to tell us by e-mail or post that you want to withdraw from the project (contact details are below). When we receive your instructions we will delete/shred all of the information you provided and will tell you this has been done.

How we will manage your information:

Any information you give to us today will be transferred into a password-protected electronic document and the hard copy stored securely by Catalyst (Christchurch) until the report has been finalised (at which point the hard copies will be shredded). Only the people who are responsible for analysing this information and writing the final report will have access to the raw electronic data.

How you can contact us:

Dr Rob Lake (ESR), Nicola King (ESR) and Jane Lancaster (Catalyst) are the project team for this study and can all be contacted by e-mail: pwnfstudy@gmail.com

All other correspondence should be directed to:

Jane Lancaster, Catalyst R&D
PO Box 37228, Christchurch 8245
Phone: 03 3296888; Mobile: 027 227 3666; Fax: 03 3296880; www.catalystnz.co.nz

ESR website: www.esr.cri.nz

YOUR CONSENT:

By signing below I acknowledge that I am willing to participate in this study and have read and understand how my information will be managed and reported.

Signed: ________________________________ Date: ______________________

First name: _____________________________ Last name: ____________________________

Client report FW11024

A REVIEW OF THE USE OF WATER AND NATURAL FERTILISERS DURING THE GROWING, HARVESTING AND PACKING OF HORTICULTURAL PRODUCE

VOLUME 4: LAWS, REGULATIONS, STANDARDS AND ASSURANCE PROGRAMMES

Prepared for the Ministry of Agriculture and Forestry
under Agreement 11875

Dr Stephen On
Food Safety Programme Leader

Dr Rob Lake
Project Leader

Wendy Williamson
Peer Reviewer

Institute of Environmental Science & Research Limited
Christchurch Science Centre
Location address: 27 Creyke Road, Ilam, Christchurch
Postal address: P O Box 29 181, Christchurch, New Zealand
Website: www.esr.cri.nz

A CROWN RESEARCH INSTITUTE

REVIEW OF THE USE OF WATER AND NATURAL FERTILISERS DURING THE GROWING, HARVESTING AND PACKING OF HORTICULTURAL PRODUCE

VOLUME 4: LAWS, REGULATIONS, STANDARDS AND ASSURANCE PROGRAMMES

Prepared for the Ministry of Agriculture and Forestry
under Agreement 11875

by

Nicola King (ESR),
Rob Lake (ESR) and
Jane Lancaster (Catalyst® R&D)

September 2011

DISCLAIMER

ACKNOWLEDGEMENTS

The authors would like to thank the following people and organisations for their contribution to this volume:

Standards New Zealand for granting permission to reproduce text from NZS 8410:2003, and Vinod Dahya (Standards New Zealand) for assisting with this process

Mike Smith (Organics Technical Manager, AsureQuality)

David Wright (Secretary, Bio Dynamic Farming and Gardening Association in New Zealand)

Matthew Dolan (Business Manager, Horticulture New Zealand)

Andrea Armitage (Advisor – Organics, New Zealand Food Safety Authority)

Dr Michelle Glogau (Chief Executive Officer, BioGro)

Kevin Geddes (Executive Director, New Zealand Fertiliser Quality Council)

Dr Henry Pak (Technical Manager, Avocado Industry Council)

Misty Johnstone (Turners and Growers Group Company)

Dr Margaret Leonard and Dr Jacqui Horswell (ESR)

The employees of the 17 Regional Councils and Unitary Authorities who assisted with the summary of regional authority rules

REFERENCES TO WEBSITES

All of the websites referred to in this document were available for access in April 2011, unless specified.

PRINTING THIS DOCUMENT

Note that some of the pages in Section 5, Appendix 1 and Appendix 2 have been formatted to print to A3 size.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ACVMA	Agricultural Compounds and Veterinary Medicines Act 1997
ANZECC	Australian and New Zealand Environment and Conservation Council
BRC	British Retail Consortium
CAC	Codex Alimentarius Commission
CFU	Colony Forming Unit
CPCC	Control Points and Compliance Criteria
DWSNZ	Drinking Water Standards for New Zealand
FAO	Food and Agriculture Organization of the United Nations
FSANZ	Food Standards Australia New Zealand
FSC	(Australia New Zealand) Food Standards Code
GAPs	Good Agricultural Practices
GMPs	Good Manufacturing Practices
GOP	Good Operating Practice
HACCP	Hazard Analysis and Critical Control Point
IFOAM	International Federation of Organic Agriculture Movements
LEAF	Linking Environment And Farming
MAF	Ministry of Agriculture and Forestry
MAVs	Maximum Acceptable Values
MPN	Most Probable Number
NOP	(USDA) National Organic Program
NZBPCC	New Zealand Biological Producers and Consumers Council
NZFSA	New Zealand Food Safety Authority, New Zealand*
NZLTC	New Zealand Land Treatment Collective*
RMA	Resource Management Act 1991
USDA	United States Department of Agriculture
USFDA	United States Food and Drug Administration
WHO	World Health Organization

* NZFSA was amalgamated into MAF, New Zealand, on 1 July 2010.

1 INTRODUCTION

This volume compiles information on the laws, regulations, standards and assurance programmes that influence the production of horticultural produce in New Zealand. This volume provides detailed information to support the main report (Volume 1).[1]

Horticultural producers must operate in accordance with New Zealand food legislation and associated regulations and standards. There are also legislation and standards that control the taking of water for irrigation, water quality and the application of natural fertilisers to land. A new Food Bill is being considered by Parliament that will update and consolidate existing food legislation, and this has implications for the horticultural industry. Section 2 outlines relevant New Zealand legislation, regulations and mandatory standards, and the proposed new Food Bill (as at 2010). This section also summarises local authority rules for application of natural fertilisers and taking of water.

There are a number of non-mandatory food safety standards that are applicable to horticultural products produced in New Zealand. There are also New Zealand guidelines for the treatment and application of natural fertilisers and the use of water. These have been described in Section 3.

Assurance programmes are designed to assure buyers that the products they are purchasing have been produced according to an agreed set of standards. The requirements of an assurance programme depend on the purpose of the programme, and may cover some or all of production processes, quality parameters, labelling, and food safety.

Assurance programmes might be put in place by overseas governments, large retailers such as supermarket chains, or by credible, independent industry bodies. If a horticultural producer is to gain access to specific markets, such as export markets, organic markets or major retail outlets, they usually need to be certified under one or several assurance programmes. In New Zealand, certification under an assurance programme is not a legal requirement for horticultural producers.

Section 4 describes the New Zealand assurance programmes applicable to domestic horticultural production, including those for organic production. This section also describes important international codes of practice, particularly the Codex Alimentarius Commission's (CAC) Code of Hygienic Practice for Fresh Fruits and Vegetables, as well as some of the assurance programmes put in place by the European Union, United States and some of the other countries that receive exported New Zealand horticultural products. Section 5 compares the CAC code of practice, two internationally recognised assurance programmes and New Zealand assurance programmes.

[1] Available from http://www.foodsafety.govt.nz

2 NEW ZEALAND LEGISLATION, REGULATIONS AND MANDATORY STANDARDS

2.1 New Zealand Legislation and Regulations

The *Health Act 1956, Food Act 1981, Resource Management Act 1991* (RMA) and *Agricultural Compounds and Veterinary Medicines Act 1997* (ACVMA) are currently the most relevant legislation for domestic horticultural production (

Figure 1).

While horticultural growers are subject to the RMA and ACVMA, they may only be subject to the Health Act or Food Act if they have a retail shop as part of their operation. The Health Act provides for the making of regulations to protect food from contamination by any communicable disease, and the Health (Registration of Premises) Regulations 1966 and Food Hygiene Regulations 1974 were both made according to these provisions. Any premises used for the retail sale of fruit or vegetables is subject to the Food Hygiene Regulations and must be registered under the Health (Registration of Premises) Regulations, unless they have been granted an exemption under the Food Act, which requires them to have a Food Safety Programme in place. A description of the minimum requirements of a Food Safety Programme is included in Section 8G of the Food Act. Among other requirements, the Food Safety Programme must be based on the principles of Hazard Analysis Critical Control Point (HACCP) and must identify the hazards involved in the preparation of food and how those hazards will be monitored and controlled.

The Food Act also provides for the issuing of food standards and regulations. The Australia New Zealand Food Standards Code (Section 2.2.1) and the Food (Safety) Regulations 2002 are both applicable to horticultural products. The Food (Prescribed Foods) Standard 2007 also applies to horticultural products, but only those imported into New Zealand.

The Food Act 1981 (and Food Hygiene Regulations 1974) only applies to imported and food for domestic sale. Fresh produce and plant products intended for export do not need to comply with the Food Act and as a consequence the Australia New Zealand Food Standards Code. In addition, in terms of the food regulations there are no requirements in the Food Act or FHR 1974 to grow produce although the ACVM Act may apply.

The Health Act and the RMA set out rules that apply to the production of natural fertilisers. The Health Act lists several “offensive trades” that require consent and most of these trades are activities that involve managing animal parts and human waste. Thus the production of natural fertilisers from animal parts (not manure) or human waste (biosolids) requires consent under the Health Act, unless resource consent has been granted under the RMA.

The purpose of the RMA is to limit any effects of activities, not to limit activities themselves. A manufacturer of natural fertilisers requires resource consent under this Act as this activity will most likely result in discharges to land. Similarly, application of natural fertilisers to land is considered to be a discharge of contaminants under the Act, and also requires resource consent. However, a Regional Authority may permit the application of natural fertilisers to land under their regional plan, in which case a resource consent is not required if a grower meets any conditions set by the Authority (see Section 2.3.1).

The RMA also sets out rules that apply to the taking of water and requires people who want to take water for irrigation to apply for resource consent. However, growers may not require a resource consent if they take water from sources and in quantities that are permitted under a Local Authority's regional plan (see Section 2.3.2).

The purpose of the ACVMA is to ensure the safe use of agricultural compounds in food production. Natural fertilisers meet the definition of an agricultural compound under this Act, and as such must either be registered as being accepted for use, or exempted from registration but accepted for use on the basis of being generally recognised as safe for use.

Table 1 provides further information on these pieces of legislation.

2.1.1 The Food Bill 2010

A new Food Bill was introduced to Parliament in May 2010. As of April 2011, the Food Bill 2010 had passed its first reading, and the Primary Production Select Committee had examined the Bill and recommended that it be passed with amendments. If passed into law, the Food Bill will replace the Food Act 1981 and, over time, replace the Food Hygiene Regulations 1974 and the Food (Safety) Regulations 2002.[2]

The Food Bill proposes that any person involved in the trade of food must operate under one of three risk-based measures: Food control plans, national programmes or food handler guidance. Schedules 1-3 of the Bill specify which risk-based measures will apply to each food sector.

The new Food Bill will apply to growers of fresh produce (horticulture), the first time that there will be food legislatory requirements for this sector. The Bill proposes that horticultural food producers and horticultural packing operations (packhouses) will operate under a national programme (Figure 2). The national programmes will specify the minimum regulatory requirements that a food business will need to comply with to assure food safety.

There are three levels of national programme, which vary according to the level of risk that needs to be managed. A level 3 national programme generally imposes a higher level of control on a food business than a level 2 national programme, and a level 2 imposes a higher level of control than a level 1. As of 2010 is it proposed that horticultural producers and packers will operate under a level 1 programme, as will manufacturers of frozen fruit or vegetables. Manufacturers of dried or dehydrated fruit or vegetables are proposed to operate under a level 2 programme, and manufacturers of fruit or vegetable beverages proposed to operate under a level 3 programme. The national programmes are under development and their implementation is subject to the parliamentary process and the Food Bill 2010 being passed into law.

[2] The Food Bill 2010 is available at http://www.legislation.govt.nz/bill/government/2010/0160/latest/DLM3435700.html?search=ts_bill_food+bill_resel&p=1&sr=1. Further information on the Food Bill 2010 and its progress through Parliament is provided by MAF, see http://www.foodsafety.govt.nz/policy-law/food-bill/.

Horticultural producers that only minimally process and handle the produce they have grown themselves (e.g. wash or rinse), and only sell this produce directly to consumers (e.g. roadside stalls) will be subject to food handler guidance. Food handler guidance will outline the steps that are necessary to achieve safe and suitable food, but does not carry with it any registration or verification requirements.

Manufacturers of fresh ready-to-eat salads that are purchased in packaging and do not require further preparation by the consumer before consumption will be subject to food control plans. Food control plans will be designed by a each food business and will identify, control, manage, and eliminate or minimise hazards or other relevant factors for the purpose of achieving safe and suitable food.

Figure 1: New Zealand Acts and related Regulations applicable to domestic horticultural production

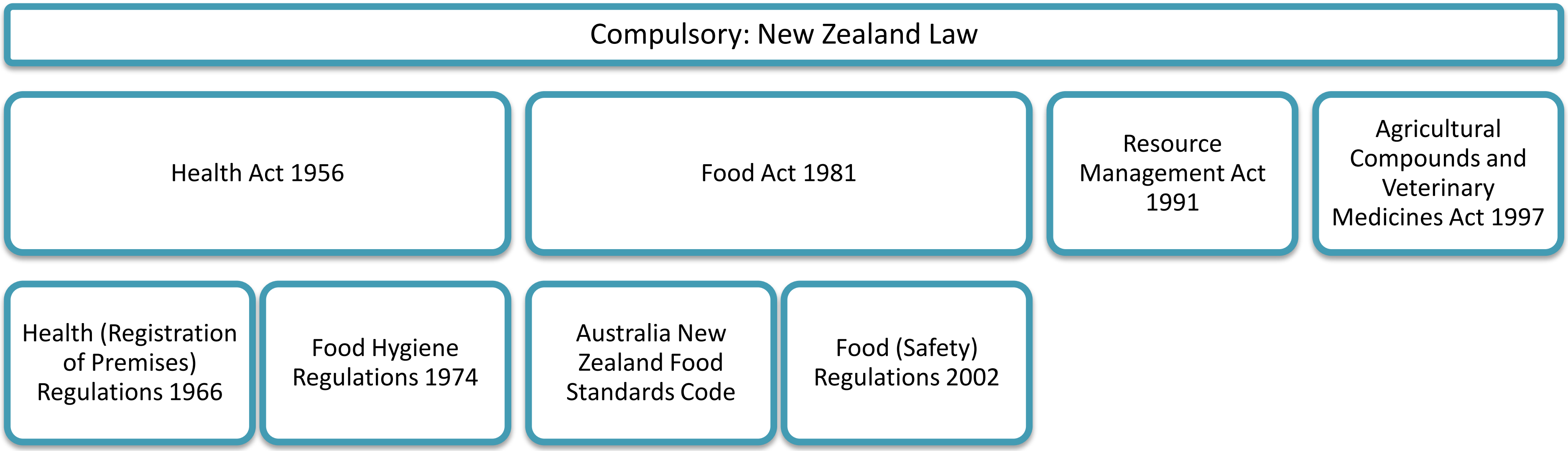


Table 1: New Zealand Acts and Regulations applicable to food safety, natural fertilisers and the use of water in horticulture

Act/Regulation	Purpose of the Act/Regulation	How this Act or Regulation applies
Health Act 1956[1]	Sets out the powers and duties of the Ministry of Health, Health Districts and Local Authorities, and includes responsibilities for providing services such as public health, drinking water and sanitation.	The Act provides for the Governor General to make regulations for the purpose of "the protection of food from the infection of any communicable disease on any premises used for the manufacture, preparation, packing, storage, or handling of any article of food for sale, and the prohibition or restriction of the handling, by persons suffering from any communicable disease, of any article of food intended for sale" (Section 117). This Act is applicable to natural fertiliser production where such production involves gut scraping and treating, blood or offal treating, bone boiling or crushing, nightsoil collection and disposal, refuse collection and disposal, or septic tank desludging and disposal of sludge (Schedule 3). These activities are classified as offensive trades under the Act and are not permitted without consent from the local authority and the Medical Officer of Health, who may impose conditions (Section 54). Permission is not required from the local authority and Medical Officer of Health if resource consent has been granted under the Resource Management Act 1991.
Health (Registration of Premises) Regulations 1966[2]	These regulations provide for the registration of premises (and the renewal and revocation of any such registration) with Local Authorities.	Under the Food Hygiene Regulations (below), premises used for the retail sale of fruit of vegetables must be registered by a local authority.
Food Hygiene Regulations 1974[3]	These regulations require food premises to be registered and set general food handling requirements as well as those specific to certain food industries, e.g. eatinghouses, breweries, the manufacture of frozen confections.	These regulations only apply to premises used for the retail sale of fruit or vegetables (Section 4(2)), which must be registered with a Local Authority. The regulations do not apply to the sorting, grading, or pre-packing of fruit or produce on orchards, farms, market gardens, or produce stores, for sale by wholesale (Section 4(3)), or the pre-processing of fruit of vegetables by stripping from stalks, sorting or washing (Section 4(3A)).

1. Available at: http://www.legislation.govt.nz/act/public/1956/0065/latest/DLM305840.html. Version assessed: As at 29 November 2010.
2. Available at: http://www.legislation.govt.nz/regulation/public/1966/0073/latest/DLM23780.html. Version assessed: As at 3 September 2007.
3. Available at: http://www.legislation.govt.nz/regulation/public/1974/0169/latest/DLM42658.html. Version assessed: As at 3 September 1997.

Table 1 (continued)

Act/Regulation	Purpose of the Act/Regulation	How this Act or Regulation applies
Food Act 1981[4]	Provides the regulatory framework for food imported or sold in New Zealand. Includes provisions for approval of food safety programmes, setting food standards and regulations, inspecting and enforcing standards or regulations and controls on advertising. The Act also gives effect to the Australia-New Zealand Joint Food Standards Agreement.	This Act applies to everyone who is involved in the production and sale of horticultural products that are intended for human consumption (Section 4 of the Act). Under this Act, food producers may apply for exemption from the Food Hygiene Regulations 1974 and having a Food Safety Programme in place is a critical part of this application (Section 8N). The Act sets out the requirements of a Food Safety Programme. This is a programme designed to identify and control food safety risk factors in order to establish and maintain food safety. The food safety risk factors may relate to the production, manufacture, preparation (Section 4A). Food Safety Programmes must be approved by territorial authorities or MAF. This Act also provides for the issuing of food standards and regulations.
Australia New Zealand Food Standards Code[5]	Sets out the required standards for food produced in New Zealand and the States, Territories and Commonwealth of Australia in relation to food sold and/or imported into both countries.	The code includes standards for labelling and composition. Of interest are standards for preliminary provisions, labelling and other information, food additives and processing aids, maximal levels of metal contaminants permitted in food, and microbiological limits (refer to Chapter 1 of the Food Standards Code). There is a product standard for fruit and vegetables (Refer to Chapter 2 of the Food Standards Code). See Section 2.2.1 of this report for further detail. There are some production standards for fruit and vegetables which only apply in Australia.
Food Regulations 1984 (incorporating Amendments 1 to 13)	Prescribe standards of composition and labelling for food and regulate the use of food additives	First and Second Tables to Regulation 257 (Incidental Constituents) specify Proportions of Elements in Foods and Proportions of Pesticides, Fumigants and Other Incidental Constituents.
Food (Safety) Regulations 2002[6]	Sets out provisions related to food safety that are not covered in the Australia New Zealand Food Standards Code.	The Medical Officer of Health is granted powers to prohibit the sale of food contaminated with an organism that is capable of causing food poisoning or communicable disease (Section 12 of the regulations). Water added to food must be of potable quality, and may include the addition of fluoride to levels permitted under the Health Act 1956, the Local Government Act 1974, or in any other enactment regulating water quality or reticulation (Section 24).

4. Available at: http://www.legislation.govt.nz/act/public/1981/0045/latest/DLM48687.html. Version assessed: As at 3 September 2007.
5. Available at: http://www.foodstandards.gov.au/foodstandards/foodstandardscode.cfm.
6. Available at: http://www.legislation.govt.nz/regulation/public/2002/0396/latest/DLM173193.html. Version assessed: As at 25 October 2007.

Table 1 (continued)

Act/Regulation	Purpose of the Act/Regulation	How this Act or Regulation applies
Resource Management Act 1991[7]	Promotes the sustainable management of natural and physical resources by setting out which activities are permitted and which require resource consent, and the functions, powers and duties of all parties (e.g. regional councils, resource consent applicants).	The Act includes rules for the taking of water and for discharges to land. Under the Act, there are only some situations where the taking, using, damming, or diverting of water is permitted (Section 14 of the Act). Taking water for growing produce requires a resource consent, unless it is permitted under a regional plan. The Act contains rules on the discharge of contaminants into the environment, which includes discharges to land (Section 15). The definition of a contaminant includes any substance (including odorous compounds, liquids, solids, and micro-organisms) that when discharged onto land changes (or is likely to change) the physical, chemical, or biological condition of the land onto which it is discharged. If any contaminant in a discharge may enter water, or if the contaminants are from industrial or trade premises (which includes wastewater treatment plants), then a resource consent is required. Consequently, the application of natural fertilisers to land is considered a discharge and requires a resource consent, unless it is a permitted activity under a regional plan.
Agricultural Compounds and Veterinary Medicines Act 1997[8]	To prevent or manage risks associated with the use of agricultural compounds, ensure that the use of agricultural compounds does not result in breaches of domestic food residue standards and ensure the provision of sufficient consumer information about agricultural compounds.	Under the Act, the definition of an agricultural compound includes any substances or biological compounds that are used in the direct management of plants or applied to the land, place or water where the plants are managed, where these compounds are being used for maintaining or promoting plant productivity or providing nutrition (Section 2(1) of the Act). Biological compounds are preparations of animal origin. This Act requires all agricultural compounds manufactured, sold or used in New Zealand to be assessed for their risks and benefits and, if accepted for use, registered (Section 4A(2)). An agricultural compound can be accepted for use but exempted from registration if it meets a set of conditions under Schedule 5 of the Act, it is generally recognised as safe for use, or under special circumstances (Section 8A(1)). Natural fertilisers meet the definition of an agricultural compound under this Act.

7. Available at: http://www.legislation.govt.nz/act/public/1991/0069/latest/DLM230265.html. Version assessed: As at 1 April 2011.
8. Available at: http://www.legislation.govt.nz/act/public/1997/0087/latest/DLM414577.html. Version assessed: As at 7 July 2010.

Figure 2: Description of what constitutes a producer of horticultural food or a horticultural packing operation under the Food Bill 2010 (Schedule 2)

Producers of horticultural food

General description
This food sector covers food businesses that are horticultural producers (farmers or growers) of fruit, vegetables, herbs, spices, nuts, cereal grains, seeds, fungi, grasses, or any components extracted or gathered from horticultural produce. It includes food businesses that—

- grow, harvest, and minimally process (for example, rinse or wash produce following harvest):
- wholesale this produce.

Examples
Examples include but are not limited to producers of—

- kiwifruit:
- carrots:
- maize:
- legumes.

What is excluded
This food sector excludes—

- horticultural packing operations (subject to national programme level 1):
- horticultural producers that sell produce they have grown themselves directly to consumers (subject to food handler guidance):
- manufacturers of dried or dehydrated fruit or vegetables (subject to national programme level 2):
- manufacturers of frozen fruit or vegetables (subject to national programme level 1):
- manufacturers of fruit or vegetable beverages (subject to national programme level 3):
- processors of herbs or spices (subject to food control plans).
- manufacturers of fresh ready-to-eat salads and processors of herbs, spices, nuts or seeds will require food control plans.

Horticultural packing operations (packhouses)

General description
This food sector covers food businesses that pack horticultural food produce. It includes food businesses that sort, grade, and undertake pre-market preparation of horticultural produce. Produce in this context includes fruit, vegetables, herbs, spices, nuts, cereal grains, seeds, fungi, grasses, or any components extracted or gathered from horticultural produce.

Example
An example includes but is not limited to apple packhouses.

What is excluded
This food sector excludes manufacturers of fresh ready-to-eat salads (subject to food control plans).

2.2 Compulsory Standards

2.2.1 Australia New Zealand Food Standards Code

Food Standards Australia New Zealand (FSANZ) administers the Australia New Zealand Food Standards Code (FSC).[3] The FSC applies to all food products sold or prepared for sale in Australia and/or New Zealand, but there are only a few standards within the code that apply to New Zealand horticultural produce.

Some horticultural products have specific standards for the maximum level (ML) of metal contaminants permitted in the food (Standard 1.4.2). However, these levels apply only in Australia.

There are only two groups of horticultural products that have specific standards for microbiological limits (Standard 1.6.1). These are:

- Pepper, paprika and cinnamon (as dried spices) (n=5, c=0 and m=0 for *Salmonella*/25g);
- Cultured seeds and grains, e.g. bean sprouts, alfalfa (n=5, c=0 and m=0 for *Salmonella*/25g).

Where:

- n = the minimum number of sample units that must be examined from a lot of food;
- c = the maximum allowable number of defective sample units
- m = the acceptable microbiological level in a sample unit.

This means that for each of the foods listed above, five lots of 25g should be tested for *Salmonella*, and *Salmonella* should not be detected in any of the samples.

Chapter 2 of the FSC includes food product standards for fruit and vegetables (Standard 2.3.1). This standard includes definitions for "fruit and vegetables" (fruit, vegetables, nuts, spices, herbs, fungi, legumes and seeds), peeled and/or cut fruit and vegetables, and surface treated fruit and vegetables. Currently, the only food product standard for fruit and vegetables is that fruit and vegetables in brine, oil, vinegar or water, other than commercially canned fruit and vegetables, must not have a pH greater than 4.6.

The FSC also includes standards that are applicable if water used as an additive or processing aid. In the context of this study, any water used for processes such as post-harvest washing or water-based chilling (e.g. spray chilling) is considered a processing aid and standard 1.3.3 applies (which permits water as a processing aid). Water is considered to be an additive when it is applied to produce after harvest as part of other mixtures (e.g. a preservative) or to maintain moisture levels (i.e. a humectant). Standard 1.3.1 contains rules for the use of additives but these rules do not specifically address the use of water as an additive to fresh produce. Additionally, standard 1.2.4 contains rules for food labelling. In the context of this study, water must be listed as an ingredient unless it constitutes less than 5% of the final food or is used as a processing aid in accordance with standard 1.3.3.

[3] The code is available from http://www.foodstandards.gov.au/foodstandards/foodstandardscode.cfm.

2.2.2 MAF import health standards for fertilisers

The Ministry of Agriculture and Forestry (MAF) has import health standards in place for the importation of fertilisers and growing media of plant origin (standard BNZ-FERTGRO-IMPRT) and guano-based fertiliser (standard FERGUAIC.ALL).[4] Alongside other regulatory requirements these products must be heat-treated. The minimum treatment for fertilisers of plant origin must either be 85ºC for 15 continuous hours with 40% relative humidity, or 121ºC for 30 minutes at 100KPa (autoclaving). Guano-based fertilisers must be treated at a minimum temperature of 100°C for at least one minute.

2.2.3 New Zealand potable water standards

The Drinking Water Standards for New Zealand (DWSNZ) define the minimum standards for drinking water in New Zealand (MoH, 2008). The standards apply to public and private supplies of water intended for drinking by the public and do not include standards for water used for agricultural purposes (the MoH is preparing standards for rural agricultural drinking-water supplies). However, several assurance programmes (Section 4) require the use of potable water during the final stages of produce processing (e.g. final rinse), and the DWSNZ sets out what is meant by this in the New Zealand context.

Potable water is drinking water that does not contain or exhibit any microbiological, chemical or radiological contaminants (called 'determinands' under the standards) to any extent that exceeds the maximum acceptable values (MAVs) specified in the DWSNZ.

The microbial MAVs are as follows:

- *Escherichia coli*: < 1/100 mL
- Total pathogenic protozoa: < 1 infectious (oo)cyst/100 L.

E. coli is an indicator for faecal contamination. No MAVs have been set for viruses.

There are 116 chemical MAVs that cover organic and inorganic chemicals. The MAVs for heavy metals relevant to this study are as follows:

- Arsenic: 0.01 mg/L
- Cadmium: 0.004 mg/L
- Lead: 0.01 mg/L.
- Mercury (inorganic): 0.007 mg/L.

There are no standards for methylmercury or tin.

The DWSNZ set out the sampling and testing criteria for these contaminants, and the allowable number of times the MAVs may be exceeded.

Bore water can be classified as secure bore water if it can be demonstrated that contamination by pathogenic microorganisms is unlikely because the water is not directly affected by surface or climate influences, and is extracted from a bore head that provides satisfactory

[4] The standards can be retrieved from http://www.biosecurity.govt.nz/regs/imports/ihs.

protection from contamination. Secure bore water does not need disinfection but requires monitoring. The DWSNZ set out the criteria and the evidence needed to demonstrate that bore water is secure. Water drawn from confined aquifers can also be classified as secure bore water if it satisfies these criteria plus additional criteria regarding well depth. In the DWSNZ, confined bores less than 10 metres deep and spring water are considered equivalent to surface water.

2.3 Local Authority Rules

Regional councils and unitary authorities[5] have responsibility for managing New Zealand's land, water and air under the provisions of the RMA. One of the main ways they do this is to set out which activities are permitted in a region, and which activities require resource consent. These rules, which aim to prevent or reduce environmental effects, are set out in regional plans. The activities are classified as one of the following:[6]

- Permitted activity: No resource consent is required, however the activity must comply with any conditions or criteria specified in the council's regional plan or proposed regional plan.
- Controlled activity: A resource consent is required for the activity and the council must grant the consent if the activity complies with any conditions specified in the regional plan or proposed regional plan. The council may impose conditions on the consent.
- Discretionary or Restricted Discretionary activity: A resource consent is required and the council has the authority to decline or grant a consent and to impose conditions on the consent. Activities listed as Permitted or Controlled Activities that do not comply with the relevant conditions are dealt with as discretionary activities.
- Prohibited activity: No application for resource consent may be made for the activity.

A non-complying activity is an activity that is not a permitted, controlled, discretionary, restricted discretionary or prohibited activity. The council must refuse a resource consent for a non-complying activity unless the effects of that activity are considered minor and the activity is aligned with the policies and objectives of all relevant plans.

2.3.1 Regional authority rules for natural fertilisers

Table 2 provides an overview of rules from the 17 regional councils and unitary authorities that are relevant to natural fertilisers. This table does not capture the conditions that the activities must comply with, which most commonly aim to protect water bodies and people (e.g. prevention of odours, protection of neighbouring properties). If the activity is permitted or controlled, and does not meet the conditions, then usually the activity becomes a discretionary activity. The table indicates where no specific rule exists in the regional plan for an activity (NR), which means that these activities can be carried out freely by growers unless these activities are likely to result in the discharge of contaminants into water, and/or they do not meet any council rules for discharges into air (e.g. odours, particulates). It should also be noted that the term "fertiliser" could include materials such as biosolids or vermicast depending on how the definition is interpreted at each regional authority.

[5] Unitary authorities are councils with combined regional and district/city functions, e.g. Nelson City Council.
[6] These definitions are set out fully in the RMA, section 87A.

Table 2: Overview of regional council and unitary authority rules for the application of fertilisers, manufacture of composts and application (discharge to land) of natural fertilisers

Regional Council	Fertiliser application	Compost manufacture[1]	Discharge to land of: manure or animal effluent	vegetative waste	compost	biosolids	vermiculture material	Ref.[2]
Northland Regional Council	Permitted (23.1)	Discretionary (20.3)[3]	Permitted (16.1)	Permitted (17.1)	Permitted (23.1)	Discretionary (15.3)	Permitted (23.1)	a
Auckland Council[4]	Permitted (5.5.38)	Permitted (5.5.34)	Permitted (5.5.34)	Permitted (5.5.34)	Permitted (5.5.34)	Discretionary (5.5.31)	NR	b
Environment Waikato	Permitted (3.9.4.11)	Permitted (5.2.8.1, 5.2.8.2) Controlled (5.2.8.3) Discretionary (5.2.8.4)[6]	Permitted (3.5.5.1, 3.5.5.2) Controlled (pig) (3.5.5.3)	NR	NR	Permitted (3.5.6.2)	NR	c
Bay of Plenty Regional Council[5]	Permitted (Rule 20)	Permitted (Rule 28 Controlled (Rule 28A)[7]	Permitted (Rule 19) Controlled (dairy, pig) (Rule 32)	Permitted (Rule 19, Rule 29)	Permitted (Rule 19)	Permitted (Rule 19)	Permitted (Rule 19)	d
Gisborne District Council[4]	NR	NR	Discretionary (6.5.3)	NR	NR	NR	NR	e
Hawke's Bay Regional Council	Permitted (Rule 11)	Permitted (Rule 13) Discretionary (Rule 28)[8]	Permitted (Rule 13) Controlled (effluent, sludge) (Rule 14)	Permitted (Rule 13)	Permitted (Rule 13)	Permitted (Rule 13)	Permitted (Rule 13)	f

Table 2 (continued)

Regional Council	Fertiliser application	Compost manufacture[1]	Discharge to land of:					Ref.[2]
			manure or animal effluent	vegetative waste	compost	biosolids	vermiculture material	
Taranaki Regional Council	Permitted (Rule 31)	NR	Controlled (Rule 35, Rule 37)	NR	NR	NR	NR	g
Horizons Regional Council[9]	Permitted (DL Rule 7)	Permitted (DL Rule 10) Discretionary (DL Rule 12)	Controlled (DL Rule 4)	NR	NR	Discretionary (DL Rule 5)	NR	h
Greater Wellington Regional Council	Permitted (Rule 12)	Permitted (green waste only) (Rule 9)	Controlled (Rule 13)	NR	NR	Discretionary (Rule 8)	NR	i
Tasman District Council[4]	Permitted (36.5.2.1)	Permitted (≤50 m^3 material) (36.1.2.9)	Permitted (animal, bird) (36.1.2.3)	NR	NR	NR	NR	j
Nelson City Council[4]	Permitted (FWr.24.1)	NR	Permitted (FWr.28.1)	NR	NR	NR	NR	k
Marlborough District Council[4,10]	M: Permitted (36.1.7.10) W: Permitted (30.1.8.3)	M: Permitted (green waste) (36.1.7.8) M: Controlled (animal waste) (36.2.4.1) W: Permitted (3.1.1.9, 3.1.8.10)	M: Permitted (dairy) (36.1.7.3) M: Controlled (intensive farms, pig) (36.2.3.1) W: Controlled (30.2.5)	W: Permitted (3.1.1.9, 3.1.8.10)	W: Permitted (3.1.1.9, 3.1.8.10)	NR	NR	l

Table 2 (continued)

Regional Council	Fertiliser application	Compost manufacture[1]	Discharge to land of: manure or animal effluent	vegetative waste	compost	biosolids	vermiculture material	Ref.[2]
West Coast Regional Council	Permitted (Rule 72) Controlled (Lake Brunner) (Rule 84)	Permitted (waste from property) (Rule 82)	Permitted (Rule 73)	NR	NR	NR	NR	m
Environment Canterbury	Permitted (WQL19)	Permitted (animal effluent, (≤1,500 m^3) (WQL26) Permitted (WQL27)	Permitted (solid) (WQL23) Permitted (effluent, property <4 ha) (WQL25)	Permitted (WQL23)	NR	Controlled (WQL12)	NR	n
Otago Regional Council	Permitted (12.8.1.5)	Permitted (7.6.12)	Permitted (12.8.1.2, 12.8.1.3) Restricted discretionary (12.8.2.1)[11]	Discretionary (12.13.1.1)[12]	Discretionary (12.13.1.1)[12]	Discretionary (12.13.1.1)[12]	Discretionary (12.13.1.1)[12]	o
Environment Southland[13]	W: Permitted (Rule 10)	W: Permitted (≤100 m^3 material) (Rule 57) W: Restricted Discretionary (organic waste recycling) (Rule 56)	E: Permitted (sludge) (Rule 5.3.1) E: Permitted (Rule 5.4.1) Controlled (Rule 5.4.5)[14]	S: Permitted (Rule 4.5.3)	W: Permitted (Rule 55)	E: Permitted (Rule 5.3.1)	W: Permitted (Rule 55)	p
Chatham Islands Council[4]	NR	NR	NR	NR	NR	NR	NR	q

Table 2 (footnotes)

NR, no rule exists in the plan

1. Often these rules are for controlling the discharge of leachate from composting operations, not the composting operations themselves.
2. References (all accessed November 2010, including plan changes that were operational before November 2010):
   a. Regional water and soil plan for Northland (August 2004). Northland Regional Council (http://www.nrc.govt.nz).
   b. Auckland regional plan: Air, land and water (operative in part, October 2010). Auckland Regional Council (http://www.arc.govt.nz).
   c. Waikato regional plan: Land and soil module (operative in part, September 2007) (http://www.ew.govt.nz/).
   d. Bay of Plenty regional water and land plan (December 2008); A Guide to Regional Plans: Horticultural Activities (http://www.envbop.govt.nz/).
   e. Gisborne District Council combined regional land and district plan (January 2006); Regional plan for discharges to land and water, waste management and hazardous substances (July 2006) (http://www.gdc.govt.nz/).
   f. Hawke's Bay regional resource management plan (August 2006) (http://www.hbrc.govt.nz).
   g. Regional fresh water plan for Taranaki (October 2001) (http://www.trc.govt.nz/).
   h. Land and water regional plan (September 2003) (http://www.horizons.govt.nz).
   i. Regional plan for discharges to land for the Wellington Region (December 1999) (http://www.gw.govt.nz).
   j. Tasman resource management plan, Part VI - Discharges (operative, February 2011) (http://www.tasman.govt.nz).
   k. Nelson resource management plan (operative in part, March 2005) (http://www.nelsoncitycouncil.co.nz).
   l. Marlborough Sounds resource management plan (operative in part, February and March 2003); Wairau/Awatere Resource Management Plan (operative March 2009) (http://www.marlborough.govt.nz).
   m. Proposed regional land and water plan (notified, September 2010) (http://www.wcrc.govt.nz/).
   n. Natural resources regional plan (operative in part, October 2009) (http://www.ecan.govt.nz).
   o. Regional plan: Water (January 2004); Regional plan: Waste (April 1997) (http://www.orc.govt.nz).
   p. Effluent land application plan (May 1998); Regional Solid Waste Management Plan for Southland (April 1996); Regional Water Plan for Southland (January 2010) (http://www.es.govt.nz).
   q. Chatham Islands resource management document (January 2001) (http://www.cic.govt.nz/).
3. Compost manufacture is considered an industry or trade and the rules for discharge in Section 20 apply.
4. Unitary authority. Auckland Regional Council and the seven city and district councils covering greater Auckland were merged from 1 November 2010.
5. All discharge rules are subject to Rules 11-11F (these rules specifically relate to activities within the Rotorua Lakes catchments).
6. The classification of the composting activity depends on the size of the operation and the type of materials being composted.
7. Rule 28A is for composting of offal and animal carcasses.
8. Rule 28 is for composting operations where more than 100 m^3 (in total) of raw material, composting material and compost is held per premise at any one time.
9. Horizons Regional Council is responsible for the Manawatu-Wanganui region. DL Rule 10 only applies to composting operations involving only vegetable matter waste generated on that property. Horizons Regional Council has prepared a new combined regional plan (the One Plan), which will become operational in 2011. Under this proposed plan, fertiliser application is permitted (13-2), composting of green waste is permitted (13-20), discharge to land of poultry litter is permitted (13-4B), discharge to land of animal manures is controlled (13-6), and discharge of compost and grade Aa biosolids are permitted (13-4).

10. Marlborough District Council has two regional plans (see references, footnote 2). An ‘M’ denotes rules from the Marlborough Sounds Resource Management Plan and a ‘W’ denotes rules from the Wairau/Awatere Resource Management Plan.
11. These rules apply to different zones within the region.
12. A resource consent might not be required if contaminants cannot possibly get to surface water or groundwater.
13. An ‘E’ denotes rules from the Effluent Land Application Plan, an ‘S’ denotes rules from the Regional Solid Waste Management Plan, and a ‘W’ denotes rules from the Regional Water Plan. Environment Southland is currently reviewing their solid waste plan and regional land effluent plan and both will be integrated into the regional water plan. This is expected to be completed late 2011.
14. The type of activity depends on the number of stock, e.g. discharge of agricultural effluent from farms with dairy sheds servicing a maximum of 50 cows or piggeries with a maximum of 70 x 50 kg pig equivalents is a permitted activity.

Note to table: This table has been prepared to support the current study and should not be used as an official guide to regional authority rules (refer to the disclaimer at the start of this report). The regional authorities provided helpful assistance in checking the information in this table (10/17 councils responded to the invitation to check the information), but the table represents the final analysis by the authors of this current report.

2.3.2 Regional authority rules for irrigation water

Most of the regional councils and unitary authorities have set rules for the taking, use, damming or diverting of surface water and ground water.[7] The most common approach is for these activities to be permitted unless the activity:

- Involves a specific water body or aquifer identified by the council (e.g. an indigenous wetland, a waterbody with cultural significance);
- Takes water that exceeds a certain volume (usually specified in cubic metres per day or per week)
- Impacts on the environment (e.g. reduces the water level below a minimum flow);
- Impacts on others' ability to take water to meet their needs.

The authorities often specify technical requirements for a permitted activity, such as the size or velocity of an intake, the placement and construction of a bore, or mechanisms that must be in place to protect freshwater fish.

Environment Waikato has set out specific rules for the use of water for crop and pasture irrigation in a variation to their regional plan, which aim to control the discharge of nutrients to surface or ground water (the variation is currently subject to the appeals process).[8] The proposed rules for a permitted activity include requirements for growers to ensure that the rate or method of water application does not exceed the water holding capacity or infiltration rate of the soil, and that they plan irrigation as part of a nutrient management plan. Environment Canterbury has set out similar rules in their proposed regional plan, requiring growers to take all practicable measures to ensure the irrigation water application rate does not exceed that required to return the soil to field capacity (these rules are also currently subject to the appeals process).[9]

[7] Gisborne District Council is currently preparing a freshwater management plan.
[8] Available at http://www.waikatoregion.govt.nz/Policy-and-plans/Water-allocation-variation/.
[9] Available at http://ecan.govt.nz/publications/Pages/chapter-5-nrrp.aspx.

3 VOLUNTARY STANDARDS AND GUIDELINES

There are a number of voluntary standards and guidelines that are relevant to food safety, to the production and use of natural fertilisers and to the use of water in horticulture.

3.1 Food safety standards

3.1.1 Ministry of Health criteria (1995)

The New Zealand Ministry of Health published the Microbiological Criteria for Foods intended as a guide for food producers where no mandatory standard exists (MoH, 1995). A number of these criteria are applicable to horticultural produce and the limits for *E. coli* and any bacterial pathogens are listed in Table 3. Some of these foods also have criteria for other indicators of microbiological quality, such as yeasts and moulds, aerobic plate count and faecal coliforms.

Table 3: Microbiological Limits for plants and plant products contained in the Ministry of Health Microbiological Reference Criteria for foods (*E. coli* and pathogens only)

Product	Indicator/pathogen	Criteria*			
		n	c	m	M
Cultured seeds and grains (bean sprouts, alfalfa, etc.)	*E. coli* (/g)	5	0	0	
	Salmonella (/25g)	5	0	0	
Dried fruit	*Salmonella* (/25g)	5	0	0	
Herbs and spices	*B. cereus* (/g)	5	2	10^3	10^4
	C. perfringens (/g)	5	2	10^2	10^3
	Coagulase producing *Staphylococcus* (/g)	5	2	10^2	10^3
	Salmonella (/25g)	5	0	0	
Salads (vegetable or fruit, excluding combination with meat)	Coagulase producing *Staphylococcus* (/g)	5	2	10^2	10^3
	Salmonella (/25g)	5	0	0	

* n = the minimum number of sample units that must be examined from a lot of food; c = the maximum allowable number of defective sample units; m = the acceptable microbiological level in a sample unit (values above it are marginally acceptable or unacceptable); M = a microbiological criterion that separates marginally acceptable quality from defective quality (values above M are unacceptable in the terms of the sampling plan and detection of one or more samples exceeding this level would be cause for rejection of the lot).

3.1.2 FSANZ guidelines (2001)

FSANZ has produced generic guidelines for the microbiological examination of ready-to-eat foods (FSANZ, 2001a). These guidelines are not applicable to nuts in the shell and whole, raw fruits and vegetables that are intended for hulling, peeling or washing by the consumer.

In the context of this study, they would apply to produce released from a packhouse that is ready for consumption (e.g. ready-to-eat salads, fresh cut fruit, hulled nuts). There are microbiological standards for indicator bacteria (*E. coli*) and a number of pathogenic bacterial species (Table 4).

Table 4: Microbiological criteria for ready-to-eat foods (FSANZ, 2001a)

Test	Microbiological quality (CFU/g)			
	Satisfactory	Marginal	Unsatisfactory	Potentially hazardous
E. coli	<3	3-100	≥100	*[1]
Coagulase positive staphylococci	$<10^2$	10^2-10^3	10^3-10^4	$≥10^4$ SET +ve[2]
C. perfringens	$<10^2$	10^2-10^3	10^3-10^4	$≥10^4$
B. cereus and other pathogenic *Bacillus* spp.	$<10^2$	10^2-10^3	10^3-10^4	$≥10^4$
V. parahaemolyticus[3]	<3	<3-10^2	10^2-10^4	$≥10^4$
Campylobacter spp.	not detected in 25g	not detected in 25g	not detected in 25g	Detected
Salmonella spp.	not detected in 25g	not detected in 25g	not detected in 25g	Detected
L. monocytogenes[4]	not detected in 25g	Detected but $<10^2$	Detected but $<10^2$	$≥10^2$

1. Pathogenic strains of *E. coli* should be absent.
2. Positive for *Staphylococcus* enterotoxin.
3. Probably not applicable for fresh produce.
4. Foods with a long shelf life stored under refrigeration should have no *L. monocytogenes* detected in 25g. The detection of *L. monocytogenes* in ready-to-eat foods prepared specifically for “at risk” population groups (the elderly, immunocompromised and infants) should also be considered as potentially hazardous.

3.2 Natural fertiliser guidelines

3.2.1 NZ Land Treatment Collective guidelines for sewage effluent (2000)

In 2000 the New Zealand Land Treatment Collective (NZLTC) and Forest Research published a two-part manual of guidelines for the utilisation of sewage effluent on land (NZLTC, 2000; Robb and Barkle, 2000). The guidelines cover the design and implementation of a land treatment system for municipal or domestic wastewater, where the final treatment is irrigation onto a standing crop intended for harvest and economic return.

The guidelines do not recommend irrigation of sewage onto crops intended for direct human consumption, although they suggest that sub-surface irrigation to human food crops is a feasible option (but not for root crops such as potatoes or onions).

3.2.2 NZ Standard for composts, soil conditioners and mulches (2005)

Standards New Zealand has published a standard for composts, soil conditioners and mulches (NZS 4454:2005).[10] The standard only applies to organic products that have been pasteurised or composted, and does not cover blood and bone, liquid organic wastes or seaweed products.

The standard addresses safety and quality issues by setting out the physical, chemical and biological requirements for composts, mulches and soil conditioners. The physical requirements are based on particle size grading. Chemical requirements include pH, essential elements (e.g. nitrogen, boron), organic matter content, moisture content and levels of chemical and organic contaminants. The maximum levels of heavy metals are (per kg):

- Arsenic 20 mg
- Cadmium 3 mg
- Chromium 600 mg
- Copper 300 mg
- Lead 250 mg
- Mercury 2 mg
- Nickel 60 mg
- Zinc 600 mg.

The biological requirements include limits for toxicity, plant propagules and pathogens. The pathogen limits only apply to products containing animal manures, animal parts (including fish/shellfish) and kitchen/food waste, and the only standard is currently for the faecal indicators *E. coli* or faecal coliforms, which must be present at less than 100 MPN/g.

Under the standard, the composting process must include pasteurisation followed by a suitable period of maturation. Pasteurisation requires the whole product to be subjected to a temperature of 55°C or above for a period of time that depends on the composting method and the materials being composted, but usually for a minimum of three consecutive days. For example:

- For in-vessel composting systems the temperature must be held for 3 days or more;
- In windrow systems the temperature must be held for 15 days or more;
- For garden organics or green wastes the temperature must be held for 3 days or more.

However, compost producers are free to use alternative methods provided that their processes can be verified and maintained as achieving pathogen reduction levels as specified in the standard. For example, in-vessel systems composting animal products might pasteurise at 70°C for one hour. The standard includes a set of best practice guidelines for composting and specifications for product testing methods.

[10] Available from http://www.standards.co.nz.

3.2.3 NZWWA biosolids guidelines (2003)

In 2003 the New Zealand Water and Wastes Association (NZWWA) published guidelines for the safe application of biosolids to land in New Zealand. The guidelines only become mandatory if they are incorporated into council regional plans or in resource consent conditions. Some councils (e.g. Horizons Regional Council) have incorporated the guidelines into their regional plans as conditions for the discharge of biosolids. Section 3 of the guidelines sets out the regulatory framework relating to the management of biosolids in New Zealand, which includes the *Health Act 1956*, RMA and ACVMA (see Section 2.1 of this report).

Under the guidelines, biosolids are graded according to their stabilisation and level of chemical contaminants. Stabilisation is the process of treating biosolids to reduce pathogens, odour, and attractiveness to disease vectors such as flies, birds and rodents. Biosolids can be rated as ‘A’ or ‘B’ for stabilisation, and ‘a’ or ‘b’ for chemical contamination, which results in four grades of Aa, Ab, Ba and Bb. The guidelines propose that councils control the discharge of Aa biosolids to land by having it as a permitted activity rule in a regional plan, and discharge of Ab, Ba or Bb biosolids as a discretionary activity requiring a resource consent. Biosolids not meeting any of these grades should be treated as sludge and disposed of (e.g. via landfill).

Section 4 of the guidelines set out the processes required to achieve each of the grades. This includes specifications for processes used to reduce pathogens, odour and vector attraction. For example, in-vessel composting operations must achieve a temperature of 55°C or higher for three or more days.

The guidelines propose that grade Aa biosolids can be safely handled by the public and applied to land without risk of significant adverse effects, including land used for horticultural production. The pathogen standards for a grade ‘A’ biosolid are:

- *E. coli* < 100 MPN/g
- *Campylobacter* < 1/25 g
- *Salmonella* < 1/25 g
- Enteric viruses < 1 PFU/4 g
- Helminth ova < 1/4 g.

Grade ‘B’ biosolids do not need to comply with these pathogen standards.

The maximum metal contaminant concentrations for a grade ‘a’ biosolid are (per mg/kg dry weight):

- Arsenic 20 mg
- Cadmium 1 mg
- Chromium 600 mg
- Copper 100 mg
- Lead 300 mg
- Mercury 1 mg
- Nickel 60 mg
- Zinc 300 mg.

The maximum metal contaminant levels are higher for a grade ‘b’ biosolid.

The guidelines also propose that grade B biosolids can be applied to land that will be used for horticultural production, specifically:

- salad crops, fruit, other crops for human consumption that may be eaten unpeeled or uncooked; or
- orchards where dropped fruit is not harvested, crops that will be peeled or cooked before eating.

However, the guidelines list recommended controls to allow stabilisation and protect public health. Irrespective of the production methods, land that will be used for salad crops, fruit and other crops for human consumption that may be eaten unpeeled or uncooked should not be sown for at least one year after grade 'B' biosolid application. Where grade 'B' biosolids are applied to orchards where dropped fruit is not harvested, the fruit should not be harvested for at least six months after application. Similarly, crops that will be peeled or cooked should not be harvested for at least six months after application of grade 'B' biosolids (there are no recommendations regarding the sowing or planting of such crops).

3.2.4 Fert Research code of practice for nutrient management (2007)

A code of practice has been published by Fert Research to assist nutrient consultants and land managers to plan fertiliser use within the broader context of nutrient management and nutrient budgeting (Fert Research, 2007). The code focuses on manufactured fertilisers where the concentration of major and minor elements are usually known, but encourages users to consider total nutrient input including nutrients from compost, manure or other organic inputs. The code encourages users to consider fertiliser suitability, and the application method, timing, and environmental risks from using fertilisers. The New Zealand GAP assurance programme (Section 4.1.1) and some regional councils (Section 2.3.2) require growers to have a nutrient management plan.

3.2.5 Fertmark

Fertmark is an assurance standard that is owned by Federated Farmers of New Zealand and administered by the New Zealand Fertiliser Quality Council. The standard focuses on quality indicators such as nutrient concentrations and particle size. Fertiliser manufacturers seeking Fertmark registration must declare the nutrients present in the fertiliser and submit to regular independent audits to ensure nutrient levels remain as declared (FFNZ, 2000). These manufacturers must also declare that the product does not contain microorganisms at pathogenic levels, or any other plant or animal pest that is likely to promote pest or disease transmission, however the standard does not specify any microbiological limits. Fertmark auditors also monitor cadmium levels in fertilisers (phosphatic fertilisers must not exceed 280 mg cadmium per kg phosphorous) (K. Geddes, NZ Fertiliser Quality Council, pers. comm.; FFNZ, 2006).

Manufacturers of poultry fertiliser can apply for the Fertmark standard. The standard defines poultry fertiliser as "products derived from chicken litter solely obtained from approved poultry houses using identified feed systems for which a Risk Assessment Analysis and traceability system is provided". As of April 2010, there were no poultry fertilisers registered under the Fertmark standard.

3.3 Water guidelines

3.3.1 ANZECC water quality guidelines

The Australian and New Zealand Environment and Conservation Council (ANZECC) published the Australian and New Zealand Guidelines for Fresh and Marine Water Quality in 2000.[11] The guidelines do not have national legal status in New Zealand, although they may be recommended if guidance was requested and may also have legal status under some regional council plans. The guidelines were being revised in 2011.

Chapter 4 of these guidelines is for "Primary Industry" and includes guidelines for irrigation water quality. The guidelines do not cover water used for hydroponics, glasshouse growing or washing of farm produce. The guidelines provide trigger values below which there should be minimal risk of adverse effects. If a trigger value is exceeded, further investigation is recommended to determine the level of risk.

Trigger values for thermotolerant coliforms in irrigation waters used for food crops have been specified:

- <10 CFU/100 mL for raw human food crops in direct contact with irrigation water (e.g. via sprays, irrigation of salad vegetables).
- <1000 CFU/100 mL for raw human food crops not in direct contact with irrigation water (edible product separated from contact with water, e.g. by peel, use of trickle irrigation) or crops sold to consumers cooked or processed.

Trigger values are also provided for some heavy metals in irrigation water. The long-term trigger value (LTV) is the maximum concentration (mg/L) of contaminant in the irrigation water which can be tolerated assuming 100 years of irrigation. The short-term trigger value (STV) is the maximum concentration (mg/L) of contaminant in the irrigation water which can be tolerated for a shorter period of time (20 years), assuming the same maximum annual irrigation loading to soil as for LTV. The LTV and STV values have been developed to minimise the build-up of contaminants in surface soils during the period of irrigation and to prevent the direct toxicity of contaminants in irrigation waters to standing crops.

The following trigger values are relevant to his project (all in mg/L):

- Arsenic LTV = 0.1 STV = 2.0
- Cadmium LTV = 0.01 STV = 0.05
- Lead LTV = 2 STV = 5
- Mercury LTV = 0.002 STV = 0.002

[11] Available from http://www.mincos.gov.au/publications/australian_and_new_zealand_guidelines_for_fresh_and_marine_water_quality

3.3.2 MAF Good Operating Practice

The Ministry of Agriculture and Forestry (MAF) has produced a number of guidance documents that set out procedures to assist producers with producing safe and suitable food by developing their own Good Operating Practice (GOP).[12] Guidance is available for operators to develop their own GOP procedures where they use water from a council/network supply, roof supply, surface supply or a groundwater supply. The guidance encourages producers to assess possible hazards in their water source, to consider whether the water should be tested or treated, to monitor their water supply, to take any corrective actions if a problem has been identified, and to document their activities.

3.3.3 Guidelines for greywater

Greywater is household wastewater excluding sewage, i.e. water from bathrooms and laundries. New Zealand Municipal Wastewater Monitoring Guidelines have been published by the New Zealand Environment Research Foundation[13]. This document provides guidance to developing risk based monitoring programmes for municipal wastewater discharges. Although discharge to food gathering areas is considered (e.g. shellfish beds), horticultural production or irrigation are not addressed.

The NZLTC recently published a literature review to aid decision making around greywater issues (Marie Heaphy (Technical Manager, NZLTC), pers. comm., 19 May 2011).[14] However, at the time of this report there were no national guidelines for the use of greywater in New Zealand.

[12] NZFSA was amalgamated into MAF, New Zealand, on 1 July 2010. The guidance documents are available from http://www.foodsafety.govt.nz/industry/general/gop/documents.htm

[13] http://www.waternz.org.nz/documents/publications/books_guides/wastewater_monitoring_guidelines.pdf accessed 24 may 2011

[14] The literature review is only available to Land Treatment Collective members.

4 ASSURANCE PROGRAMMES

The requirements of an assurance programme depend on the purpose of the programme. For example, an assurance programme for organic production sets out the practices that a grower must demonstrate before their product can be certified as being grown by organic methods. Other assurance programmes might focus on, for example, sustainable land management, the ethical treatment of workers or animals, or food safety.

Good Agricultural Practices (GAPs) are the basic environmental and operational conditions necessary for the production of safe and wholesome fresh fruits and vegetables (Gravani, 2009). GAPs form the basis of two important assurance programmes for New Zealand, New Zealand GAP (Section 4.1.1) and GLOBALG.A.P. (Section 4.3.1). A set of GAPs were published by the United States Food and Drug Administration (USFDA) in their 1998 guide for the producers of fresh fruit and vegetables (USFDA, 1998). The guide focussed on microbial hazards and was based on a set of eight principles; two are directly relevant to this project:

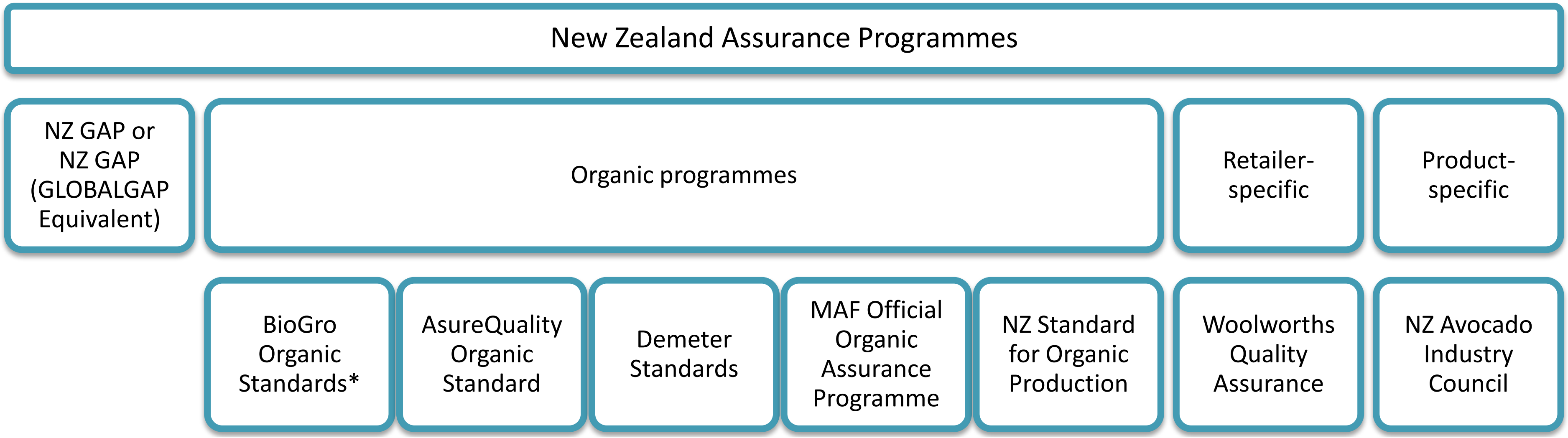
- Whenever water comes in contact with produce, its source and quality dictates the potential for contamination. Minimise the potential of microbial contamination from water used with fresh fruits and vegetables.
- Practices using animal manure or municipal biosolid wastes should be managed closely to minimize the potential for microbial contamination of fresh produce.

These principles are often reflected in New Zealand assurance programmes relevant to this study, which are summarised in Figure 3 and described in Section 4.1.

The Codex Alimentarius is a collection of internationally-adopted food standards, guidelines, codes of practice and other recommendations. The Codex Alimentarius represents the work of the Codex Alimentarius Commission (CAC), which is an intergovernmental body with over 170 members that operates within the framework of the Joint FAO/WHO Food Standards Programme established by the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO). The CAC has produced a number of codes of practice and guidelines that are relevant to the production of fresh fruit and vegetables, the most important being the Code of hygienic practice for fresh fruits and vegetables (CAC/RCP 53–2003). Information from this code, and other relevant documents published by CDC, is summarised in Section 4.2.

There are a number of internationally-recognised assurance programmes that are relevant to New Zealand produce exporters. Section 4.3 summarises the GLOBALG.A.P. and Safe Quality Food programmes. For the organic sector, standards published by the International Federation of Organic Agriculture Movements (IFOAM), called the Basic Standards for Organic Production and Processing, are internationally recognised. However, the IFOAM standards provide a framework for certification bodies and standard-setting organisations to develop their own certification standards; they are not used for certification on their own (IFOAM, 2005). The IFOAM standards are under review and will become a certification standard in the future (IFOAM, 2010). Section 4.4 describes some assurance programmes specific to the markets of certain countries that import New Zealand produce.

Figure 3: New Zealand assurance programmes applicable to horticultural production



* These standards are also used for the OrganicFarmNZ assurance programme.

4.1 New Zealand Assurance Programmes

There are several New Zealand assurance programmes available to New Zealand horticultural producers (Figure 3). Some of them include specific requirements for the use of water and natural fertilisers, and these are described below.

4.1.1 New Zealand Good Agricultural Practice (New Zealand GAP)

The New Zealand GAP programme (previously called the New Zealand Fresh Produce Approved Supplier Programme) is a domestic programme owned by Horticulture New Zealand and is available to growers and packhouses. To become certified, horticultural producers must meet a wide set of criteria that cover all aspects of production. Most of the criteria are mandatory for certification, but the programme also contains some recommended criteria that growers might choose to meet. There are several criteria that are directly relevant to this study and these are summarised in Table 5.

Table 5: New Zealand GAP criteria applicable to the use of water and natural fertilisers

Management area	Growers are required to
Nutrient management	- Evaluate the risks associated with animal manure and other natural fertilisers and act on the results of the evaluation[1] - Purchase fertiliser from companies with Fertmark product registration (recommended)[2] - Record the application of animal manure and other natural fertilisers - Have a nutrient management plan in place for the use and application of fertiliser (recommended, but compulsory if the regional council requires compliance with NZ GAP for the use and application of fertiliser)
Water management	- Evaluate the sources of water used in the production process (hydroponics, irrigation) against potential risks of contamination, document the evaluation and actions and the effectiveness of these actions, and take steps to ensure the water quality is made adequate for its intended use where a risk has been identified[1] - Develop and maintain a water management plan (recommended) - Evaluate the sources of water used in the post-harvest process against potential risks of contamination, and document the evaluation and actions and the effectiveness of these actions[1]

Reference: New Zealand GAP Manual 2009 (version 5.0).
1. Decision diagrams are given in the manual that guide growers through this evaluation process.
2. Fertmark is a fertiliser quality assurance scheme administered by the New Zealand Fertiliser Quality Council. Poultry manure can be certified under this scheme (see Section 3.2.5).

The manual includes decision diagrams that guide growers through the process of evaluating the risks associated with natural fertilisers, water used for irrigation or hydroponic production, and water used for final washing after harvest. The decision diagram for natural fertilisers asks growers to consider the type of fertiliser product they are using (organic or animal vs. non-organic or non-animal), whether the fertiliser contacts the edible part of the crop, how close to harvest the fertiliser is applied, and whether the crop is normally washed, peeled and/or cooked before consumption. All three decision diagrams for water ask growers to consider water potability. The decision diagram for irrigation water also asks growers to consider whether the water comes into contact with the crop, how close to harvest water is applied, whether the produce surface can trap water and encourage microbial growth, and whether the produce will be washed, peeled and/or cooked prior to consumption. Depending on the answers to these questions, the grower should test the water for generic *E. coli* and agrichemical contamination.

The New Zealand GAP manual (HortNZ, 2009) expands on these criteria by providing best practice. Some of the best practices relevant to the use of natural fertilisers are:

- Do not use manure, biosolids and other organic fertilisers contaminated with heavy metals or other chemicals at levels that may affect the safety of fresh fruits and vegetables.
- Use an application method or growing practice that minimises the chance of the organic fertiliser coming into contact with the edible part of the crop.
- Incorporate the organic fertiliser into the soil to minimise contamination of the crop and adjoining crops, from wind drift or runoff.
- Maximise the period between when the organic fertiliser is applied and when the crop is harvested.
- Adopt proper treatment procedures (e.g. composting, heat drying) that are designed to reduce or eliminate pathogens in manure, biosolids and other organic fertilisers.
- Growers who are purchasing manure, biosolids and other organic fertilisers that have been treated to reduce microbial or chemical contaminants, should, where possible, obtain documentation from the supplier that identifies the origin, treatment used, tests performed and the respective results. An example is pelletised manure.
- Avoid locating treatment or storage sites in proximity to fresh fruit and vegetable production areas. Prevent cross-contamination from runoff or leaching by securing areas where manure, biosolids and other organic fertilisers are treated and stored.

Some of the best practices relevant to the use of water are:

- Water quality should be adequate for its intended use. This should include irrigation water, water used for mixing sprays, wash water, water and ice used in cooling and other operations involving contact with the edible part of the produce.
- The temperature of the water (especially where contact is prolonged e.g. wash water) may contribute to the absorption of microbes and contaminants into the produce, by osmosis and therefore, the water temperature should be as close to that of the produce as possible (or slightly warmer) to help prevent the absorption.
- Evaluation should be carried out at a frequency which allows management of the potential risk, e.g. when the condition of the water source changes, but shall be carried out at least annually.

4.1.2 New Zealand GAP (GLOBALG.A.P. Equivalent)

The New Zealand GAP programme has been further developed to align with GLOBALG.A.P., which is an internationally-recognised assurance programme with its basis in the European Union (see Section 4.3.1). Growers who are certified to this assurance programme, called New Zealand GAP (GLOBALG.A.P. Equivalent), are recognised as meeting the standards of GLOBALG.A.P.

New Zealand GAP and New Zealand GAP (GLOBALG.A.P. Equivalent) share many of the same criteria, including the mandatory criteria summarised in Table 5. Some of the recommended criteria and best practices recorded in the New Zealand GAP Manual are mandatory criteria for New Zealand GAP (GLOBALG.A.P. Equivalent), such as having a nutrient management plan, or storing fertilisers separately from fresh produce. The New Zealand GAP (GLOBALG.A.P. Equivalent) programme also has some additional criteria, including requirements that growers:

- Do not use human sewage sludge or untreated sewage water.
- Keep records of the calibration of fertiliser application equipment.
- Use the most efficient and practical irrigation method to optimise water utilisation and minimise waste.

4.1.3 Assurance programmes for organic production

New Zealand growers can become certified to four different organic assurance programmes (Figure 3). The BioGro, AsureQuality and Demeter certification programmes support domestic and international market access. The OrganicFarmNZ certification programme is designed for small producers selling produce on the domestic market and currently uses the BioGro standards.

MAF also has in place an Official Organic Assurance Programme which facilitates access to export markets.

Additionally, New Zealand has a voluntary standard for organic production. While this is not recognised as an assurance programme, the standard includes requirements for the use of natural fertilisers and water so has been included in this report.

4.1.3.1 BioGro New Zealand Organic Standards (2009)

The BioGro Organic Standards are administered by the New Zealand Biological Producers and Consumers Council (NZBPCC). There are separate modules for orchards (perennial orchard crops, bush, vine and tree crops, nut groves and berries (excluding strawberries)) and for crops (fresh and process vegetables, arable and seed crops, herbs, flowers, and annual fruit crops, e.g. strawberries).[15] The Standards include both recommendations and requirements. The requirements that are applicable to the use of water and natural fertilisers are the same for orchards and crops, and are summarised in Table 6.

[15] Available from http://biogro.co.nz (accessed 25 August 2010).

Animal by-products, such as blood, bone and meat meal, are also permitted for restricted use, as are plant by-products (e.g. wood ash) and natural sources of minerals (e.g. Epsom salts).

Table 6: Requirements under the BioGro Organic Standards that are applicable to the use of water and natural composts

Management area	Summary of requirements
Composts and vermicasts	Can be made on the premises or purchased from BioGro certified/approved sources, but must be made according to the BioGro Compost Guide, which requires heating, aeration, mixing and sufficient maturation (vermicasts made from low risk ingredients do not require heat treatment).*
Raw animal manures	Must not be applied directly to soils and must be hot composted before use.
Sewage	Sewage sludge, sewage biosolids and manures containing human excrement are prohibited and must not be applied directly or used in composts.
Industrial by-products	Food and textile industry by-products of biodegradable material, i.e. of microbial, plant, or animal origin, free of synthetic additives, may be used provided they are hot composted.
Mulches	Must be sourced from certified farms. However, if certified mulches are not available, mulches from conventional sources may be used subject to a set of conditions.
Liquid fertilisers	e.g. vermicast liquids, compost teas. May be made on the premises or sourced from BioGro certified premises.
Water source purity	Where there is potential for contamination, proof must be provided annually that irrigation water is not contaminated.
Catchment	Information must be supplied to BioGro describing the catchment area and detailing any likely contamination of water sources.
Post-harvest water	Water used for washing produce must be of potable quality.

Reference: BioGro New Zealand Organic Standards (4 May 2009).

* The BioGro compost guide (BioGro, 2009) contains guidelines for the production of hot aerobic composts, including selection of raw materials. Compost produced by BioGro certified producers for their own use does not normally require testing, but companies certified by BioGro to supply compost to BioGro certified properties are required to have an annual testing regime based on the risks posed by the non-organic ingredients used and the composting process.

There are maximum permitted levels for heavy metals in composts. These are (per kg dry weight of compost):

- Arsenic 20 mg
- Cadmium 1 mg
- Chromium 150 mg
- Copper 60 mg
- Lead 250 mg
- Mercury 1 mg
- Nickel 60 mg
- Zinc 300 mg.

The maximum permitted levels are lower if the compost includes household waste as an ingredient.

4.1.3.2 AsureQuality Organic Standard (2010)

The AsureQuality Organic Standard covers organic primary production.[16] To comply with the standard, growers must use material of microbial, plant or animal origin as the basis of their fertility programme. This means using, in the first instance, organic material (composted or not) from premises producing in accordance with the AsureQuality Organic Standard, including by-products from livestock farming such as manure. Fertilisers and soil conditioners from other premises require AsureQuality approval and the standard includes a list of these inputs and the conditions for their use. The list includes natural fertilisers relevant to this study:

- Animal excrement: Farmyard manure (fresh or composted), guano.
- Animal products or by-products, e.g. blood meal, hoof meal, bone meal, fish meal, wool.
- Plant products or by-products, e.g. straw, cocoa husks, seaweed, sawdust, composts from spent mushroom substrate, stillage.
- Composts from organic household refuse.
- Vermicompost.

Human excrement is prohibited for use.

There are specific sections for growing sprouts, wheat or barley grass, and mushrooms. Sprout growers are required to use potable water, and there are restrictions over the substrates permitted for growing wheat grass, barley grass or mushrooms.

The standard includes maximum levels for heavy metals in compost:

- Arsenic 20 mg/kg
- Cadmium 3 mg/kg
- Chromium 400 mg/kg
- Copper 270 mg/kg
- Lead 200 mg/kg
- Mercury 1 mg/kg
- Nickel 60 mg/kg
- Zinc 575 mg/kg.

Water used as an ingredient or a processing aid must be potable.

4.1.3.3 Demeter Standards (2008)

The Bio Dynamic Farming and Gardening Association in New Zealand is the New Zealand certifier for the Organic Production Standards for Biodynamic Agriculture, also known as the Demeter Standards.[17] Demeter is an internationally-recognised standard but certification in New Zealand is only for suppliers to domestic markets. The Demeter Standards place rules around the types of natural fertilisers permitted for use and how much can be applied. The use of uncomposted plant- or animal-based materials as fertiliser requires permission from Demeter New Zealand. There are no microbiological limits for the fertilisers, but the grower must ensure that they are free from heavy metals. There are no microbiological or chemical

[16] Available from http://www.organiccertification.co.nz. This report considers Version 4 of the standard, released 13 December 2010. Operators certified before this date will operate under Version 3 until 13 December 2011.
[17] Available from http://www.biodynamic.org.nz.

limits for water used in primary production, but "tap water" or "pure drinking water" are required for post-harvest product washing.

4.1.3.4 MAF Official Organic Assurance Programme

The MAF administers the Official Organic Assurance Programme (OOAP). Certification under the OOAP opens access for organic producers to export to the European Union, Switzerland, the United States, Japan and Taiwan. OOAP does not cover organic products sold in New Zealand. To be certified, organic operators must comply with NZFSA Standard OP3 and the standard's technical rules for organic production.[18] There are no technical rules on the use of water in horticultural production, but there are controls over the use of natural fertilisers, in summary growers:

- Must maintain/increase the fertility and the biological activity of the soil "in the first instance" by incorporating animal manure (preferably from organic animal production) or other organic material, preferably composted first. By-products from animal farming, such as farmyard manure, may also be used if they come from animal holdings respecting organic animal production principles recognised in New Zealand. Other organic fertilisers may be applied as a complement but only if they are needed to ensure adequate crop nutrition or soil conditioning.
- Can use plant-based preparations, preparations of micro-organisms ("biodynamic preparations"), or preparations from stone meal, farmyard manure or plants for compost activation.
- Can only apply manure up to 170 kg of nitrogen per year/hectare of agricultural area.
- Must keep plant production records that must include information on fertiliser application.

There are also rules for the substrates permitted for mushroom production.

The technical rules include a table ("Table 1") that lists the fertilisers and soil conditioners permitted for use in organic production, their composition requirements and conditions for use. These include:

- Animal manure: Farmyard manure (can include vegetable matter (e.g. animal bedding), can be dried, can be dehydrated poultry manure), guano, composted animal excrements (including poultry manure and composted farmyard manure);
- Liquid animal excrements (slurry, urine, etc.) that have been fermented and/or diluted
- Composted or fermented household waste (there are maximum concentrations for some metals);
- Products or by-products of animal origin (e.g. blood meal, fish meal, wool);
- Products and by-products of plant origin (e.g. cocoa husks, oilseed cake meal), seaweeds and seaweed products, sawdust, wood chips, composted bark and wood ash;
- Composted or fermented vegetable matter;
- Mushroom culture wastes; and
- Dejecta of worms (vermicompost) and insects.

---

[18] Available from http://www.foodsafety.govt.nz/industry/sectors/organics/exporting/ooap.htm.

4.1.3.5 New Zealand Standard for Organic Production (NZS 8410:2003)

Standards New Zealand has published a standard for organic production that sets the minimum requirements for the production, handling, processing and labelling of organic products.[19] Compliance with the standard is voluntary.

The standard includes a list of acceptable natural fertilisers and requires growers to keep detailed records of the nutrient inputs (i.e. source, technical characteristics, any certification, amount, use). The standard allows for uncomposted mulch to be applied, but this must also be documented. The natural fertilisers permitted for use include:

- Animal manures;
- Compost from plant material and animal manures;
- Fermented fish or fishmeal;
- Crushed mineral deposits, e.g. limestone, sulphur, potash; and
- Other plant products such as peat, oilseed cake, sawdust, seaweed and straw.

Other waste products from animal processing, such as blood and bone, are restricted and may be used only when the need is justified.

The standard sets limits for heavy metals in composts. For each kilogram of dry compost, the maximum levels are:

- Arsenic 20 mg
- Cadmium 1 mg
- Chromium 150 mg
- Copper 60 mg
- Lead 250 mg
- Mercury 1 mg
- Nickel 60 mg
- Zinc 300 mg.

Growers are required to maintain the quality of water as much as practicable and manage its use, but the standard places the responsibility on growers to decide whether the water they use is appropriate for use. However, during food processing the grower must use potable water where the water comes into contact with a food product.

There are specific standards for mushrooms, sprouts, and barley or wheat grass. These specify the growing media to be used, which includes natural fertilisers, and require the use of potable water for sprout production.

4.1.4 Brand-specific assurance programmes

A number of retailers and product groups ("brands") operate their own assurance programmes for suppliers of horticultural produce.

4.1.4.1 Woolworths Quality Assurance

Suppliers of horticultural products sold under the Woolworths brand or by other supermarkets operated by Progressive Enterprises Ltd. (Foodtown, Countdown) need to be certified to the

[19] Standard NZS 8410:2003 is available from http://www.standards.co.nz/.

Woolworths Quality Assurance (WQA) Standard.[20] This standard requires Woolworths suppliers to have a HACCP plan in place that identifies and controls potential hazards to food safety, quality criteria and regulatory criteria. Suppliers must also demonstrate that they have in place a series of Good Manufacturing Practices (GMPs), some of which are relevant to this study:

- Water quality should be tested for safety wherever it is being used in food production.
- Procedures shall be documented to ensure potable water is available for post harvest wash treatments.
- The quality of water, steam, ice, air, compressed air or gas that comes into contact with food or packaging, that in itself does not constitute an ingredient, shall be regularly monitored and shall present no risk to product safety or quality.
- Ice shall be prepared from potable water.

This standard does not consider the use of natural fertilisers.

There are also specific requirements for suppliers of produce, which includes a list of what Woolworths consider to be high risk products (e.g. fresh cut salad, ready-to-eat salad vegetables, precut fruit or vegetables, mushrooms, berries), but does not contain specific requirements for the use of water or natural fertilisers. This document does, however, give microbiological criteria for these high risk products and require that microbiological and chemical testing is undertaken where potential hazards may exist. There are microbiological criteria for *E. coli* (<10 CFU/g), thermotolerant coliforms (<100 CFU/g), *L. monocytogenes* (<10 CFU/g), coagulase-positive staphylococci (<100 CFU/g) and *Salmonella* (not detected in 25 g). Spent irrigation water used for growing sprouts must also be tested for *Salmonella*.

4.1.4.2 New Zealand Avocado Industry Council

The New Zealand Avocado Growers' Association & Industry Council administers a quality assurance scheme for domestic and export growers.[21] The scheme requires avocado producers to put in place a HACCP-based food safety programme and there are specific requirements for managing natural fertilisers:

- Using composts/biosolids/organic mulches during prior to planting: Manures, biosolids and mulches are certified or sourced from reputable suppliers following appropriate composting standards to ensure proper treatment. Stockpiles are located and secured to prevent contamination of field (e.g. run-off and/or leaching).
- Using natural fertilisers during planting: Time between manure, biosolids or other natural fertiliser is appropriate (there is at least three years between harvesting and planting).
- Soil is not applied to the fruit and fruit is not harvested from the ground.
- Growers are required to record fertiliser applications in a fertiliser diary.

Growers and packers are also required to assess the risk of faecal, chemical and/or physical contaminants in the water supply and develop a water management programme. Packers are

[20] Available from http://www.wowlink.com.au.
[21] The information in this section was sourced from Part 7 (Food Safety) of the Avocado Quality Manual, which was kindly provided by Dr Henry Pak (Technical Manager, Avocado Industry Council) in September 2010.

required to use potable water wherever water comes into contact with fruit. If the packhouse water is not a reticulated municipal supply the water must be tested annually for *E. coli* (limit ≤0 CFU/100 ml).

4.2 International Standards for Horticulture: Codex Alimentarius

The CAC has produced a number of codes of practice and guidelines that are relevant to the production of fresh fruit and vegetables:

- Recommended international code of practice – general principles of food hygiene (CAC/RCP 1-1969, Rev.4-2003).
- Code of hygienic practice for fresh fruits and vegetables (CAC/RCP 53–2003).
- Guidelines for the production, processing, labelling and marketing of organically produced foods (GL 32–1999).
- Recommended international code of practice for packaging and transport of fresh fruit and vegetables (CAC/RCP 44–1995).
- General standard for contaminants and toxins in food and feed (standard 193-1995).

As of May 2011, guidelines on the application of general principles of food hygiene to the control of viruses in food were being drafted.

The CAC has also produced codes of practice for specific produce groups:

- Recommended international code of hygienic practice for dehydrated fruits and vegetables including edible fungi (CAC/RCP 5–1971).
- Recommended international code of hygienic practice for dried fruits (CAC/RCP 3–1969).
- Code of hygienic practice for spices and dried aromatic plants (CAC/RCP 42–1995)
- Recommended international code of hygienic practice for tree nuts (CAC/RCP 6–1972).

The CAC's *Code of hygienic practice for fresh fruits and vegetables* includes two annexes that recommend Good Manufacturing Practices (GMPs) for ready-to-eat fresh pre-cut fruits and vegetables, and for sprout production. The Codex Committee on Food Hygiene has drafted another annex to this document, on fresh leafy vegetables, and has proposed that an annex be prepared on melons.[22]

There are also CAC standards for specific horticultural foods, e.g. asparagus, grapefruits, tomatoes, fungi and oats. Many of these have been summarised in the Codex document *Fresh Fruits and Vegetables*, published in 2007.[23] These standards consider quality and marketing parameters such as size, classification, packaging and labelling and are not considered further in this study.

[22] See the report of the 42nd session of the Codex Committee on Food Hygiene at http://www.codexalimentarius.net/web/archives.jsp?lang=en.

[23] This document is available at: http://www.fao.org/docrep/010/a1389e/a1389e00.HTM. A full list of Codex standards can be found at: http://www.codexalimentarius.net/web/standard_list.jsp.

4.2.1 General principles of food hygiene

The code, *Recommended international code of practice – general principles of food hygiene* (CAC/RCP 1-1969, Rev.4-2003), makes recommendations to ensure good food hygiene. The code covers general principles that are applicable to all foods across the whole food chain, from primary production through to final consumption, and supports the use of a HACCP-based approach to identify and control activities that may contaminate food. Recommendations that are specific to the use of water and natural fertilisers are summarised in Table 7.

Table 7: Recommendations on the use of water and natural fertiliser from the CAC's General Principles of Food Hygiene

Section	Summary of recommendations
3.2 Hygienic production of food sources	Producers should control contamination from soil, water, and fertilisers (including natural fertilisers), and protect food sources from faecal and other contamination.
5.5.1 Water in contact with food	Only potable water should be used in food handling and processing. Water recirculated for reuse should be treated and maintained in such a condition that no risk to the safety and suitability of food results from its use, and the treatment process should be effectively monitored. However, non-potable water, recirculated water that has received no further treatment, or water recovered from processing of food by evaporation or drying may be used, provided use does not constitute a risk to the safety and suitability of food.
5.5.2 Water as an ingredient	Potable water should be used wherever necessary to avoid food contamination.
5.5.3 Ice and steam	Ice should be made from potable water. Ice and steam should be produced, handled and stored to protect them from contamination. Steam used in direct contact with food or food contact surfaces should not constitute a threat to the safety and suitability of food.

Reference: Recommended international code of practice general principles of food hygiene (CAC/RCP 1-1969, Rev. 4-2003). Codex Alimentarius Commission. Available at: http://www.codexalimentarius.net/web/standard_list.do?lang=en.

4.2.2 Code of Hygienic Practice for Fresh Fruits and Vegetables

This code (CAC/RCP 53–2003) recommends Good Agricultural Practices (GAPs) and Good Manufacturing Practices (GMPs) to help control microbial, chemical and physical hazards associated with all stages of the production of fresh fruits and vegetables from primary production to packing. The base of this code is the earlier CAC code of practice covering the general principles of food hygiene (CAC/RCP 1-1969; Section 4.2.1), but the *Code of hygienic practice for fresh fruits and vegetables* focuses on hygienic issues that are specific to the primary production and packing of fresh fruits and vegetables. Recommendations that are specific to the use of water and natural fertilisers are summarised in Table 8.

Table 8: Recommendations on the use of water and natural fertiliser from the CAC's Code of Hygienic Practice for Fresh Fruits and Vegetables

Section	Summary of recommendations
3.2.1 Agricultural input requirements	Agricultural inputs, including fertilisers and water, should not contain microbial or chemical contaminants at levels that may adversely affect the safety of fresh fruits and vegetables.
3.2.1.2 Manure, biosolids and other natural fertilisers	The use of manure, biosolids and other natural fertilisers in the production of fresh fruits and vegetables should be managed to limit the potential for microbial, chemical and physical contamination. Natural fertilisers contaminated with heavy metals or other chemicals at levels that may affect the safety of fresh fruits and vegetables should not be used. To minimize microbial contamination the following practices should be considered: - Adopt proper treatment procedures (e.g. composting, pasteurization, heat drying, UV irradiation, alkali digestion, sun drying or combinations of these) that are designed to reduce or eliminate pathogens in natural fertilisers. The level of pathogen reduction achieved by different treatments should be taken into account when considering suitability for different applications. - Natural fertilisers that are untreated or partially treated may be used only if appropriate corrective actions are being adopted to reduce microbial contaminants such as maximizing the time between application and harvest of fresh fruits and vegetables. - Growers who are purchasing natural fertilisers that have been treated should obtain documentation from the supplier that identifies the origin, treatment used, tests performed and the results thereof. - Minimize direct or indirect contact between natural fertilisers, and fresh fruits and vegetables, especially close to harvest. - Minimize contamination by natural fertilisers from adjoining fields. - Avoid locating natural fertilizer treatment or storage sites in proximity to fresh fruit and vegetable production areas.
3.2.1.1 Water for primary production	Growers should identify the sources of water used on the farm (e.g. potable, re-used irrigation water, well, river) and assess its microbial and chemical quality, and its suitability for intended use, and identify corrective actions to prevent or minimise contamination (e.g. from livestock, sewage treatment, human habitation). Where necessary, growers should have the water they use tested for microbial and chemical contaminants, with the frequency of testing depending on the water source and the risks of environmental contamination including intermittent or temporary contamination (e.g. heavy rain, flooding). If the water source is found to be contaminated corrective actions should be taken to ensure that the water is suitable for its intended use.

Table 8 (continued)

Section	Summary of recommendations
3.2.1.1.1 Water for irrigation and harvesting	Water used for agricultural purposes should be of suitable quality for its intended use. Special attention to water quality should be considered when: - Irrigation by water delivery techniques exposes the edible portion of fresh fruits and vegetables directly to water (e.g. sprayers) especially close to harvest time. - Irrigating fruits and vegetables that have physical characteristics such as leaves and rough surfaces which can trap water. - Irrigating fruits and vegetables that will receive little or no post-harvest wash treatments prior to packing, such as field-packed produce.
3.2.1.1.3 Hydroponic water	Plants grown in hydroponic systems absorb nutrients and water at varying rates, constantly changing the composition of the re-circulated nutrient solution. Because of this, water used in hydroponic culture should be changed frequently, or if recycled, should be treated to minimize microbial and chemical contamination. Water delivery systems should be maintained and cleaned, as appropriate, to prevent microbial contamination of water.
5.2.2.1 Post-harvest water use	Water quality management will vary throughout all operations. Packers should follow good management practices to prevent or minimize the potential for the introduction or spread of pathogens in processing water. The quality of water used should be dependent on the stage of the operation, e.g. clean water for initial washing stages, potable water for final rinses. Also: - Post-harvest systems that use water should be designed in a manner to minimize places where product lodges and dirt builds up. - Antimicrobial agents should only be used where absolutely necessary to minimize cross-contamination during post-harvest and where their use is in line with good hygienic practices. The antimicrobial agents levels should be monitored and controlled to ensure that they are maintained at effective concentrations. Application of antimicrobial agents, followed by a wash as necessary, should be done to ensure that chemical residues do not exceed levels as recommended by the CAC. - Where appropriate, the temperature of the post-harvest water should be controlled and monitored. - Recycled water should be treated and maintained in conditions that do not constitute a risk to the safety of fresh fruits and vegetables. The treatment process should be effectively monitored and controlled. - Recycled water may be used with no further treatment provided its use does not constitute a risk to the safety of fresh fruits and vegetables (e.g. use water recovered from the final wash for the first wash). - Ice should be made from potable water. Ice should be produced, handled and stored to protect it from contamination.

Table 8 (continued)

5.2.2.3 Cooling of fresh fruits and vegetables	Potable water should be used in cooling systems where water or ice is in direct contact with fresh fruits and vegetables (e.g. hydro cooling, ice cooling). The water quality in these systems should be controlled and maintained.
5.7 Documentation and records	Where appropriate, records of processing, production and distribution should be kept long enough to facilitate a recall and food borne illness investigation, if required. Growers should keep current all relevant information on agricultural activities such as agricultural inputs, irrigation practices, and water quality data. Packers should keep current all information concerning each lot such as data on the quality of processing water.

Reference: Code of hygienic practice for fresh fruits and vegetables (CAC/RCP 53-2003). Codex Alimentarius Commission. Available at: http://www.codexalimentarius.net/web/standard_list.do?lang=en.

The annexes in the *Code of hygienic practice for fresh fruits and vegetables* largely refer to the main document's recommendations for primary production. The annex on ready-to-eat fresh pre-cut fruits and vegetables considers production from the point of receipt of raw materials to a facility that will cut and pack the foods and includes recommendations for the use of clean or potable water. The annex on sprout production also makes recommendations for the control of water sources and water contamination, and suggests that spent irrigation water be tested for microbial contamination.

The draft annex on fresh leafy vegetables considers all vegetables of a leafy nature where the leaf is intended to be consumed fresh, ready-to-eat or pre-cut (e.g. lettuce, spinach, cabbage, fresh herbs). The annex regularly refers to the *Code of hygienic practice for fresh fruits and vegetables*, but emphasises the GAPs and GMPs for the use of water and natural fertilisers.

In regard to water used for primary production, the draft annex on fresh leafy vegetables emphasises the need for growers to consider the quality of their water sources and to actively manage water quality by microbial testing and treatment. The draft annex also contains recommendations on irrigation methods and the risks and benefits of different approaches:

- Overhead irrigation presents the highest risk of contamination because it wets the edible portion of the crop. The duration for wetting can be several hours, and the physical force of water droplet impact may drive contamination into protected sites on the leaf. Therefore, only the clean water should be used for this type of irrigation.
- Subsurface or drip irrigation that results in no wetting of the plant is the irrigation method with the least risk of contamination, although these methods can still experience localized problems. For drip-irrigation, care should be taken to avoid creating pools of water on the soil surface or in furrows that may come into contact with the edible portion of the crop.
- Irrigation of fresh leafy vegetables that have physical characteristics such as rough surfaces where water may accumulate, a vase-like growth characteristic, or high density seeding or transplant rates should be irrigated with only clean water. Irrigation of these products should be applied in a way to minimize wetting of the edible portion because the plant characteristics can provide niches for microbial attachment and survival.

The draft annex also recommends that where water is used during harvest, e.g. to hydrate harvested crops in containers, that this water is clean. However, the draft annex states that products at this point are not considered ready-to-eat.

Regarding the use of water in post-harvest activities, the draft annex emphasises the use of potable water for final rinse steps and suggests that the pH, hardness and temperature of the post-harvest water should be controlled as well as the microbial quality. The draft annex also emphases that any water that is used in cooling and that might come into contact with the vegetables is free from human pathogens, e.g. cooling by ice (e.g. parsley), and if water is recirculated it is treated, e.g. when cooling by forced-air, vacuum (e.g. iceberg lettuce), hydrocooling, spray-vacuum (hydrovac).

The draft annex also includes recommendations for the use of manure, biosolids and other natural fertilisers. This annex emphasises the likelihood that natural fertilisers will contain human pathogens, and the need to ensure that these fertilisers are treated properly. The annex recommends composting and includes some instructions for good composting techniques. Importantly, the draft annex recommends that manure, biosolids, and other natural fertilisers should not be applied to leafy vegetables after plant emergence unless it can be demonstrated that product contamination will not occur. Growers are also cautioned to minimise the risk of vegetable contamination from contaminated soils by rain splash or plant uptake, by considering the timing of fertilisation, planting and plant growth.

4.2.3 Other CAC standards, guidelines and codes of practice

The other CAC documents listed in Section 4.2 were reviewed for information on the use of water and natural fertilisers, as well as standards for microbiological or chemical contaminants. Those that contain relevant information are discussed below.

4.2.3.1 Guidelines for the production, processing, labelling and marketing of organically produced foods (GL 32–1999)

These guidelines do not consider the use of water for irrigation or post-harvest activities but have detailed criteria on the use of natural fertilisers.

Regarding the plants and plant products, the guidelines state that the fertility and biological activity of the soil can be maintained or increased by the incorporation of organic material (composted or not) from holdings that also operate under these organic guidelines. This includes by-products from livestock farming such as farmyard manure.

The guidelines also include a substantial list of substances that can be used for soil fertilisation or conditioning. The list includes:

- Animal wastes, e.g. farmyard and poultry manure, slurry or urine, guano, slaughterhouse waste.
- Plant products and by-products, e.g. straw, used mushroom substrate, seaweeds, sawdust, wood ash, peat, cocoa bean pods.

Treated human excrement is also permitted, but cannot be applied to crops intended for human consumption or to the edible parts of plants.

4.2.3.2 General standard for contaminants and toxins in food and feed (standard 193-1995)

This standard contains the maximum levels permitted for aflatoxins in peanuts, almonds hazelnuts and pistachios. There are also maximum levels for heavy metals in fruit and vegetables (Table 9).

Table 9: Maximum levels of heavy metals permitted in fruit and vegetables under the CAC general standard for contaminants and toxins in food and feed

Metal, maximum level	Food
Cadmium, 0.05 mg/kg	Brassica vegetables Bulb vegetables Fruiting vegetables
Cadmium, 0.1 mg/kg	Legume vegetables Potato (peeled) Pulses (excluding dry soya bean dry) Root and tuber vegetables (excluding potato and celeriac) Stalk and stem vegetables Cereal grains (excluding buckwheat, cañihua, quinoa wheat, rice, bran and germ)
Cadmium, 0.2 mg/kg	Leafy vegetables Wheat
Cadmium, 0.4 mg/kg	Rice, polished
Lead, 0.1 mg/kg	Assorted (sub)tropical fruits Citrus fruits Pome fruits Stone fruits Bulb vegetables Fruiting vegetables Root and tuber vegetables (including peeled potatoes)
Lead, 0.2 mg/kg	Berries and other small fruits Legume vegetables Pulses Cereal grains (except buckwheat, cañihua and quinoa)
Lead, 0.3 mg/kg	Brassica vegetables (excluding kale) Leafy vegetables (including Brassica leafy vegetables, excluding spinach)

4.2.3.3 Draft guidelines on the application of general principles of food hygiene to the control of viruses in food

In reference to horticultural production, the draft guidelines are based on the two 2003 CAC codes of practice for the general principles of food hygiene (CAC/RCP 1-1969, Rev.4-2003) and fresh fruits and vegetables (CAC/RCP 53–2003). Because food workers are an important source of viral contamination, the main focus of the draft guidelines is on food worker hygiene. The guidelines contain similar recommendations to the 2003 CAC codes of practice on using natural fertilisers that are treated, and using clean or potable water in primary production and food processing. The guidelines recommend that the HACCP programme should particularly address the potential for the food to come into contact with faecal material of either human or animal sources or faecally contaminated water during the production phase (irrigation, washing, freezing/icing).

The draft guidelines contain an annex specifically for the control of hepatitis A virus and norovirus in fresh produce. Human excreta used as fertilizer (i.e. biosolids) and irrigation water are identified as source of these viruses. However, other than detailing some potential hazards and their control measures (e.g. water testing), the annex does not make any recommendations on the use of water and natural fertilisers that are significantly different to those made in the CAC code of practice for fresh fruits and vegetables.

4.2.3.4 Produce group codes of practice

The codes of practice for dehydrated fruits and vegetables (including edible fungi), dried fruits, tree nuts, and spices and dried aromatic plants do not contain information about the use of natural fertilisers (though some of the documents specify that the raw foods be free from contamination by human or animal faecal material). They all contain recommendations for the use of water in primary production and/or processing, which generally requires that the water is of a standard that does not constitute a public health hazard to the consumer through the product. Only the code of practice for spices and dried aromatic plants contained specific microbiological criteria, requiring treated, ready-to-eat spices to be free from *Salmonella* when ten samples of 25 g are analysed.

4.3 International Assurance Programmes for Horticulture

4.3.1 GLOBALG.A.P.

GLOBALG.A.P. is a voluntary standard open to producers worldwide and covers production activities up until a product leaves the farm. It was originally developed by British and European retailers and was previously called EurepG.A.P. Version 4.0 was released 1 March 2011 and will become obligatory from 1 January 2012.

There are three tiers to the standard and each has a list of control points and compliance criteria. The first tier is the “All farm base” which all producers must meet. The second tier separates out producers into cropping, livestock and aquaculture, and horticultural producers must meet the criteria of the “Crops base”. At the third tier, cropping activities are further divided and there is a separate set of criteria specifically for producers of fruit and vegetables, and for “combinable crops”. The “Fruit and vegetables” document covers fruit and vegetables used for fresh, cooked or processed consumption by humans, and the “Combinable crops” document covers crops for cooked or processed consumption by humans or animals or for use in the industry (e.g. arable crops such as wheat) (GlobalGAP, 2011).

All three tiers include Control Points and Compliance Criteria (CPCC) that relate to the use of natural fertilisers and water (Table 10).

Table 10: GLOBALG.A.P. control points and compliance criteria (CPCC) relevant to this study

Tier	Summary of control points	Ref.[1]
All farm base (AF)	Requires a risk assessment of new sites, which should include an evaluation of water quality, availability and authorisation for use.	a
Crops base (CB)	- Growers must consider the needs of the soil and crop when applying fertilisers, must maintain records all applications of fertilisers, and must take care with fertiliser storage. - Human sewage sludge is banned on the farm, as is the use of untreated sewage water for irrigation or fertigation. - Growers must undertake a risk assessment for organic fertiliser before application, and take account of the nutrient contribution of these fertilisers.[2] - Growers must optimise the use of water for irrigation or fertigation and should maintain records of its use, and must complete an annual risk assessment of this water for pollution. - Fertiliser spreaders and irrigation systems must be calibrated annually.	b
Fruit and vegetables (FV)	- Before harvest, the grower must consider the quality of the water used to make plant protection product mixtures, the timing of application of any organic fertilisers, and must check for any animal activity in the crop production area. - The grower must undertake risk assessments covering physical, chemical and microbiological contaminants for the harvest and pre-farm gate transport processes, and for produce handing after harvest. - Growers must consider the quality of water used during harvest, or for ice, product washing and any post-harvest treatments.	c
Combinable crops (CC)	The source of water used for any post-harvest treatment must be potable and/or analysed within the last 12 months.	d

1. References: All available from http://www.globalgap.org
   a. GLOBALG.A.P. Control Points and Compliance Criteria: Integrated Farm Assurance – All Farm Base. Version 4.0 (March 2011).
   b. GLOBALG.A.P. Control Points and Compliance Criteria: Integrated Farm Assurance – Crops Base. Version 4.0 (March 2011).
   c. GLOBALG.A.P. Control Points and Compliance Criteria: Integrated Farm Assurance – Fruit and Vegetables. Version 4.0 (March 2011).
   d. GLOBALG.A.P. Control Points and Compliance Criteria: Integrated Farm Assurance – Combinable Crops. Version 4.0 (March 2011).
2. GLOBALG.A.P. defines an “organic fertiliser” as being materials of animal origin used to maintain or improve plant nutrition and the physical and chemical properties and biological activity of soils, e.g. manure, compost, digestion residues.

The "Crops base" includes, as an annex, a guideline for the identification of microbiological hazards during the harvest of fresh fruit and vegetables. The guideline considers microbiological contamination from water, animals/birds, the use of manure and organic fertilisers, people (workers) and materials.

The guidelines encourage growers to consider water used close to harvest (e.g. irrigation, fertigation[24], application of plant protection products), particularly where this water directly contacts the edible part of the produce. The annex includes a decision tree to assess the hazards of post-harvest microbial contamination from water. Water used to wash produce "must be from safe sources, preferably potable water or water that has been treated to eliminate bacteria". Growers are asked to consider the source of their water, treatment and replacement of any recirculating water, and cleaning of water delivery structures. They are advised never to use irrigation water for washing or refreshing produce, unless that water is potable. Growers are also advised to use potable water for making ice, and keeping that ice free from contamination.

To reduce that possibility that crops will become contaminated through the use of manure, the guidelines encourage growers to take care that the edible portion of the crop does not contact the ground, to maximise the time between manure application and harvest (specifically, untreated organic fertilisers should not be used from 60 days previous to the harvest season), to avoid possible contamination from manure on neighbouring land, to store manures separately from crop areas and to clean any vehicles or equipment that have been in contact with untreated manure prior to them being introduced to cropping areas.

The "All farm" base includes microbiological quality guidelines for wastewater use in agriculture. Wastewater used for irrigating crops likely to be eaten uncooked needs to have one or less intestinal nematodes per litre, and 1,000 or less faecal coliforms per 100 ml. The microbiological quality guidelines for the use of wastewater to irrigate cereal crops and trees are less stringent, although these note that sprinkler irrigation should not be used, and irrigation of fruit trees should cease two weeks before the fruit is picked and no fruit should be picked off the ground.

4.3.2 Safe Quality Food (SQF)

The Safe Quality Food (SQF) Program is administered by the SQF Institute (SQFI) located in the United States. AsureQuality is the New Zealand certification body. SQF is an internationally-recognised food safety and quality program based on HACCP principles. There are two sets of standards based on the type of food supplier; the SQF 1000 code for primary producers and the SQF 2000 code for manufacturers and distributors (SQFI, 2010a).[25] The growing of fresh produce, and packing on the grower's property (either in the field or in an adjacent pack house) falls under the SQF 1000 code. Commercial fresh produce pack houses that pack produce from multiple growers fall under both codes. Fertiliser manufacture falls under the SQF 2000 code (SQFI, 2010b).

There are also three levels of certification under each code: food safety fundamentals (for low risk products), certified HACCP food safety plans (for high risk products), and

[24] 'Fertigation' is the technique of supplying water-dissolved fertiliser to crops through an irrigation system.
[25] The codes are available from http://www.sqfi.com/documents/.

comprehensive quality management systems development (food quality control) (SQFI, 2010a). The growing and production of fresh produce, fresh produce pack house operations and fertiliser manufacture are all classified as low risk activities and, subject to customer expectations, need only achieve a Level 1 certification. However, the growing and production of some ready-to-eat produce (e.g. sprouts) is classified as a high risk activity and requires certification to Level 2 or 3 (SQFI, 2010b).

Because the codes are based on HACCP there is a general requirement for producers to identify and mitigate any hazards that might impact on their ability to deliver a safe product. However, the codes also include specific standards for the use of water and natural fertilisers. Relevant standards from SQF 1000 are summarised in Table 11.

Table 11: SQF 1000 standards relevant to this study

Standard	Summary of standard
5.4.1 Irrigation water	- Irrigation water shall be drawn from a known clean source or treated to make it suitable for use. - The Producer shall conduct an analysis of the hazards to the irrigation water supply, establish acceptance criteria and verify the integrity of the water used to ensure it if fit for the purpose. - In circumstances where irrigation water is treated to render it acceptable, the water shall conform to the microbiological standards as outlined under 6.9.1.
5.5.7 Use and Storage of Fertilisers	- Organic (manure) soil amendments shall be isolated and stored separately so as not to pose a food safety risk. - An inventory of all organic and inorganic soil amendment storage and use shall be maintained.
5.7.1 Product Protection	- Water used in the packing shed or field to wash produce must be potable. - Water potability test results must be reviewed and kept on file.
5.7.5 Monitoring	- Flume water treated with chemicals must be monitored to verify compliance with the target range (e.g. pH, ppm, temperature).
6.9.1 Standard	- Water used for washing and treating product shall comply with potable water microbiological standards in the country of production. - Separate criteria will be established for irrigation water, frost control, humidifying, etc. as applicable, based on the hazard analysis, best practices within country of production and legislation.
6.9.2 Monitoring Water Microbiology and Quality	- Water quality shall be monitored to verify it complies with the established water microbiological standard or criteria. - A verification schedule shall be prepared indicating the location and frequency of monitoring, which shall be decided by the hazard analysis, best practices within country of production, or applicable legislation.

Table 11 (continued)

Standard	Summary of standard
6.9.3 Corrective Actions	- When monitoring shows that water does not meet established criteria or standard, producer will have a corrective action plan developed which could include additional treatment for water, additional sources for water, product identification and disposition or other alternative actions to adequately control the identified hazards.
6.9.4 Ice	- Ice shall be made from potable water. Producer will verify that any ice used is made from potable water.
6.13.1 Soil Amendment Protocol	- No raw untreated manure shall be used. - Soil amendment treatment and application methods shall be documented, implemented and designed to prevent contamination of product. A soil amendment protocol shall outline - The methods used to treat manure and other untreated organic fertilisers, ensuring the treatment methods inactivate pathogens, a hazard analysis of treatment methods is conducted before use, treatment methods are validated, and records of the validation and verification of treatments are maintained. - The methods to ensure organic soil amendment applications are timed to pose minimum risk to product safety and human health, including ensuring applications in accordance with National or Local Guidelines, Best Practices and Codes of Good Agricultural Practice, application equipment is maintained and calibrated, and that records of maintenance and application are kept.

Reference: SQF 1000 code: A HACCP based supplier assurance code for the primary producer. Safe Quality Food Institute (Food Marketing Institute). Available from http://www.sqfi.com/documents/.

SQF 2000 includes standards for water microbiology and quality (Standards 5.3, 6.8), which ensure that any water that comes into contact with food (e.g. washwater, ice) complies with national or internationally recognised potable water microbiological and quality standards (this includes a requirement for microbial analysis of water and ice supplies) (SQFI, 2008).

4.4 Country-specific assurance programmes

There are many country-specific assurance programmes and this project does not seek to summarise them all. Programmes from some of the more important New Zealand markets are summarised in this section.

4.4.1 United Kingdom

4.4.1.1 British Retail Consortium Global Standards

The British Retail Consortium (BRC) Global Standards are a suite of four standards that set out requirements for production, packaging, storage and distribution of food. The Global Standard for Food Safety sets out requirements for businesses that process food or are involved in the preparation of primary products for supply as retailer branded products, branded products, and food or ingredients for use by food service companies, caterers or manufacturers (BRC, 2008).[26] Food businesses are audited under their product category, and there are three categories relevant to this study: (1) Fruits, vegetables and nuts, (2) Prepared fruit, vegetables and nuts (e.g. ready-to-eat salads, chips, frozen vegetables), and (3) Dried foods and ingredients (e.g. herbs, dried fruit).

The Food Safety Standard applies to horticulture production from the point where produce reaches the site of sorting and packing. In the scope of this study, the relevant businesses are those that operate as packhouses, cool storage facilities or producers of ready-to-eat, dried or semi-dried produce. The standard requires these businesses to produce a HACCP-based food safety plan, following the CAC's HACCP principles (CAC, 2003). This includes identifying hazards and their controls. Because the standard is intended to be applicable to a wide range of food businesses there are no specific standards for horticulture production, however the standard includes requirements for water use, in particular: "Based on risk assessment, the microbiological and chemical quality of water, steam, ice, air, compressed air or other gases that does not constitute an ingredient but comes into direct contact with food or packaging shall be regularly monitored. It shall present no risk to product safety or quality and comply with relevant legal regulations" (standard 4.4.2).

The BRC maintains an open directory of certified businesses.[27] At October 2010, there were 226 New Zealand businesses certified against the BRC Standard for Food Safety. When separated by their product category, 128 businesses were certified under 'Fruits, vegetables and nuts'. These businesses were all packhouses and cool storage facilities, and were commonly certified for receipt, grading, packing, storage and dispatch of produce. Most of the businesses supported the apple, pear and kiwifruit industries. There were only two businesses certified under the 'Prepared fruit, vegetables and nuts' product category and both of these produced frozen vegetables. There were four businesses certified under the 'Dried foods and ingredients' product category, for products such as fruit snacks and pastes, and bakery ingredients.

4.4.1.2 LEAF Marque Global Standard

LEAF (Linking Environment And Farming) Marque is a certification and labelling scheme that is based on environmentally responsible farming principles. Growers must meet the LEAF Marque Global Standard (LEAF, 2010) in addition to any other assurance schemes they want to be certified for, such as GLOBALG.A.P.[28]

There are LEAF Marque standards for water use, including a requirement for a water management plan, but these focus on efficient water use and protection of waterways. There are several standards that are relevant to the use of natural fertilisers, but none of these specifically address managing microbial or chemical contamination of horticultural produce:

[26] Available from http://www.brcglobalstandards.com.
[27] The directory is available at http://www.brcdirectory.com/Index.aspx.
[28] The LEAF Marque standard is available from http://www.leafuk.org/leaf/farmers/LEAFmarquecertification/standard.eb.

- Growers must have a nutrient management plan to optimise crop performance and minimise environmental impact, and this should integrate with a manure management plan (standard 2.2).
- Growers must have a manure management plan which needs to include any manure, slurry, compost, products from anaerobic digestion and industrial waste used on the farm, and must also identify where by-products must not be spread. Growers must record the application rate and timing of organic fertiliser by field (standard 4.3).
- Growers must record all inorganic and organic fertiliser applications (standard 2.10).
- Growers must carry out regular maintenance and calibration of equipment and machinery, including fertiliser and manure spreaders (standard 4.5).
- Growers must identify and document all potential pollutants on the farm, including fertilisers and organic wastes, so that they can make provision to safely store and handle them and their risk to the environment (standard 4.7).
- Growers must comply with best practice in the storage of organic material such as slurry, silage and manure, including ensuring that their safe holding capacity for animal manure and slurry is adequate (standards 7.4 and 7.5).

4.4.2 United States: USDA NOP

The United States Department of Agriculture (USDA) administers a National Organic Program (USDA NOP). The standards for this programme are set down in part 205 of the Code of Federal Regulations.[29] Section 205.203 sets out the rules for nutrient management. Specifically, "The producer must manage plant and animal materials to maintain or improve soil organic matter content in a manner that does not contribute to contamination of crops, soil, or water by plant nutrients, pathogenic organisms, heavy metals, or residues of prohibited substances."

Growers must compost animal manure before applying it to land used for food production, unless the manure is incorporated into the soil either ≥120 days before harvesting a product whose edible portion has direct contact with the soil, or ≥90 days before harvesting a product whose edible portion does not have direct contact with the soil. The temperature and time required for composting plant and animal material is described: Maintenance of a temperature of 131-170°F (55-77°C) for three days using an in-vessel or static aerated pile system or for 15 days using a windrow composting system, turning the material a minimum of five times. Uncomposted plant materials are permitted. Sewage sludge is not permitted.

There are no specific requirements for the use of water.

4.4.3 Japan: JAS

The Japanese Agricultural Standard (JAS) is an organic label administered by the Ministry of Agriculture, Forestry and Fisheries in Japan.[30] The JAS is as quality standard, not a food safety standard. As of March 2007, New Zealand organic rules and standards are approved as equivalent with the organic JAS system, which means than an importer of organic products from New Zealand to Japan can attach the JAS mark.

[29] These can be viewed at http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=667649822bbeca727e6e0f910ef3e4fe&tpl=/ecfrbrowse/Title07/7cfr205_main_02.tpl.
[30] Further information on the JAS can be found at: http://www.maff.go.jp/e/jas/jas/index.html.

The JAS standard for organic plants (MAFF, 2009) does not include requirements for the use of water in horticulture production, but includes a list of permitted natural fertilisers and permitted materials/composts for growing fungi.

5 COMPARISON OF CODEX CODE OF PRACTICE, STANDARDS AND ASSURANCE PROGRAMMES

The CAC *Code of Hygienic Practice for Fresh Fruits and Vegetables* provides a useful benchmark to compare voluntary standards and assurance programmes. This Code was analysed for information on the use of natural fertilisers and water during horticultural production (Section 4.2.2) alongside the New Zealand Standard for Organic Production (Section 4.1.3.5) and the following eight assurance programmes:

- New Zealand GAP (Section 4.1.1)
- New Zealand GAP (GLOBALG.A.P. Equivalent) (Section 4.1.2)
- GLOBALG.A.P. (Section 4.3.1)
- Safe Quality Food (Section 4.3.2)
- NZFSA Official Organic Assurance Programme (Section 4.1.3.4)
- BioGro New Zealand Organic Standards (Section 4.1.3.1)
- AsureQuality Organic Standard (Section 4.1.3.2)
- Demeter Standards (Section 4.1.3.3).

A set of generic criteria were developed to standardise the content across the programmes for easier comparison. These criteria were grouped by considering if they relate to the source of the water or fertiliser, its quality, its application, or record keeping. The criteria were initially developed from the CAC code, but were expanded to encompass requirements or recommendations included in the other assurance programmes where these did not appear in the CAC code.

Table 12 presents a summary of this comparison using section numbers or criterion numbers from the relevant documents. Table 12 has been separated into six sub-tables:

Table 12A: Natural fertilisers.

Table 12B: Water for primary production. The information is relevant to all water used for primary production, irrespective of the purpose of the water (e.g. irrigation, hydroponics). Tables C-E refer to the information in Table B, where relevant.

Table 12C: Water for irrigation (outdoor or indoor non-hydroponic growing systems).

Table 12D: Water for hydroponic growing systems.

Table 12E: Water for agricultural chemicals. This includes water used for mixing or diluting liquid organic preparations, e.g. compost teas.

Table 12F: Water for post-harvest processes.

Appendices 1 and 2 contain lists of the documents reviewed to produce this summary table and the full text from these documents. Readers are advised to consult these appendices as they contain important notes for this document review. It is important to note that this evaluation only considers requirements that are specifically included in the documents analysed. Some programmes require growers to produce HACCP plans or similar, and in the process of doing this it would be expected that growers would undertake many of the activities listed as criteria in the tables. For example, the SQF codes are based on HACCP planning and this would prompt the grower to assess the microbial and/or chemical quality of fertiliser or irrigation water inputs.

These tables can be used to rapidly assess how specific assurnace programmes address the criteria, and locate alternate or additional controls from other programmes where coverage is considered insufficient. A summary concerning the coverage of these assurance programmes is provided in Volume 1 Section 7.5.

Table 12: Requirements for the use of natural fertilisers and water in horticulture: Comparison between the CAC code of practice, the New Zealand Organic Standard and eight international and domestic assurance programmes used in New Zealand

<u>Note</u>: ESR and Catalyst invited the publishers of each document or set of documents to comment on the following analysis (and that presented in appendices 1 and 2), except for the Codex Alimentarius Committee, GLOBALG.A.P. and the SQFI. Their comments have been considered in this analysis, but readers should note that these results are those agreed by ESR and Catalyst and the publishers may hold different views. Standards New Zealand provided copyright permission but did not comment on the results of this analysis.

Key to tables:

N/I (Not Included) marks where there is no requirement or recommendation presented in the document for a generic criterion.

(R) (Recommended) marks where a requirement is recommended rather than mandatory (some documents include recommended and mandatory requirements).

CAC/RCP 53-2003	CAC Code of Hygienic Practice for Fresh Fruits and Vegetables
New Zealand GAP	New Zealand GAP
NZ GAP (GLOBALGAP)	New Zealand GAP (GLOBALG.A.P. Equivalent)
GLOBALG.A.P.	GLOBALG.A.P.
SQF	Safe Quality Food
NZS 8410	New Zealand Standard for Organic Production (NZS 8410:2003)
NZFSA OOAP	NZFSA Official Organic Assurance Programme
BioGro	BioGro New Zealand Organic Standards
AsureQuality	AsureQuality Organic Standard
Demeter	Demeter Standards

Table 12A: NATURAL FERTILISERS

	GENERIC CRITERIA	CAC/RCP 53-2003	New Zealand GAP	NZ GAP (GLOBALGAP)	GLOBALG.A.P.	SQF	NZS 8410	NZFSA OOAP	BioGro	AsureQuality	Demeter
SOURCE	A1. Producers must only use fertilisers accredited to, or specified by, a specific programme or standard (e.g. organic standard, Fertmark)	N/I	Criterion 43(R)	N/I	N/I	N/I	4.1.4, 7.3.1	5.1.4, Table 1 (Section 13)	3.1.1, 3.1.3	4.2.1, 4.2.2, 4.2.3	4.4.2, 5.4.1.3, 6.5.1.3, 6.5.1.7
	A2. Producers must not use untreated human sewage sludge or any human sewage sludge	3.2.1	N/I	Criterion 34	CB5.5.1	N/I	4.1.4	Table 1	3.1.3	Table 1 (Section 10)	5.4.14, 6.5.14
	A3. Producers can use treated human sewage sludge if it meets appropriate standards (e.g. NZWWA guidelines, WHO guidelines)	3.2.1	N/I	Not applicable: None permitted (Criterion 34)	Not applicable: None permitted (CB5.5.1)	N/I	Not applicable: None permitted (4.1.4)	Not applicable: None permitted (Table 1)	Not applicable: None permitted (3.1.3)	Not applicable: None permitted (Table 1)	Not applicable: None permitted (5.4.14, 6.5.14)
QUALITY	A4. Producers should evaluate the food safety risks associated with the fertiliser * = evaluation guidelines are given	3.2.1, 3.2.1.2	*Criterion 40, Section C3.1	*Criterion 33, Section G3.3	*CB5.5.2	*6.13.1.2 (SQF1000)	N/I	N/I	N/I	N/I	N/I
	A5. Producers should test the microbial quality of the fertiliser if necessary (or obtain test results from supplier) * = microbial standards are specified	3.2.1.2	Section C3.1	Section G3.3	N/I	N/I	N/I	N/I	N/I	N/I	N/I
	A6. Producers should test the chemical quality of the fertiliser if necessary (or obtain test results from supplier) * = chemical standards are specified	3.2.1.2	Section C3.1	Section G3.3	N/I	N/I	*4.1.6(R)	N/I	*Appendix A	*4.5.2, *Table 1	5.4.7.1, 6.5.7.1, Supplement
	A7. Producers should (or must) use treated fertiliser (e.g. pasteurised, composted)	3.2.1.2	Section C3.1	Section G3.3	N/I	6.13.1.1 (SQF1000)	4.4.1, 5.1.1	5.1.4	3.1.3	N/I	5.4.1.7, 6.5.1.8
APPLICATION	A8. Producers should base the application of natural fertilisers on the nutritional requirements of the soil or crops and the nutritional content of the fertiliser, or specialist advice	N/I	Criterion 41(R), Criterion 42	Criterion 26, Criterion 27, Criterion 28	CB5.1.1, CB5.2.1, CB5.5.3	6.13.1.3 (SQF1000)	N/I	5.1.5	3.1.3	Table 1 (Section 10)	N/I
	A9. Producers should minimise contact between the fertiliser and the produce	3.2.1.2	Criterion 40, Section C3.1	Criterion 33, Section G3.3	CB5.5.2, FV3.2.1	N/I	N/I	N/I	N/I	N/I	N/I
	A10. Producers should maximise the time between final natural fertiliser application and harvest	3.2.1.2	Criterion 40, Section C3.1	Section G3.3	FV3.2.1	N/I	N/I	N/I	N/I	N/I	N/I
	A11. Producers should minimise contamination from natural fertilisers applied in adjoining areas	3.2.1.2	Section C3.1	Section G3.3	N/I	N/I	N/I	N/I	N/I	N/I	N/I
	A12. Producers should maintain fertiliser application machinery	N/I	N/I	Criterion 120	CB9.1, CB9.2	6.13.1.3 (SQF1000)	N/I	N/I	N/I	N/I	N/I
	A13. Producers should store natural fertilisers away from produce production areas	3.2.1.2	Section C3.1	Criterion 32, Section G3.3	CB5.4.6	5.5.7.1 (SQF1000)	N/I	N/I	N/I	N/I	N/I
RECORDS	A14. Producers should maintain records of fertiliser source (e.g. name of supplier, type of product such as manure or vermicast)	5.7	Criterion 44, Criterion 45	Criterion 30	CB5.3.3	5.5.7.4 (SQF1000)	4.1.1, Appendix A, 4.4.3, 5.1.1	9.1.6	8.4	4.11.4	3.15.2, 5.4.7.4, 6.5.7.4, Annual report, Supplement
	A15. Producers should maintain records of fertiliser quality (e.g. *E. coli* or lead concentration)	N/I	N/I	N/I	N/I	6.13.1.2 (SQF1000)	4.4.3	N/I	N/I	N/I	5.4.7.1, 6.5.7.1, 6.5.1.7, Annual report, Supplement
	A16. Producers should maintain records of fertiliser application (e.g. date applied, amount applied, where applied, how applied)	N/I	Criterion 44, Criterion 45	Criterion 29, Criterion 30	CB5.3.1, CB5.3.2, CB5.3.4, CB5.3.5	5.5.7.4, 6.13.1.1, 6.13.1.3 (SQF1000)	4.1.1, 4.4.3, 4.4.4, 5.1.1	9.1.6	N/I	4.11.4	3.15.2, Annual report
	A17. Producers should maintain records of the operator who applied the fertiliser (e.g. contact details, qualifications/training)	N/I	N/I	Criterion 30	CB5.3.6	N/I	N/I	N/I	N/I	N/I	N/I

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK

Table 12B: WATER FOR PRIMARY PRODUCTION											
GENERIC CRITERIA		CAC/RCP 53-2003	New Zealand GAP	NZ GAP (GLOBALGAP)	GLOBALG.A.P.	SQF	NZS 8410	NZFSA OOAP	BioGro	AsureQuality	Demeter
SOURCE	B1. Producers should consider whether the water sources are suitable for their intended use	3.2.1.1	Section C5.1	Section G6.1	AF1.2.1, AF1.2.2	N/I	4.5.2	N/I	N/I	N/I	Farm profile template
	B2. Producers must not use untreated sewage water or any sewage water	N/I	N/I	Criterion 97	N/I	N/I	N/I	N/I	N/I	N/I	5.4.14, 6.5.14
	B3. Producers can use treated sewage water if it meets appropriate standards (e.g. NZWWA guidelines, WHO guidelines)	3.2.1	N/I	N/I	N/I	N/I	N/I	N/I	N/I	N/I	Not applicable: None permitted (5.4.14, 6.5.14)
QUALITY	B4. Producers should prevent or minimise contamination to their source waters	3.2.1.1	N/I	N/I	N/I	N/I	4.5.1	N/I	N/I	N/I	Management plan
	B5. Producers should evaluate the food safety risks associated with the water * = evaluation guidelines are given	3.2.1	N/I	Criterion 95	N/I	N/I	N/I	N/I	N/I	N/I	N/I
	B6. Producers should test the microbial quality of the water if necessary (or obtain test results from supplier) * = microbial standards are specified	3.2.1.1	N/I	N/I	*AF1.2.1	N/I	N/I	N/I	N/I	N/I	N/I
	B7. Producers should test the chemical quality of the water if necessary (or obtain test results from supplier) * = chemical standards are specified	3.2.1.1	N/I	N/I	N/I	N/I	N/I	N/I	N/I	N/I	N/I
	B8. Producers should take corrective action to address any contamination at, or after, water uptake from source (e.g. treatment)	3.2.1.1	N/I	Criterion 95	N/I	N/I	N/I	N/I	N/I	N/I	N/I
	B9. Producers should control and monitor the effectiveness of any water treatment	N/I	N/I	Criterion 95	N/I	N/I	N/I	N/I	N/I	N/I	N/I
	B10. Producers should control and monitor the water temperature	N/I	Section C5.1	Section G6.1	N/I	N/I	N/I	N/I	N/I	N/I	N/I
RECORDS	B11. Producers should maintain records of water quality (e.g. *E. coli* concentration, treatments)	5.7	N/I	Criterion 95	N/I	N/I	N/I	N/I	N/I	N/I	N/I

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK

Table 12C: WATER FOR IRRIGATION (OUTDOOR OR INDOOR NON-HYDROPONIC GROWING SYSTEMS)											
GENERIC CRITERIA		CAC/RCP 53-2003	New Zealand GAP	NZ GAP (GLOBALGAP)	GLOBALG.A.P.	SQF	NZS 8410	NZFSA OOAP	BioGro	AsureQuality	Demeter
SOURCE	C1. Producers should consider whether the water sources are suitable for their intended use	3.2.1.1, 3.2.2.2	Section C5.1, Criterion 73	Section G6.1	CB6.3.2, AF1.2.1, AF1.2.2	5.4.1.1 (SQF1000)	4.5.2	N/I	3.2.2, Appendix B	N/I	Farm profile template
	C2. Producers must not use untreated sewage water or any sewage water	N/I	N/I	Criterion 97	CB6.3.1	N/I	N/I	N/I	N/I	N/I	5.4.14, 6.5.14
	C3. Producers can use treated sewage water if it meets appropriate standards (e.g. NZWWA guidelines, WHO guidelines)	3.2.1.1	N/I	N/I	CB6.3.1	N/I	N/I	N/I	N/I	N/I	Not applicable: None permitted (5.4.14, 6.5.14)
QUALITY	C4. Producers should prevent or minimise contamination to their source waters	3.2.1.1, 3.2.2.2	N/I	N/I	N/I	N/I	4.5.1	N/I	N/I	N/I	Management plan
	C5. Producers should evaluate the food safety risks associated with the water * = evaluation guidelines are given	3.2.1, 3.2.1.1.1	*Criterion 73, Section C5.1.2	*Criterion 95, Section G6.1	*CB6.3.2	5.4.1.1 (SQF1000)	N/I	N/I	N/I	N/I	N/I
	C6. Producers should test the microbial quality of the water if necessary (or obtain test results from supplier) * = microbial standards are specified	3.2.1.1	N/I	N/I	*AF1.2.1 *CB6.3.3, CB6.3.4, CB6.3.5(R)	*5.4.1.1, 5.4.2.1 (SQF1000)	N/I	N/I	N/I	N/I	N/I
	C7. Producers should test the chemical quality of the water if necessary (or obtain test results from supplier) * = chemical standards are specified	3.2.1.1	N/I	N/I	CB6.3.3, CB6.3.5(R)	5.4.1.1 (SQF1000)	N/I	N/I	3.2.2, 3.2.3, *Appendix A	N/I	N/I
	C8. Producers should take corrective action to address any contamination at, or after, water uptake from source (e.g. treatment)	3.2.1.1	Criterion 73	Criterion 95	CB6.3.6	5.4.2.1 (SQF1000)	N/I	N/I	N/I	N/I	N/I
	C9. Producers should control and monitor the effectiveness of any water treatment	N/I	Criterion 73	Criterion 95	N/I	N/I	N/I	N/I	N/I	N/I	N/I
	C10. Producers should control and monitor the water temperature	N/I	Section C5.1	Section G6.1	N/I	N/I	N/I	N/I	N/I	N/I	N/I
APPLICATION	C11. Producers should base the application of water on the water requirements of the soil or crops, or specialist advice	N/I	Criterion 74(R)	Criterion 69(R), Criterion 70	CB6.1.1(R), CB6.2.1, CB6.2.2(R)	N/I	4.5.1	N/I	3.2.3, Appendix B	N/I	N/I
	C12. Producers should minimise contact between the water and the produce	N/I	Criterion 73	Section G6.1	N/I	N/I	N/I	N/I	N/I	N/I	N/I
	C13. Producers should maximise the time between final irrigation and harvest (e.g. >48 hours)	N/I	Criterion 73	Section G6.1	N/I	N/I	N/I	N/I	N/I	N/I	N/I
	C14. Producers should maintain water delivery systems	3.2.2.2	N/I	N/I	CB9.1, CB9.2	N/I	N/I	N/I	Appendix B	N/I	N/I
RECORDS	C15. Producers should maintain records of water quality (e.g. *E. coli* concentration, treatments)	5.7, Table B	N/I	Criterion 95	N/I	N/I	N/I	N/I	N/I	N/I	N/I
	C16. Producers should maintain records of water application (e.g. date applied, amount applied, where applied, how applied)	5.7	N/I	Criterion 69(R)	CB6.2.3(R)	N/I	N/I	N/I	N/I	N/I	N/I

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK

Table 12D: WATER FOR HYDROPONIC GROWING SYSTEMS

	GENERIC CRITERIA	CAC/RCP 53-2003	New Zealand GAP	NZ GAP (GLOBALGAP)	GLOBALG.A.P.	SQF	NZS 8410	NZFSA OOAP	BioGro	AsureQuality	Demeter
SOURCE	D1. Producers should consider whether the water sources are suitable for their intended use: Potable water should be available	3.2.1.1, 3.2.2.2	Section C5.1, Criterion 73	Section G6.1	CB6.3.2, AF1.2.1, AF1.2.2	N/I					
	D2. Producers must not use untreated sewage water or any sewage water	N/I	N/I	Criterion 97	CB6.3.1	N/I					
	D3. Producers can use treated sewage water if it meets appropriate standards (e.g. NZWWA guidelines, WHO guidelines)	3.2.1	N/I	N/I	CB6.3.1	N/I					
QUALITY	D4. Producers should prevent or minimise contamination to their source waters	3.2.1.1, 3.2.2.2	N/I	N/I	N/I	N/I					
	D5. Producers should evaluate the food safety risks associated with the water * = evaluation guidelines are given	3.2.1	*Criterion 73, Section C5.1.1	Criterion 95, Section G6.1	*CB6.3.2	N/I					
	D6. Producers should test the microbial quality of the water if necessary (or obtain test results from supplier) * = microbial standards are specified	3.2.1.1	*Criterion 73	N/I	*AF1.2.1 *CB6.3.3, CB6.3.4, CB6.3.5(R)	N/I					
	D7. Producers should test the chemical quality of the water if necessary (or obtain test results from supplier) * = chemical standards are specified	3.2.1.1	N/I	N/I	CB6.3.3, CB6.3.5(R)	N/I					
	D8. Producers should take corrective action to address any contamination at, or after, water uptake from source (e.g. treatment)	3.2.1.1	Criterion 73	Criterion 95	CB6.3.6	N/I	(NOT APPLICABLE – HYDROPONIC PRODUCTION IS PROHIBITED)				
	D9. Producers should control and monitor the effectiveness of any water treatment	N/I	Criterion 73	Criterion 95	N/I	N/I					
	D10. Producers should control and monitor the water temperature	N/I	Section C5.1	Section G6.1	N/I	N/I					
	D11. Producers should control and monitor the quality of water in recirculated water/fertigation systems	3.2.2.2, 3.2.1.1.3	Criterion 73, Section C5.1.1	N/I	N/I	N/I					
APPLICATION	D12. Producers should base the application of water on the water requirements (and nutrient requirements) of the crops, or specialist advice	N/I	N/I	N/I	CB6.1.1(R), CB6.2.1, CB6.2.2(R)	N/I					
	D13. Producers should minimise contact between the water and the produce	N/I	N/I	N/I	N/I	N/I					
	D14. Producers should maximise the time between final irrigation and harvest (e.g. >48 hours)	N/I	N/I	N/I	N/I	N/I					
	D15. Producers should maintain water delivery systems	3.2.2.2, 3.2.1.1.3	N/I	N/I	CB9.1, CB9.2	N/I					
RECORDS	D16. Producers should maintain records of water quality (e.g. *E. coli* concentration, treatments)	5.7	Criterion 73	Criterion 95	N/I	N/I					
	D17. Producers should maintain records of water application (e.g. date applied, amount applied, where applied, how applied)	N/I	N/I	N/I	CB5.3.1, CB6.2.3(R)	N/I					

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK

Table 12E: WATER FOR AGRICULTURAL CHEMICALS											
GENERIC CRITERIA		CAC/RCP 53-2003	New Zealand GAP	NZ GAP (GLOBALGAP)	GLOBALG.A.P.	SQF	NZS 8410	NZFSA OOAP	BioGro	AsureQuality	Demeter
SOURCE	E1. Producers should consider whether the water sources are suitable for their intended use	3.2.1.1	Section C5.1	Section G6.1	AF1.2.1, AF1.2.2, FV3.1.1	N/I	4.5.2	N/I	N/I	N/I	Farm profile template
	E2. Producers must not use untreated sewage water or any sewage water	N/I	N/I	Criterion 97	N/I	N/I	N/I	N/I	N/I	N/I	5.4.14, 6.5.14
	E3. Producers can use treated sewage water if it meets appropriate standards (e.g. NZWWA guidelines, WHO guidelines)	3.2.1	N/I	N/I	N/I	N/I	N/I	N/I	N/I	N/I	Not applicable: None permitted (5.4.14, 6.5.14)
QUALITY	E4. Producers should prevent or minimise contamination to their source waters	3.2.1.1	N/I	N/I	N/I	N/I	4.5.1	N/I	N/I	N/I	Management plan
	E5. Producers should evaluate the food safety risks associated with the water * = evaluation guidelines are given	3.2.1, 3.2.1.1.2	N/I	Criterion 95, Section G6.1	FV3.1.1	N/I	N/I	N/I	N/I	N/I	N/I
	E6. Producers should test the microbial quality of the water if necessary (or obtain test results from supplier) * = microbial standards are specified	3.2.1.1	N/I	N/I	*AF1.2.1	N/I	N/I	N/I	N/I	N/I	N/I
	E7. Producers should test the chemical quality of the water if necessary (or obtain test results from supplier) * = chemical standards are specified	3.2.1.1	N/I	N/I	N/I	N/I	N/I	N/I	N/I	N/I	N/I
	E8. Producers should take corrective action to address any contamination at, or after, water uptake from source (e.g. treatment)	3.2.1.1	N/I	Criterion 95	FV3.1.1	N/I	N/I	N/I	N/I	N/I	N/I
	E9. Producers should control and monitor the effectiveness of any water treatment	N/I	N/I	Criterion 95	N/I	N/I	N/I	N/I	N/I	N/I	N/I
	E10. Producers should control and monitor the water temperature	N/I	Section C5.1	Section G6.1	N/I	N/I	N/I	N/I	N/I	N/I	N/I
RECORDS	E11. Producers should maintain records of the quality of the water used for agricultural chemicals (e.g. *E. coli* concentration, treatments)	5.7	N/I	Criterion 95	N/I	N/I	N/I	N/I	N/I	N/I	N/I

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK

Table 12F: WATER FOR POST-HARVEST PROCESSES

	GENERIC CRITERIA	CAC/RCP 53-2003	New Zealand GAP	NZ GAP (GLOBALGAP)	GLOBALG.A.P.	SQF	NZS 8410	NZFSA OOAP	BioGro	AsureQuality	Demeter
SOURCE	F1. Producers should consider whether the water sources are suitable for their intended use	5.2.2.1, 4	Section D3.1	Section H6.1	AF1.2.1, AF1.2.2	5.3.1.1 (SQF2000)	N/I	N/I	N/I	N/I	Farm profile template
QUALITY	F2. Producers should prevent or minimise contamination to their source waters	5.2.2.1	N/I	N/I	N/I	5.3.2.1 (SQF2000)	N/I	N/I	N/I	N/I	Management plan
	F3. Producers should evaluate the food safety risks associated with the water * = evaluation guidelines are given	5.2.2.1	*Criterion 73, Section D3.1	*Criterion 96, Section H6.1	N/I	6.9.2.1 (SQF1000)	N/I	N/I	N/I	N/I	N/I
	F4. Producers should test the microbial quality of the water if necessary (or obtain test results from supplier) * = microbial standards are specified	N/I	*Criterion 73	*Criterion 96	*AF1.2.1, *FV5.7.1, FV5.7.3, *FV5.8.5, *CC5.3.6	5.7.1.5, 6.9.2.1 (SQF1000), 6.8.3.1, 6.8.3.2 (SQF2000)	N/I	N/I	4.2.2	N/I	N/I
	F5. Producers should test the chemical quality of the water if necessary (or obtain test results from supplier) * = chemical standards are specified	N/I	N/I	N/I	FV5.7.1, FV5.7.3, FV5.8.5, CC5.3.6	5.7.1.5 (SQF1000)	N/I	N/I	4.2.2	N/I	N/I
	F6. Producers should take corrective action to address any contamination at, or after, water uptake from source (e.g. treatment)	5.2.2.1	Section D3.1	Criterion 96	N/I	6.9.3.1 (SQF1000)	N/I	N/I	N/I	N/I	N/I
	F7. Producers should control and monitor the effectiveness of any water treatment	5.2.2.1	Criterion 73	Criterion 96	N/I	5.7.5.2 (SQF1000), 6.8.2.2, 6.8.3.1 (SQF2000)	N/I	N/I	N/I	N/I	N/I
	F8. Producers should control and monitor the temperature of the water	5.2.2.1	Section D3.1	Section H6.1	N/I	5.7.5.2 (SQF1000)	N/I	N/I	N/I	N/I	N/I
	F9. Producers should control and monitor the quality of water in recirculated water systems	5.2.2.1	N/I	Section H6.1	FV5.7.2	5.7.5.2 (SQF1000)	N/I	N/I	N/I	N/I	N/I
APPLICATION	F10. Producers should base the application of water on the requirements of the crops, or specialist advice	N/I	N/I	N/I	N/I	N/I	N/I	N/I	N/I	N/I	N/I
	F11. Producers should minimise contact between water and produce	N/I	N/I	N/I	N/I	N/I	N/I	N/I	N/I	N/I	N/I
	F12. Producers should use potable water wherever water comes into contact with produce, or for any final rinsing steps	5.2.2.1, 5.5	Criterion 73	Criterion 96	FV4.1.12, FV5.7.1, FV5.8.5, CC5.3.6	5.7.1.5, 6.9.1.1 (SQF1000), 5.3.1.1, 6.8.1.1 (SQF2000)	10.4.1, Table E1	8.2.2	3.6.3, 4.2.2, Appendix C	6.2.1, 6.2.7, 6.6.2, Table 3 (Section 10)	1.3.1.1, 2.3.1.1 (Part B-I, fruit & vegetables), 1 (Part B-V, herbs & spices)
	F13. Producers should use potable water in cooling systems wherever water comes into contact with produce (e.g. ice, spray coolers)	5.2.2.1, 5.2.2.3	N/I	N/I	FV4.1.12	5.3.3.1 (SQF2000), 6.8.1.1, 6.9.4.1 (SQF1000)	10.4.1, Table E1	8.2.2	4.2.2, Appendix C	Table 3 (Section 10)	N/I
	F14. Producers should minimise water on the produce before packing	N/I	N/I	N/I	N/I	N/I	N/I	N/I	N/I	N/I	1 (Part B-V, herbs & spices)
	F15. Producers should maintain water delivery systems	N/I	N/I	N/I	N/I	5.7.4.6 (SQF1000)	N/I	N/I	N/I	N/I	N/I
RECORDS	F16. Producers should maintain records of water quality (e.g. *E. coli* concentration, treatments)	N/I	Criterion 73	Criterion 96	N/I	5.7.1.5 (SQF1000)	N/I	9.1.6	4.2.2	N/I	N/I
	F17. Producers should maintain records of water use (e.g. date applied, amount applied, how applied)	N/I	N/I	N/I	N/I	N/I	N/I	9.1.6	N/I	N/I	N/I

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK

6 REFERENCES

BioGro (2009) BioGro compost guideline. BioGro New Zealand.

BRC (2008) Global standard for food safety. British Retail Consortium. Available at: http://www.brcglobalstandards.com. Accessed 20 May 2011.

CAC (2003) Recommended international code of practice general principles of food hygiene (CAC/RCP 1-1969, Rev. 4-2003). Codex Alimentarius Commission. Available at: http://www.codexalimentarius.net/web/standard_list.jsp. Accessed 20 May 2011.

Fert Research (2007) Code of practice for nutrient management. New Zealand Fertiliser Manufacturers Research Association Available at: http://www.fertresearch.org.nz/code-of-practice. Accessed 18 April 2011.

FFNZ (2000) Code of practice for the sale of fertiliser in New Zealand. The Fertmark code of practice: Fertmark application form. Federated Farmers of New Zealand Inc.

FFNZ (2006) Code of practice for the sale of fertiliser in New Zealand. The Fertmark code of practice: Fertmark product classifications. Federated Farmers of New Zealand Inc.

FSANZ (2001a) Guidelines for the microbiological examination of ready-to-eat foods. Food Safety Australia New Zealand. Available at: http://www.foodstandards.gov.au/scienceandeducation/publications/guidelinesformicrobi1306.cfm. Accessed 18 April 2011.

FSANZ (2001b) Microbiological Limits for Foods. Guide to Standard 1.6.1 - Microbiological Limits for Food with additional guideline criteria. Food Standards Australia New Zealand. Available at: http://www.foodstandards.gov.au/foodstandards/userguides/microbiologicallimit1410.cfm. Accessed 18 April 2011.

GlobalGAP (2011) GlobalGAP General Regulations. Part 1: General rules. Version 4.0. GLOBALG.A.P c/o FoodPLUS GmbH. Available at: http://www.globalgap.org. Accessed 20 April 2011.

Gravani R (2009).The role of good agricultural practices in produce safety. In: Microbial safety of fresh produce, Ed: X. Fan, B. Niemira, C. Doona, F. Feeherry and R. Gravani, 101-117. Wiley-Blackwell: Iowa.

HortNZ (2009) New Zealand GAP Manual. Version 5.0. Horticulture New Zealand.

IFOAM (2005) The IFOAM norms for organic production and processing. International Federation of Organic Agriculture Movements. Available at: http://www.ifoam.org/about_ifoam/standards/norms.html. Accessed 20 May 2011.

IFOAM (2010) Organic Guarantee System (OGS) 2010 Revision. Electronic Membership vote 18th July 2010. International Federation of Organic Agriculture Movements. Available at: http://www.ifoam.org/about_ifoam/standards/pdfs/IFOAM_OGS_2010_Public.pdf. Accessed 20 May 2011.

LEAF (2010) LEAF Marque Global Standard. Version 9.0. LEAF Marque Ltd. Available at: http://www.leafuk.org/leaf/farmers/LEAFmarquecertification/standard.eb. Accessed 20 April 2011.

MAFF (2009) Japanese agricultural standard for organic plants. Ministry of Agriculture, Forestry and Fisheries. Available at: http://www.maff.go.jp/e/jas/specific/criteria_o.html. Accessed 20 May 2011.

MoH (1995) Microbiological reference criteria for food. Ministry of Health. Available at: http://www.foodsafety.govt.nz/elibrary/industry/Microbiological_Reference-Guide_Assess.pdf. Accessed 18 April 2011.

MoH (2008) Drinking-water Standards for New Zealand 2005 (Revised 2008). Ministry of Health. Available at: http://www.moh.govt.nz/moh.nsf/pagesmh/8534. Accessed 20 May 2011.

NZLTC (2000) New Zealand guidelines for utilisation of sewage effluent on land. Part 2: Issues for design and management. Ed: LJ Whitehouse, H Wang and M Tomer. New Zealand Land Treatment Collective and Forest Research.

Robb C and Barkle G (2000) New Zealand guidelines for utilisation of sewage effluent on land. Part 1: The design process. Ed: LJ Whitehouse, H Wang and M Tomer. New Zealand Land Treatment Collective and Forest Research.

SQFI (2008) SQF 2000 code: A HACCP based supplier assurance code for the food industry. Safe Quality Food Institute (Food Marketing Institute). Available at: http://www.sqfi.com/documents/. Accessed 8 March 2011.

SQFI (2010a) The SQF program: A basic guide. Safe Quality Food Institute (Food Marketing Institute). Available at: http://www.sqfi.com. Accessed 8 March 2011.

SQFI (2010b) SQF program food sector categories. Safe Quality Food Institute (Food Marketing Institute). Available at: http://www.sqfi.com. Accessed 8 March 2011.

USFDA (1998) Guide to minimize microbial food safety hazards for fresh fruits and vegetables. US Department of Health and Human Services, Food and Drug Administration, and the Center for Food Safety and Applied Nutrition (CFSAN). Available at: http://www.fda.gov/downloads/Food/GuidanceComplianceRegulatoryInformation/GuidanceDocuments/ProduceandPlanProducts/UCM169112.pdf. Accessed 20 May 2011.

WHO (2006) Guidelines for the safe use of wastewater, excreta and greywater. Volume 2: Wastewater use in agriculture. World Health Organization. Available at: http://www.who.int/water_sanitation_health/wastewater/gsuww/en/index.html. Accessed 20 May 2011.

7 APPENDIX 1: ALIGNMENT OF ASSURANCE PROGRAMMES FOR CONVENTIONAL PRODUCTION

Table 12 (Section 5) presents an alignment of the CAC *Code of Hygienic Practice for Fresh Fruits and Vegetables*, the New Zealand Standard for Organic Production (NZS 8410:2003) and eight assurance programmes against generic criteria, using criterion or section numbers. This Appendix and Appendix 2 support Table 12 by presenting the text of each criterion or section from the documents that were assessed.

This Appendix presents the text from the CAC code and four assurance programmes applicable to conventional production:

- New Zealand GAP
- New Zealand GAP (GLOBALG.A.P. Equivalent)
- GLOBALG.A.P.
- Safe Quality Food.

Appendix 2 presents the text from the organic standard and four assurance programmes applicable to organic production.

The text is summarised in six tables:

Table A:	Natural fertilisers.
Table B:	Water for primary production. The information is relevant to all water used for primary production, irrespective of the purpose of the water (e.g. irrigation, hydroponics, sprays). Tables C-E refer to the information in Table B, where relevant.
Table C:	Water for irrigation (outdoor or indoor non-hydroponic growing systems).
Table D:	Water for hydroponic growing systems.
Table E:	Water for agricultural chemicals. This includes water used for mixing or diluting liquid organic preparations, e.g. compost teas, seaweed preparations.
Table F:	Water for post-harvest processes.

In these tables:

- N/I (Not Included) marks where there is no requirement or recommendation presented in the document for a generic criterion.
- Some of the text may be abbreviated to present only the relevant information (e.g. where a document lists several bullet points, only those relevant to the criterion are presented).
- Where a piece of text from a document aligns against several generic criteria, the document text is only reproduced against one generic criterion; the other relevant generic criteria will contain a reference to the generic criterion where the text has been located.
- Italicised text has been used by the authors of this report for any summaries or commentary.

Furthermore, each table is preceded by any additional information relating to the table including any numbered footnotes relating to the table.

The text presented in Tables A-F in this Appendix has been extracted from the following documents:

1. CAC Code of Hygienic Practice for Fresh Fruits and Vegetables (CAC/RCP 53-2003)

Documents reviewed:

- Code of Hygienic Practice for Fresh Fruits and Vegetables (CAC/RCP 53-2003)
- Recommended International Code of Practice – General Principles of Food Hygiene (CAC/RCP 1-1969, Rev.4-2003)

Notes: CAC/RCP 53-2003 is intended to be read in conjunction with the CAC/RCP 1-1969. Where applicable, the relevant text from CAC/RCP 1-1969, Rev.4-2003 has been included as footnotes to the following tables.

CAC/RCP 53-2003 includes two annexes that present additional recommendations for ready-to-eat fresh pre-cut fruits and vegetables and for sprout production. The information in these annexes has not been included in the following tables.

2. New Zealand GAP

Documents reviewed:

- New Zealand GAP Manual, November 2009 Version 5.0 (incorporating Sections G and H which list the New Zealand GAP (GLOBALG.A.P. Equivalent) requirements).
- New Zealand GAP Assessment (November 2009)

Notes: The New Zealand GAP programme has a set of criteria that is assessed as part of certification, but the manual also contains additional advice on how to meet these criteria. These have been identified separately in the tables as 'criterion' or the section number of the manual where the additional information can be found.

While compliance with most criteria is compulsory for accreditation, some of the criteria are recommendations and compliance is not mandatory for accreditation. An (R) signals the recommendations.

3. New Zealand GAP (GLOBALG.A.P. Equivalent)

Documents reviewed:

- New Zealand GAP Manual, November 2009 Version 5.0 (incorporating Sections G and H which list the New Zealand GAP (GLOBALG.A.P. Equivalent) requirements).
- New Zealand GAP (GLOBALG.A.P. Equivalent) Assessment (May 2009)

Notes: As above for New Zealand GAP.

4. GLOBALG.A.P.

Documents reviewed:

- Control points and compliance criteria. Integrated Farm Assurance. All Farm Base (Final Version 4.0_Mar2011, valid from 1 March 2011)
- Control points and compliance criteria. Integrated Farm Assurance. Crops Base (Final Version 4.0_Mar2011, valid from 1 March 2011)
- Control points and compliance criteria. Integrated Farm Assurance. Fruit and Vegetables (Final Version 4.0_Mar2011, valid from 1 March 2011)
- Control points and compliance criteria. Integrated Farm Assurance. Combinable Crops (Final Version 4.0_Mar2011, valid from 1 March 2011)

Notes: The compliance criteria numbers begin with the letters AF (All Farm base), CB (Crops Base), FV (Fruit and Vegetables) or CC (Combinable Crops).

While compliance with most criteria is compulsory for accreditation, some of the criteria are recommendations and compliance is not mandatory for accreditation. An (R) signals the recommendations.

5. <u>Safe Quality Food (SQF)</u>

Documents reviewed:

- SQF 1000 Code (5th edition, January 2010)
- SQF 2000 Code (6th edition, August 2008)
- SQF 2000 Guidance. Guidance for Food Sector Category 4 – Fresh Produce Pack House Operations (6th edition, 2008)

Notes: The SQF 1000 Code is applicable to primary producers and their own packhouses. The SQF 1000 and the SQF 2000 Codes are both applicable to commercial packhouses, i.e. those that pack produce from multiple growers. The SQF 2000 Code is also applicable to organic fertiliser manufacturers.

Sections 5 and 6 of these documents contain information specific to natural fertilisers and water, which have been listed in the following tables.

TABLE A: NATURAL FERTILISERS

Footnotes for Table A:

1. CAC/RCP 53-2003: Definition of contaminant from CAC/RCP 1-1969, Rev 3 (1997): "Any biological or chemical agent, foreign matter, or other substances not intentionally added to food which may compromise food safety or suitability."
2. New Zealand GAP: Questions in decision diagram:
   What type of fertiliser is used? (non organic, non animal = Risk not significant)
   ↳Organic, animal: Can the fertiliser product contact the edible part of the crop either directly or indirectly through soil contact? (No = Risk not significant)
   ↳Yes: Is the fertiliser applied shortly before harvest? (Yes = Best Management practices required to minimise risk)
   ↳No: Is the product normally washed and/or peeled and/or cooked adequately before it is consumed? (Yes = Risk not significant; No/Unsure = Best Management practices required to minimise risk.
3. New Zealand GAP (GLOBALG.A.P. Equivalent): Questions in decision diagram:
   What type of fertiliser is used? (non organic, non animal = Risk not significant)
   ↳Organic, animal: Can the fertiliser product contact the edible part of the crop either directly or indirectly through soil contact? (No = Risk not significant)
   ↳Yes: Is the product normally washed and/or peeled and/or cooked adequately before it is consumed? (Yes = Risk not significant; No/Unsure = Best Management practices required to minimise risk.
4. New Zealand GAP (GLOBALG.A.P. Equivalent): Section B covers management responsibility, health and safety, training, purchasing, complaints and records. Section E covers contractors.

Table A: NATURAL FERTILISERS							
GENERIC CRITERIA		CAC/RCP 53-2003	New Zealand GAP	NZ GAP (GLOBALGAP)	GLOBALG.A.P.	SQF
SOURCE	A1. Producers must only use fertilisers certified to, or specified by, a specific programme or standard (e.g. organic standard, Fertmark)	N/I	Criterion 43(R) Fertiliser should be purchased from companies with the Fertmark product registration.	N/I	N/I	N/I
SOURCE	A2. Producers must not use untreated human sewage sludge or any human sewage sludge	3.2.1 (A4, below)	N/I	Criterion 34 Human sewage sludge shall not be used.	CB5.5.1 Has the use of human sewage sludge been banned on the farm? Compliance: No human sewage sludge is used on the farm for the production of GLOBALG.A.P. registered crops.	N/I
SOURCE	A3. Producers can use treated human sewage sludge if it meets appropriate standards (e.g. NZWWA guidelines, WHO guidelines)	3.2.1 (A4, below)	N/I	Not applicable *(Criterion 34 (A2, above): No human sewage sludge is permitted)*	Not applicable *(CB5.5.1 (A2, above): No human sewage sludge is permitted)*	N/I
QUALITY	A4. Producers should evaluate the food safety risks associated with the fertiliser	3.2.1 Agricultural input requirements Agricultural inputs should not contain microbial or chemical contaminants (as defined under the Recommended International Code of Practice – General Principles of Food Hygiene (CAC/RCP 1-1969, Rev 3 (1997)[1]) at levels that may adversely affect the safety of fresh fruits and vegetables and taking into consideration the WHO guidelines on the safe use of wastewater and excreta in agriculture and aquaculture as appropriate. 3.2.1.2 Manure, biosolids and other natural fertilizers The use of manure, biosolids and other natural fertilizers in the production of fresh fruits and vegetables should be managed to limit the potential for microbial, chemical and physical contamination. Manure, biosolids and other natural fertilizers contaminated with heavy metals or other chemicals at levels that may affect the safety of fresh fruits and vegetables should not be used.	Criterion 40 Growers shall evaluate the risks associated with animal manure and other natural fertilisers using the decision diagram below and act on the results of the evaluation.[2] Section C3.1 Animal manures and natural fertilisers The use of manure, biosolids and other natural fertilisers in the production of fresh fruits and vegetables should be managed to limit the potential for microbial, chemical and physical contamination. Manure, biosolids and other organic fertilisers contaminated with heavy metals or other chemicals at levels that may affect the safety of fresh fruits and vegetables should not be used.	Criterion 33 Growers shall evaluate the risks associated with animal manure and other natural fertilisers using the decision diagram below .[3] Section G3.3 Fertiliser The use of manure, biosolids and other natural fertilisers in the production of fresh fruits and vegetables should be managed to limit the potential for microbial, chemical and physical contamination. Manure, biosolids and other organic fertilisers contaminated with heavy metals or other chemicals at levels that may affect the safety of fresh fruits and vegetables should not be used.	CB5.5.2 Has a risk assessment been carried out for organic fertiliser which, prior to application, considers its source, characteristics and intended use? Compliance: Documentary evidence is available to demonstrate that at least the following potential risks have been considered: type of organic fertiliser, method of composting, weed/seed content, heavy metal content, timing of application, and placement of organic fertiliser (e.g. direct contact to edible part of crop, ground between crops, etc.). This also applies to substrates from biogas plants. See Annex CB.1 Microbiological Hazards. *(Annex contains evaluation guidelines)*	6.13.1.2 (SQF1000) A soil amendment protocol shall outline: The methods used to treat manure and other untreated organic fertilizers ensuring: i. The treatment methods applied inactivate pathogens in organic soil amendments; ii. A hazard analysis or organic soil amendments treatment methods is conducted before use; iii. Treatment methods are validated and treatments of organic soil amendments are verified as being in compliance with the method applied; iv. Records of the validation and verification of organic soil amendment treatments are maintained.
QUALITY	A5. Producers should test the microbial quality of the fertiliser if necessary (or obtain test results from supplier)	3.2.1.2 (A4, above), which continues: Where necessary, in order to minimize microbial contamination the following practices should be considered: • Growers who are purchasing manure, biosolids and other natural fertilizers that have been treated to reduce microbial or chemical contaminants, should, where possible, obtain	Section C3.1 (A4, above), which continues: Where necessary, in order to minimise microbial contamination the following best management practices should be considered: • Growers who are purchasing manure, biosolids and other organic fertilisers that have been treated to reduce	Section G3.3 (A4, above), which continues: Where necessary, in order to minimise microbial contamination the following best management practices should be considered: • Growers who are purchasing manure, biosolids and other organic fertilisers that have been treated to reduce	N/I	N/I

Table A: NATURAL FERTILISERS

GENERIC CRITERIA		CAC/RCP 53-2003	New Zealand GAP	NZ GAP (GLOBALGAP)	GLOBALG.A.P.	SQF
		documentation from the supplier that identifies the origin, treatment used, tests performed and the results thereof.	microbial or chemical contaminants, should, where possible, obtain documentation from the supplier that identifies the origin, treatment used, tests performed and the respective results. An example is pellatised manure.	microbial or chemical contaminants, should, where possible, obtain documentation from the supplier that identifies the origin, treatment used, tests performed and the respective results. An example is pellatised manure.		
	A6. Producers should test the chemical quality of the fertiliser if necessary (or obtain test results from supplier)	3.2.1.2 (A4, above), which continues: Where necessary, in order to minimize microbial contamination the following practices should be considered: • Growers who are purchasing manure, biosolids and other natural fertilizers that have been treated to reduce microbial or chemical contaminants, should, where possible, obtain documentation from the supplier that identifies the origin, treatment used, tests performed and the results thereof.	Section C3.1 (A4, above), which continues: Where necessary, in order to minimise microbial contamination the following best management practices should be considered: • Growers who are purchasing manure, biosolids and other organic fertilisers that have been treated to reduce microbial or chemical contaminants, should, where possible, obtain documentation from the supplier that identifies the origin, treatment used, tests performed and the respective results. An example is pellatised manure.	Section G3.3 (A4, above), which continues: Where necessary, in order to minimise microbial contamination the following best management practices should be considered: • Growers who are purchasing manure, biosolids and other organic fertilisers that have been treated to reduce microbial or chemical contaminants, should, where possible, obtain documentation from the supplier that identifies the origin, treatment used, tests performed and the respective results. An example is pellatised manure.	N/I	N/I
	A7. Producers should (or must) use treated fertiliser (e.g. pasteurised, composted)	3.2.1.2 (A4, above), which continues: Where necessary, in order to minimize microbial contamination the following practices should be considered: • Adopt proper treatment procedures (e.g. composting, pasteurization, heat drying, UV irradiation, alkali digestion, sun drying or combinations of these) that are designed to reduce or eliminate pathogens in manure, biosolids and other natural fertilizers. The level of pathogen reduction achieved by different treatments should be taken into account when considering suitability for different applications.	Section C3.1 A4, above), which continues: Where necessary, in order to minimise microbial contamination the following best management practices should be considered: • Adopt proper treatment procedures (e.g. composting, heat drying) that are designed to reduce or eliminate pathogens in manure, biosolids and other organic fertilisers.	Section G3.3 (A4, above), which continues: Where necessary, in order to minimise microbial contamination the following best management practices should be considered: • Adopt proper treatment procedures (e.g. composting, heat drying) that are designed to reduce or eliminate pathogens in manure, biosolids and other organic fertilisers.	N/I	6.13.1.1 (SQF1000) No raw untreated manure shall be used. Soil amendment treatment and application methods shall be documented and implemented and designed to prevent contamination of product.
APPLICATION	A8. Producers should base the application of natural fertilisers on the nutritional requirements of the soil or crops and the nutritional content of the fertiliser, or specialist advice	N/I	Criterion 41(R) A nutrient management plan should be in place for the use and application of fertiliser. The *Code of Practice for Nutrient Management* should be used to develop the nutrient management plan. Criterion 42 Where your regional council plan requires compliance with New Zealand GAP for the use and application of fertiliser, a nutrient management plan shall be in place. Where a regional council plan requires compliance with New Zealand GAP, the *Code of Practice*	Criterion 26 If advice on fertiliser application is obtained from a Consultant, the Consultant shall comply with the requirements set down in Section B of this manual.[4] Criterion 27 If advice is not obtained from a consultant, growers shall comply with the relevant sections of the *Code of Practice for Nutrient Management*. Criterion 28 A nutrient management plan shall be in	CB5.1.1 Is the application of all fertilisers done according to the specific needs of the crop and soil condition? Compliance: Producer must demonstrate that consideration has been given to nutritional needs of the crop and soil fertility. Records of analyses and/or other crop-specific literature must be available as evidence. CB5.2.1 Are recommendations for application of fertilisers (organic or inorganic) given by competent, qualified persons?	6.13.1.3 (SQF1000) A soil amendment protocol shall outline: The methods to ensure organic soil amendment applications are timed to post minimum risk to product safety and human health including: i. All applications of soil amendments are in accordance with National or Local Guidelines, Best practices and Codes of Good Agricultural Practice.

Table A: NATURAL FERTILISERS						
GENERIC CRITERIA		CAC/RCP 53-2003	New Zealand GAP	NZ GAP (GLOBALGAP)	GLOBALG.A.P.	SQF
			for Nutrient Management or a relevant council approved code of practice shall be used to develop the nutrient management plan. Where the regional council plan has specific standards for the discharge of nutrients the nutrient management plan shall demonstrate that those standards can be met.	place for the use and application of fertiliser. This should include applicable soil, water and leaf tests from testing laboratories who can comply with the requirements set down in Section E of this manual.[4]	Compliance: Where the fertiliser records show that the technically responsible person making the choice of the fertiliser (organic or inorganic) is an external adviser, training and technical competence must be demonstrated via official qualifications, specific training courses, etc., unless employed for that purpose by a competent organisation (e.g. official advisory services). Where the fertilizer records show that the technically responsible person determining quantity and type of fertiliser (organic or inorganic) is the producer, experience must be complemented by technical knowledge (e.g. access to product technical literature, specific training course attendance, etc.) and/or the use of tools (software, on farm detection methods, etc.). CB5.5.3 Has account been taken of the nutrient contribution of organic fertiliser applications? Compliance: An analysis is carried out or recognized standard values are used, which takes into account the contents of N·P·K nutrients in organic fertiliser applied.	
	A9. Producers should minimise contact between the fertiliser and the produce	3.2.1.2 (A4, above), which continues: Where necessary, in order to minimize microbial contamination the following practices should be considered: • Minimize direct or indirect contact between manure, biosolids and other natural fertilizers, and fresh fruits and vegetables, especially close to harvest.	Criterion 40 (A4, above), from decision diagram:[2] … Can the fertiliser product contact the edible part of the crop either directly or indirectly through soil contact? Section C3.1 (A4, above), which continues: Where necessary, in order to minimise microbial contamination the following best management practices should be considered: • Use an application method or growing practice that minimises the chance of the organic fertiliser coming into contact with the edible part of the crop. • Incorporate the organic fertiliser into the soil to minimise contamination of the crop and adjoining crops, from wind drift or runoff.	Criterion 33 (A4, above), from decision diagram:[3] … Can the fertiliser product contact the edible part of the crop either directly or indirectly through soil contact? Section G3.3 (A4, above), which continues: Where necessary, in order to minimise microbial contamination the following best management practices should be considered: • Use an application method or growing practice that minimises the chance of the organic fertiliser coming into contact with the edible part of the crop. • Incorporate the organic fertiliser into the soil to minimise contamination of the crop and adjoining crops, from wind drift or runoff.	CB5.5.2 (A4, above) FV3.2.1 Is organic fertilizer incorporated into the soil prior to planting or bud burst (i.e. for tree crops) and not applied during the growing season? Compliance: Interval between application and harvest does not compromise food safety (see also CB 5.5.2). Fertiliser application and harvest records should show this.	N/I
	A10. Producers should maximise the time between final natural	3.2.1.2 (A4, above), which continues: Where necessary, in order to minimize	Criterion 40 (A4, above), from decision diagram:[2]	Section G3.3 (A4, above), which continues:	FV3.2.1 (A9, above)	N/I

Table A: NATURAL FERTILISERS					
GENERIC CRITERIA	**CAC/RCP 53-2003**	**New Zealand GAP**	**NZ GAP (GLOBALGAP)**	**GLOBALG.A.P.**	**SQF**
fertiliser application and harvest	microbial contamination the following practices should be considered: • Manure, biosolids and other natural fertilizers which are untreated or partially treated may be used only if appropriate corrective actions are being adopted to reduce microbial contaminants such as maximizing the time between application and harvest of fresh fruits and vegetables.	… Is the fertiliser applied shortly before harvest? Section C3.1 (A4, above), which continues: Where necessary, in order to minimise microbial contamination the following best management practices should be considered: • Maximise the period between when the organic fertiliser is applied and when the crop is harvested.	Where necessary, in order to minimise microbial contamination the following best management practices should be considered: • Maximise the period between when the organic fertiliser is applied and when the crop is harvested.		
A11. Producers should minimise contamination from natural fertilisers applied in adjoining areas	3.2.1.2 (A4, above), which continues: Where necessary, in order to minimize microbial contamination the following practices should be considered: • Minimize contamination by manure, biosolids and other natural fertilizers from adjoining fields. If the potential for contamination from the adjoining fields is identified, preventative actions (e.g. care during application and run-off controls) should be implemented to minimize the risk.	Section C3.1 (A4, above), and: Where necessary, in order to minimise microbial contamination the following best management practices should be considered: • Incorporate the organic fertiliser into the soil to minimise contamination of the crop and adjoining crops, from wind drift or runoff.	Section G3.3 (A4, above), and: Where necessary, in order to minimise microbial contamination the following best management practices should be considered: • Incorporate the organic fertiliser into the soil to minimise contamination of the crop and adjoining crops, from wind drift or runoff.	N/I	N/I
A12. Producers should maintain fertiliser application machinery	N/I	N/I	Criterion 120 Any equipment and machinery which requires calibration shall have records kept e.g. weighing equipment, fertiliser application equipment, thermometers, sprayers and chemical dispensers. Calibration shall be at least annual.	CB9.1 Are equipment sensitive to food safety and the environment (e.g. fertilizer spreaders, plant protection product sprayers, irrigation systems, equipment used for weighing and temperature control) routinely verified and, where applicable, calibrated at least annually? Compliance: The equipment is kept in a good state of repair with documented evidence of up-to-date maintenance sheets for all repairs, oil changes, etc. undertaken. For example: Fertiliser spreader: There must, as a minimum, be documented records stating that the verification of calibration has been carried out by a specialized company, supplier of fertilisation equipment or by the technically responsible person of the farm within the last 12 month. CB9.2(R) Is the producer involved in an independent calibration-certification scheme, where available? Compliance: The producer's involvement in a calibration scheme is documented.	6.13.1.3 (A8, above), which continues: A soil amendment protocol shall outline: The methods to ensure organic soil amendment applications are timed to post minimum risk to product safety and human health including: ii. Equipment used for soil amendment application is maintained in good condition and calibrated to ensure accurate application; iii. Records of all equipment maintenance and calibration are maintained;
A13. Producers should store natural fertilisers away from produce production areas	3.2.1.2 (A4, above), which continues: Where necessary, in order to minimize microbial contamination the following	Section C3.1 (A4, above), which continues: Where necessary, in order to minimise	Criterion 32 Fertilisers shall be stored physically separate from or segregated from	CB5.4.6 Are all fertilisers stored: Not together with harvested products?	5.5.7.1 (SQF1000) Soil amendments shall be stored separate from crop, field or irrigation

Table A: NATURAL FERTILISERS							
GENERIC CRITERIA		CAC/RCP 53-2003	New Zealand GAP	NZ GAP (GLOBALGAP)	GLOBALG.A.P.	SQF
		practices should be considered: • Avoid locating treatment or storage sites in proximity to fresh fruit and vegetable production areas. Prevent cross-contamination from runoff or leaching by securing areas where manure, biosolids and other natural fertilizers are treated and stored.	microbial contamination the following best management practices should be considered: • Avoid locating treatment or storage sites in proximity to fresh fruit and vegetable production areas. Prevent cross-contamination from runoff or leaching by securing areas where manure, biosolids and other organic fertilisers are treated and stored.	agrichemicals (except for packaged foliar nutrients) and produce. Section G3.3 (A4, above), which continues: Where necessary, in order to minimise microbial contamination the following best management practices should be considered: • Avoid locating treatment or storage sites in proximity to fresh fruit and vegetable production areas. Prevent cross-contamination from runoff or leaching by securing areas where manure, biosolids and other organic fertilisers are treated and stored.	Compliance: Fertilisers cannot be stored with harvested products.	water sources such that contamination from run off is avoided either by locating of the soil amendment a suitable distance from the crop or by the utilization of other physical barriers.
RECORDS	A14. Producers should maintain records of fertiliser source (e.g. name of supplier, type of product such as manure or vermicast)	5.7 Documentation and records Where appropriate, records of processing, production and distribution should be kept long enough to facilitate a recall and food borne illness investigation, if required. This period could be much longer than the shelf life of fresh fruits and vegetables. Documentation can enhance the credibility and effectiveness of the food safety control system. • Growers should keep current all relevant information on agricultural activities such as the site of production, suppliers' information on agricultural inputs, lot numbers of agricultural inputs, irrigation practices, use of agricultural chemicals, water quality data, pest control and cleaning schedules for indoor establishments, premises, facilities, equipment and containers.	Criterion 44 A system shall be in place for recording the application of animal manure and other natural fertilisers and inorganic fertiliser, nutrients and conditioners Criterion 45 The application recording system shall record the following: • purchase record for traceability • fertiliser type.	Criterion 30 Application recording system needs to include: • purchase record for traceability • fertiliser type.	CB5.3.3 Do records of all applications of soil and foliar fertilisers, both organic and inorganic, include the following criteria: Applied fertiliser types? Compliance: Detailed in the records of all fertiliser applications are the trade name, type of fertilizer (e.g. N, P, K), and concentrations (e.g. 17-17-17).	5.5.7.4 (SQF1000) An inventory of all organic and inorganic soil amendment storage and use shall be maintained.
	A15. Producers should maintain records of fertiliser quality (e.g. *E. coli* or lead concentration)	N/I	N/I	N/I	N/I	6.13.1.2 (A4, above)
	A16. Producers should maintain records of fertiliser application (e.g. date applied, amount applied, where applied, how applied)	N/I	Criterion 44 (A14, above) Criterion 45 (A14, above), which continues: The application recording system shall record the following: • amount applied • placement (sidedress, base application, liquid application or compost) • date of application • block location and crop applied to	Criterion 29 A system for recording the amount, placement and timing of organic and inorganic fertiliser applied shall be maintained. Criterion 30 (A14, above), which continues: Application recording system needs to include: • amount applied • placement (sidedress, base	CB5.3.1 Do records of all applications of soil and foliar fertilisers, both organic and inorganic, include the following criteria: Field, orchard or greenhouse reference? Compliance: Records are kept of all fertilizer applications, detailing the geographical area and the name or reference of the field, orchard or greenhouse where the registered product crop is located. Records must also be kept for hydroponic situations	5.5.7.4 (A14, above) 6.13.1.1 (A7, above) 6.13.1.3 (A8, above), which continues: A soil amendment protocol shall outline: The methods to ensure organic soil amendment applications are timed to post minimum risk to product safety and human health including: v. Sufficient data is recorded to provide a detailed record of soil amendment

Table A: NATURAL FERTILISERS						
GENERIC CRITERIA		CAC/RCP 53-2003	New Zealand GAP	NZ GAP (GLOBALGAP)	GLOBALG.A.P.	SQF
				application, liquid application or compost) • date of application • block location and crop applied to	and where fertigation is used. CB5.3.2 Do records of all applications of soil and foliar fertilisers, both organic and inorganic, include the following criteria: Application dates? Compliance: Detailed in the records of all fertiliser applications are the exact dates (day/month/year) of the application. CB5.3.4 Do records of all applications of soil and foliar fertilisers, both organic and inorganic, include the following criteria: Applied quantities? Compliance: Detailed in the records of all fertiliser application is the amount of product to be applied in weight or volume. The actual quantity applied must be recorded, as this is not necessarily the same as the recommendation. CB5.3.5 Do records of all applications of soil and foliar fertilisers, both organic and inorganic, include the following criteria: Method of application? Compliance: Detailed in the records of all fertiliser applications are the method (e.g. via irrigation or mechanical distribution) and machinery used, if applicable.	applications.
	A17. Producers should maintain records of the operator who applied the fertiliser (e.g. contact details, qualifications/training)	N/I	N/I	Criterion 30 (A14, above), which continues: Application recording system needs to include: • operator/applicator name.	CB5.3.6 Do records of all applications of soil and foliar fertilisers, both organic and inorganic, include the following criteria: Operator details? Compliance: Detailed in the records of all fertiliser applications is the name of the operator who has applied the fertilizer. If a single individual makes all of the applications, it is acceptable to record the operator details only once.	N/I

TABLE B: WATER FOR PRIMARY PRODUCTION

Notes to Table B:
There are no Application criteria in Table B. The application of water is covered separately in Tables C, D and F (it is not covered in Table E because water application is based on the agrichemical requirements of the crop, not on the water requirements).

Footnotes for Table B:
1. CAC/RCP 53-2003: Definition of contaminant from CAC/RCP 1-1969, Rev 3 (1997): "Any biological or chemical agent, foreign matter, or other substances not intentionally added to food which may compromise food safety or suitability."
2. New Zealand GAP: The New Zealand GAP requirements for water are separated by water use (irrigation, hydroponics and post-harvest) and are consequently listed in Tables C, D and F. The equivalent requirements under NZ GAP (GLOBALG.A.P. Equivalent) are not separated by water use and appear in this table.
3. GLOBALG.A.P: The GLOBALG.A.P. requirements for water are separated by water use (irrigation, fertigation (hydroponics) and post-harvest) and are consequently listed in Tables C, D and F. The equivalent requirements under NZ GAP (GLOBALG.A.P. Equivalent) are not separated by water use and appear in this table.

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK

Table B: WATER FOR PRIMARY PRODUCTION

GENERIC CRITERIA		CAC/RCP 53-2003	New Zealand GAP[2]	NZ GAP (GLOBALGAP)	GLOBALG.A.P.[3]	SQF
SOURCE	B1. Producers should consider whether the water sources are suitable for their intended use	3.2.1.1 Water for primary production • Growers should identify the sources of water used on the farm (municipality, re-used irrigation water, well, open canal, reservoir, rivers, lakes, farm ponds etc.). They should assess its microbial and chemical quality, and its suitability for intended use, and identify corrective actions to prevent or minimize contamination (e.g. from livestock, sewage treatment, human habitation). • Where necessary, growers should have the water they use tested for microbial and chemical contaminants. The frequency of testing will depend on the water source and the risks of environmental contamination including intermittent or temporary contamination (e.g. heavy rain, flooding, etc.). If the water source is found to be contaminated corrective actions should be taken to ensure that the water is suitable for its intended use.	Section C5.1 Water suitability Water quality should be adequate for its intended use. This should include irrigation water, water used for mixing sprays, wash water, water and ice used in cooling and other operations involving contact with the edible part of the produce.	Section G6.1 Water Water quality should be adequate for its intended use. This should include irrigation water, water used for mixing sprays, wash water, water and ice used in cooling and other operations involving contact with the edible part of the produce.	AF1.2.1 Is there a risk assessment available at the initial inspection for all sites registered for certification? During subsequent inspections, a risk assessment for new or existing production sites where risks have changed (this includes rented land) is available. Does this risk assessment show that the site in question is suitable for production, with regards to food safety, the environment, and animal health where applicable? Compliance: *(Refers to annexes 1 and 2 for information on risk assessment. Annex 2 contains factors to be considered and includes specifications for water quality)* AF1.2.2 Has a management plan been developed which establishes strategies to minimize the risks identified in the risk assessment (AF1.2.1)?	N/I
	B2. Producers must not use untreated sewage water or any sewage water	N/I	N/I	Criterion 97 Untreated sewage water shall not be used.	N/I	N/I
	B3. Producers can use treated sewage water if it meets appropriate standards (e.g. NZWWA guidelines, WHO guidelines)	3.2.1 (B5, below)	N/I	N/I	N/I	N/I
QUALITY	B4. Producers should prevent or minimise contamination to their source waters	3.2.1.1 (B1, above)	N/I	N/I	N/I	N/I
	B5. Producers should evaluate the food safety risks associated with the water	3.2.1 Agricultural input requirements: Agricultural inputs should not contain microbial or chemical contaminants (as defined under the Recommended International Code of Practice – General Principles of Food Hygiene (CAC/RCP 1-1969, Rev 3 (1997)[1]) at levels that may adversely affect the safety of fresh fruits and vegetables and taking into consideration the WHO guidelines on the safe use of wastewater and excreta in agriculture and aquaculture as appropriate.	N/I	Criterion 95 Sources of water used in the production and harvesting process shall be evaluated against potential risks of contamination and the results of the evaluation documented, actions documented and an assessment of the effectiveness of the actions recorded. Evaluation shall occur at least annually. Where a risk has been identified, steps shall be taken to ensure the water quality is made adequate for its intended use, for example: • Alternative sources known to be acceptable for human consumption and fit for purpose,	N/I	N/I

Table B: WATER FOR PRIMARY PRODUCTION					
GENERIC CRITERIA	CAC/RCP 53-2003	New Zealand GAP[2]	NZ GAP (GLOBALGAP)	GLOBALG.A.P.[3]	SQF
			• Using an irrigation system where the water does not come in contact with the edible portion of the crop. Section G6.1 Water The frequency should allow for the management of the potential risk, e.g. when the condition of the water source changes.		
B6. Producers should test the microbial quality of the water if necessary (or obtain test results from supplier)	3.2.1.1 (B1, above)	N/I	N/I	AF1.2.1 (B1, above) *(Refers to annexes 1 and 2. Annex 2 contains microbiological limits for water quality)*	N/I
B7. Producers should test the chemical quality of the water if necessary (or obtain test results from supplier)	3.2.1.1 (B1, above)	N/I	N/I	N/I	N/I
B8. Producers should take corrective action to address any contamination at, or after, water uptake from source (e.g. treatment)	3.2.1.1 (B1, above)	N/I[2]	Criterion 95 (B5, above)	N/I	N/I
B9. Producers should control and monitor the effectiveness of any water treatment	N/I	N/I	Criterion 95 (B5, above)	N/I	N/I
B10. Producers should control and monitor the water temperature	N/I	Section C5.1 Water suitability The temperature of the water (especially where contact is prolonged e.g. wash water) may contribute to the absorption of microbes and contaminants into the produce, by osmosis and therefore, the water temperature should be as close to that of the produce as possible (or slightly warmer) to help prevent the absorption.	Section G6.1 Water The temperature of the water (especially where contact is prolonged e.g. wash water) may contribute to the absorption of microbes and contaminants into the produce, by osmosis and therefore, the water temperature should be as close to that of the produce as possible (or slightly warmer) to help prevent the absorption.	N/I	N/I

Table B: WATER FOR PRIMARY PRODUCTION						
GENERIC CRITERIA		CAC/RCP 53-2003	New Zealand GAP[2]	NZ GAP (GLOBALGAP)	GLOBALG.A.P.[3]	SQF
RECORDS	B11. Producers should maintain records of water quality (e.g. *E. coli* concentration, treatments)	5.7 Documentation and records Where appropriate, records of processing, production and distribution should be kept long enough to facilitate a recall and food borne illness investigation, if required. This period could be much longer than the shelf life of fresh fruits and vegetables. Documentation can enhance the credibility and effectiveness of the food safety control system. • Growers should keep current all relevant information on agricultural activities such as the site of production, suppliers' information on agricultural inputs, lot numbers of agricultural inputs, irrigation practices, use of agricultural chemicals, water quality data, pest control and cleaning schedules for indoor establishments, premises, facilities, equipment and containers.	N/I	Criterion 95 (B5, above)	N/I	N/I

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK

TABLE C: WATER FOR IRRIGATION (OUTDOOR OR INDOOR NON-HYDROPONIC GROWING SYSTEMS)

Footnotes for Table C:

1. New Zealand GAP: Questions in decision diagram:
   Does the irrigation water come in contact with the edible part of the crop? (No = Risk is not significant)
   - ↳ Yes: is the irrigation water from a potable source, i.e. known to be acceptable for human consumption and fit for purpose? (Yes = Risk is not significant)
   - ↳ No/Unsure: Is the irrigation water applied within 48 hours of harvest and can the produce surface trap moisture and encourage microbial growth? (No = Risk is not significant)
   - ↳ Yes: Will the produce be adequately washed and/or peeled and/or cooked prior to consumption? (Yes = Risk is not significant)
   - ↳ No/Unsure: Test the produce for generic *E. coli* (Result is <20 CFU/g = Risk is not significant; Result is 20-<100 CFU/g = Marginal risk. Work to reducing the risk e.g. using an alternate source)
   - ↳ Result equals or exceeds 100 CFU/g of produce = Unacceptable risk. Manage the risk by e.g. using an alternative source known to be acceptable for human consumption, system preventing contact with edible portion of crop.

   NB: There is also a line of questioning that requires agrichemical levels to be measured against DWSNZ2008 and MRL, but these have not been reproduced here as this study does not consider agrichemical residues.
2. New Zealand GAP (GLOBALG.A.P. Equivalent): Questions in decision diagram:
   Does the irrigation water come in contact with the edible part of the crop? (No = Risk is not significant)
   - ↳ Yes: is the irrigation water from a potable source, i.e. known to be acceptable for human consumption and fit for purpose? (Yes = Risk is not significant)
   - ↳ No/Unsure: Is the irrigation water applied within 48 hours of harvest and can the produce surface trap moisture and encourage microbial growth? (No = Risk is not significant)
   - ↳ Yes: Will the produce be adequately washed (packhouse and/or domestic) and/or peeled and/or cooked prior to consumption? (Yes = Risk is not significant)
   - ↳ No/Unsure: Test the produce for generic *E. coli* (<20 CFU/g = Risk is not significant; 20-<100 CFU/g = Risk acceptable, work to reducing the risk e.g. using an alternative source)
   - ↳ Equal or exceed 100 CFU/g of produce = Manage the risk by e.g. using an alternative source known to be acceptable for human consumption, system preventing contact with edible portion of crop.

   NB: There is also a line of questioning that requires agrichemical levels to be measured against DWSNZ2008 and MRL, but these have not been reproduced here as this study does not consider agrichemical residues.
3. New Zealand GAP and New Zealand GAP (GLOBALG.A.P. Equivalent): Growers are only required to test the produce, not the water.
4. SQF: Requirement 6.9.1 reads "Water used for washing and treating product, cleaning food contact surfaces and mixing sanitizer solutions shall comply with potable water microbiological standards in the country of production. Separate criteria will be established for irrigation water, frost control, humidifying, pesticide application, etc. as applicable, based on the hazard analysis, best practices within country of production and any application legislation, or applicable legislation."

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK

Table C: WATER FOR IRRIGATION (OUTDOOR OR INDOOR NON-HYDROPONIC GROWING SYSTEMS)						
GENERIC CRITERIA		CAC/RCP 53-2003	New Zealand GAP	NZ GAP (GLOBALGAP)	GLOBALG.A.P.	SQF
SOURCE	C1. Producers should consider whether the water sources are suitable for their intended use	(3.2.1.1, Table B) 3.2.2.2 Indoor facilities associated with growing and harvesting: Water supply Where appropriate an adequate supply of potable or clean water with appropriate facilities for its storage and distribution should be available in indoor primary production facilities. Non-potable water should have a separate system. Non-potable water systems should be identified and should not connect with, or allow reflux into, potable water systems. • Avoid contaminating potable and clean water supplies by exposure to agricultural inputs used for growing fresh produce. • Clean and disinfect potable and clean water storage facilities on a regular basis. • Control the quality of the water supply.	(Section C5.1, Table B) Criterion 73 (C5, below), from decision diagram:[1] Is the irrigation water from a potable source, i.e. known to be acceptable for human consumption and fit for purpose?	(Section G6.1, Table B) Section G6.1 (C5, below), from decision diagram:[2] Is the irrigation water from a potable source, i.e. known to be acceptable for human consumption and fit for purpose?	(AF1.2.1, AF1.2.2, Table B) CB6.3.2 (C5, below)	5.4.1.1 (SQF1000) Irrigation water shall be drawn from a known clean source or treated to make it suitable for use. The Producer shall conduct an analysis of the hazards to the irrigation water supply from source through to application, establish acceptance criteria for the monitoring of water and validate and verify the integrity of the water used to ensure it is fit for the purpose.
SOURCE	C2. Producers must not use untreated sewage water or any sewage water	N/I	N/I	(Criterion 97, Table B)	CB6.3.1 Has the use of untreated sewage water for irrigation/fertigation been banned? Compliance: Untreated sewage is not used for irrigation/fertigation. Where treated sewage water or reclaimed water is used, water quality complies with the WHO published Guidelines for the Safe Use of Wastewater and Excreta in Agriculture and Aquaculture 1989. Also, when there is doubt if water is coming from a possibly polluted source (i.e. because of a village upstream, etc.) the farmer has to demonstrate through analysis that the water complies with the WHO guideline requirements or the local legislation for irrigation water. See Table 3 in Annex AF.1 for Risk Assessments. *(Annex contains WHO microbiological guidelines)*	N/I
SOURCE	C3. Producers can use treated sewage water if it meets appropriate standards (e.g. NZWWA guidelines, WHO guidelines)	(3.2.1.1, Table B)	N/I	N/I	CB6.3.1 (C2, above)	N/I
QUALITY	C4. Producers should prevent or minimise contamination to their source waters	(3.2.1.1, Table B) 3.2.2.2 (C1, above)	N/I	N/I	N/I	N/I
QUALITY	C5. Producers should evaluate	(3.2.1, Table B)	Criterion 73	(Criterion 95, Section G6.1, Table B)	CB6.3.2	5.4.1.1 (C1, above)

Table C: WATER FOR IRRIGATION (OUTDOOR OR INDOOR NON-HYDROPONIC GROWING SYSTEMS)						
GENERIC CRITERIA		CAC/RCP 53-2003	New Zealand GAP	NZ GAP (GLOBALGAP)	GLOBALG.A.P.	SQF
	the food safety risks associated with the water	3.2.1.1.1 Water for irrigation and harvesting Water used for agricultural purposes should be of suitable quality for its intended use. Special attention to water quality should be considered for the following situations: • Irrigation by water delivery techniques that expose the edible portion of fresh fruits and vegetables directly to water (e.g. sprayers) especially close to harvest time. • Irrigation of fruits and vegetables that have physical characteristics such as leaves and rough surfaces which can trap water. • Irrigation of fruits and vegetables that will receive little or no post-harvest wash treatments prior to packing, such as field-packed produce.	Sources of water used in the production process shall be evaluated using the decision diagram below against potential risks of contamination and the results of the evaluation documented, actions documented and an assessment of the effectiveness of the actions recorded. Where a risk has been identified, steps shall be taken to ensure the water quality is made adequate for its intended use.[1] Section C5.1.2 Water used for irrigation Evaluation should be carried out at a frequency which allows management of the potential risk, e.g. when the condition of the water source changes, but shall be carried out at least annually.	Section G6.1 Water The decision diagram below helps determine whether risks to food safety, through microbial and chemical contamination, from irrigation water are significant or not.[2]	Has an annual risk assessment for irrigation/fertigation water pollution been completed? Compliance: The risk assessment must consider potential microbial, chemical and physical pollution of all sources of irrigation/fertigation water. At a minimum, the risk assessment shall cover: • Identification of the water sources • Irrigation method(s) • Timing of irrigation (during crop growth stage) • Contact of irrigation water with the crop Type of crop: - • Crops that can be eaten raw and which do not have a protective skin that is removed before eating • Crops that can be eaten raw and either have no protective skin that is removed before eating or do have some risk or history of pathogen contamination • Crops that can be eaten raw and either have a protective skin that is removed before eating, or grow clear of the ground or have no significant history of pathogen contamination. • Crops that are always cooked See Annex CB.1 Microbiological Hazards. *(Annex contains further guidelines)*	
	C6. Producers should test the microbial quality of the water if necessary (or obtain test results from supplier)	(3.2.1.1, Table B)	N/I[3]	N/I[3]	(AF1.2.1, Table B) CB6.3.3 Is irrigation water analysed at a frequency in line with the risk assessment (CB6.3.2)? Compliance: The water analysis is carried out at a frequency according to the results of the risk assessment which takes the characteristics of the crop into account. Samples are to be taken at exit point of the irrigation system or the nearest practical sampling point. CB6.3.4 According to the risk assessment in CB.6.3.2, does the laboratory analysis consider microbial contaminants? Compliance: According to the risk analysis (if there is a risk of microbial contaminants), laboratory analysis provides a documented record of the	5.4.1.1 (C1, above) 5.4.2.1 (SQF1000) In circumstances where irrigation water is treated to render it acceptable, the water, after treatment shall conform to the microbiological standards as outlined under 6.9.1.[4]

Table C: WATER FOR IRRIGATION (OUTDOOR OR INDOOR NON-HYDROPONIC GROWING SYSTEMS)						
GENERIC CRITERIA		CAC/RCP 53-2003	New Zealand GAP	NZ GAP (GLOBALGAP)	GLOBALG.A.P.	SQF
					relevant microbial contaminants through a laboratory analysis. CB6.3.5(R) Does a suitable laboratory carry out the analysis? Compliance: Analysis results from appropriate laboratories, capable of performing microbiological analyses up to ISO 17025 level, or equivalent standard, should be available.	
	C7. Producers should test the chemical quality of the water if necessary (or obtain test results from supplier)	(3.2.1.1, Table B)	N/I[3]	N/I[3]	CB6.3.3, CB6.3.5(R) (C6, above)	5.4.1.1 (C1, above)
	C8. Producers should take corrective action to address any contamination at, or after, water uptake from source (e.g. treatment)	(3.2.1.1, Table B)	Criterion 73 (C5, above)	(Criterion 95, Table B)	CB6.3.6 If the risk analysis so requires, have adverse results been acted upon before the next harvest cycle? Compliance: Records are available of corrective actions and/or decisions taken.	5.4.2.1 (C6, above)
	C9. Producers should control and monitor the effectiveness of any water treatment	N/I	Criterion 73 (C5, above)	(Criterion 95, Table B)	N/I	N/I
	C10. Producers should control and monitor the water temperature	N/I	(Section C5.1, Table B)	(Section G6.1, Table B)	N/I	N/I
APPLICATION	C11. Producers should base the application of water on the water requirements of the soil or crops, or specialist advice	N/I	Criterion 74(R) A documented water management plan should be developed and maintained.	Criterion 69(R) Documented, irrigation water management should be employed. Irrigation management should, consider predicted rainfall, utilise data from rainfall records, total predicted and actual irrigation water applied, evaporation and water tension meters. Calculations should take into account the crop requirement and soil types. The calculated and actual irrigation water applied should be recorded. Criterion 70 The most efficient and practical irrigation method shall be employed so water utilization is optimised and waste is minimised.	CB6.1.1(R) Have systematic methods of prediction been used to calculate the water requirement of the crop? Compliance: Calculations are available and are supported by data records (e.g. rain gauges, drainage trays for substrate, evaporation meters, water tension meters (determining % of moisture in the soil) and soil maps). The data can be accumulated on a regional scale. CB6.2.1 Can the producer justify the method of irrigation used in light of water conservation? Compliance: The idea is to avoid wasting water. The irrigation system used is efficient. The producer uses the most efficient irrigation system – as is technically available and financially affordable, and complies with any legislation about local restrictions on water usage. CB6.2.2(R)	N/I

Table C: WATER FOR IRRIGATION (OUTDOOR OR INDOOR NON-HYDROPONIC GROWING SYSTEMS)

GENERIC CRITERIA		CAC/RCP 53-2003	New Zealand GAP	NZ GAP (GLOBALGAP)	GLOBALG.A.P.	SQF
					Is there a water management plan to optimise water usage and reduce waste? Compliance: There must be a written action plan, which aims to optimize water usage on the farm. This can be either an individual plan or a regional activity if the farm is participating in and/or covered by such.	
	C12. Producers should minimise contact between the water and the produce	N/I	Criterion 73 (C5, above), from decision diagram:[1] Does the irrigation water come in contact with the edible part of the crop?	Section G6.1 (C5, above), from decision diagram:[2] Does the irrigation water come in contact with the edible part of the crop?	CB6.3.2 (C5, above)	N/I
	C13. Producers should maximise the time between final irrigation and harvest (e.g. >48 hours)	N/I	Criterion 73 (C5, above), from decision diagram:[1] … Is the irrigation water applied within 48 hours of harvest and can the produce surface trap moisture and encourage microbial growth?	Section G6.1 (C5, above), from decision diagram:[2] … Is the irrigation water applied within 48 hours of harvest and can the produce surface trap moisture and encourage microbial growth?	CB6.3.2 (C5, above)	N/I
	C14. Producers should maintain water delivery systems	3.2.2.2 (C1, above)	N/I	N/I	CB9.1 Are equipment sensitive to food safety and the environment (e.g. fertilizer spreaders, plant protection product sprayers, irrigation systems, equipment used for weighing and temperature control) routinely verified and, where applicable, calibrated at least annually? Compliance: The equipment is kept in a good state of repair with documented evidence of up-to-date maintenance sheets for all repairs, oil changes, etc. undertaken. For example: Fertiliser spreader: There must, as a minimum, be documented records stating that the verification of calibration has been carried out by a specialized company, supplier of fertilisation equipment or by the technically responsible person of the farm within the last 12 month. CB9.2(R) Is the producer involved in an independent calibration-certification scheme, where available? Compliance: The producer's involvement in a calibration scheme is documented.	N/I
RECORDS	C15. Producers should maintain records of water quality (e.g. *E. coli* concentration, treatments)	(5.7, Table B)	N/I[3]	(Criterion 95, Table B)	N/I	N/I
RECORDS	C16. Producers should maintain records of water application (e.g. date applied, amount applied, where applied, how applied)	5.7 Documentation and records Where appropriate, records of processing, production and distribution should be kept long enough to facilitate a recall and food borne illness	N/I	Criterion 69(R) (C11, above)	CB6.2.3(R) Are records of irrigation/fertigation water usage maintained? Compliance: Records are kept which indicate the date and volume per water meter or per irrigation unit. If the	N/I

Table C: WATER FOR IRRIGATION (OUTDOOR OR INDOOR NON-HYDROPONIC GROWING SYSTEMS)						
GENERIC CRITERIA		CAC/RCP 53-2003	New Zealand GAP	NZ GAP (GLOBALGAP)	GLOBALG.A.P.	SQF
		investigation, if required. This period could be much longer than the shelf life of fresh fruits and vegetables. Documentation can enhance the credibility and effectiveness of the food safety control system. Growers should keep current all relevant information on agricultural activities such as the site of production, suppliers' information on agricultural inputs, lot numbers of agricultural inputs, irrigation practices, use of agricultural chemicals, water quality data, pest control and cleaning schedules for indoor establishments, premises, facilities, equipment and containers.			producer works with irrigation programmes, the calculated duration of irrigation and actual quantity of irrigated water should be recorded.	

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK

TABLE D: WATER FOR HYDROPONIC GROWING SYSTEMS

Footnotes for Table D:

1. New Zealand GAP: Questions in decision diagram:
   Is the water used for growing hydroponically potable? Does Local Authority documentation or water test results show that pathogen levels are acceptable against the DWSNZ2008? (Yes = Risk is not significant)
   - ↳ No: Test water for microbiological contamination. Microbial contamination by the indicator organism generic *E. coli* (No = Risk is not significant).
   - ↳ Yes: >1 generic *E. coli* in 100 ml water sample (Negative = Risk is not significant)
   - ↳ Positive: Remove risk immediately e.g. alternative source or recognised treatment.

   NB: There is also a line of questioning that requires agrichemical levels to be measured against DWSNZ2008 and MRL, but these have not been reproduced here as this study does not consider agrichemical residues.
2. New Zealand GAP: The decision diagram also requires testing for agrichemicals, but these are not included in this study and have not been recorded in Table D.
3. GLOBALG.A.P: The GLOBALG.A.P. requirements for irrigation and fertigation are the same, so the same criteria listed in Table C also appear in this table.

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK

Table D: WATER FOR HYDROPONIC GROWING SYSTEMS

GENERIC CRITERIA		CAC/RCP 53-2003	New Zealand GAP	NZ GAP (GLOBALGAP)	GLOBALG.A.P.[3]	SQF
SOURCE	D1. Producers should consider whether the water sources are suitable for their intended use: Potable water should be available	(3.2.1.1, Table B) 3.2.2.2 Indoor facilities associated with growing and harvesting: Water supply Where appropriate an adequate supply of potable or clean water with appropriate facilities for its storage and distribution should be available in indoor primary production facilities. Non-potable water should have a separate system. Non-potable water systems should be identified and should not connect with, or allow reflux into, potable water systems. • Avoid contaminating potable and clean water supplies by exposure to agricultural inputs used for growing fresh produce. • Clean and disinfect potable and clean water storage facilities on a regular basis. Control the quality of the water supply.	(Section C5.1, Table B) Criterion 73 (D5, below), from decision diagram:[1] Is the water used for growing hydroponically potable?	(Section G6.1, Table B)	(AF1.2.1, AF1.2.2, Table B) CB6.3.2 (D5, below)	N/I
SOURCE	D2. Producers must not use untreated sewage water or any sewage water	N/I	N/I	(Criterion 97, Table B)	CB6.3.1 Has the use of untreated sewage water for irrigation/fertigation been banned? Compliance: Untreated sewage is not used for irrigation/fertigation. Where treated sewage water or reclaimed water is used, water quality complies with the WHO published Guidelines for the Safe Use of Wastewater and Excreta in Agriculture and Aquaculture 1989. Also, when there is doubt if water is coming from a possibly polluted source (i.e. because of a village upstream, etc.) the farmer has to demonstrate through analysis that the water complies with the WHO guideline requirements or the local legislation for irrigation water. See Table 3 in Annex AF.1 for Risk Assessments. *(Annex contains WHO microbiological guidelines)*	N/I
SOURCE	D3. Producers can use treated sewage water if it meets appropriate standards (e.g. NZWWA guidelines, WHO guidelines)	(3.2.1, Table B)	N/I	N/I	CB6.3.1 (C2, above)	N/I
QUALITY	D4. Producers should prevent or minimise contamination to their source waters	(3.2.1.1, Table B) 3.2.2.2 (D1, above)	N/I	N/I	N/I	N/I
QUALITY	D5. Producers should evaluate the food safety risks associated	(3.2.1, Table B)	Criterion 73 Sources of water used in the production	(Criterion 95, Section G6.1, Table B)	CB6.3.2 Has an annual risk assessment for	N/I

Table D: WATER FOR HYDROPONIC GROWING SYSTEMS							
GENERIC CRITERIA		**CAC/RCP 53-2003**	**New Zealand GAP**	**NZ GAP (GLOBALGAP)**	**GLOBALG.A.P.[3]**	**SQF**
	with the water		process shall be evaluated using the decision diagram below against potential risks of contamination and the results of the evaluation documented, actions documented and an assessment of the effectiveness of the actions recorded. Where a risk has been identified, steps shall be taken to ensure the water quality is made adequate for its intended use.[1,2] Section C5.1.1 Water used for growing hydroponically Evaluation should be carried out at a frequency which allows management of the potential risk, e.g. when the condition of the water source changes, but shall be carried out at least annually.		irrigation/fertigation water pollution been completed? Compliance: The risk assessment must consider potential microbial, chemical and physical pollution of all sources of irrigation/fertigation water. At a minimum, the risk assessment shall cover: • Identification of the water sources • Irrigation method(s) • Timing of irrigation (during crop growth stage) • Contact of irrigation water with the crop Type of crop: - • Crops that can be eaten raw and which do not have a protective skin that is removed before eating • Crops that can be eaten raw and either have no protective skin that is removed before eating or do have some risk or history of pathogen contamination • Crops that can be eaten raw and either have a protective skin that is removed before eating, or grow clear of the ground or have no significant history of pathogen contamination. • Crops that are always cooked See Annex CB.1 Microbiological Hazards. *(Annex contains further guidelines)*	
	D6. Producers should test the microbial quality of the water if necessary (or obtain test results from supplier)	(3.2.1.1, Table B)	Criterion 73 (D5, above), from decision diagram:[1] Test water for microbiological contamination.	N/I	(AF1.2.1, Table B) CB6.3.3 Is irrigation water analysed at a frequency in line with the risk assessment (CB6.3.2)? Compliance: The water analysis is carried out at a frequency according to the results of the risk assessment which takes the characteristics of the crop into account. Samples are to be taken at exit point of the irrigation system or the nearest practical sampling point. CB6.3.4 According to the risk assessment in CB.6.3.2, does the laboratory analysis consider microbial contaminants? Compliance: According to the risk analysis (if there is a risk of microbial contaminants), laboratory analysis provides a documented record of the relevant microbial contaminants through	N/I

Table D: WATER FOR HYDROPONIC GROWING SYSTEMS

GENERIC CRITERIA		CAC/RCP 53-2003	New Zealand GAP	NZ GAP (GLOBALGAP)	GLOBALG.A.P.[3]	SQF
					a laboratory analysis. CB6.3.5(R) Does a suitable laboratory carry out the analysis? Compliance: Analysis results from appropriate laboratories, capable of performing microbiological analyses up to ISO 17025 level, or equivalent standard, should be available.	
	D7. Producers should test the chemical quality of the water if necessary (or obtain test results from supplier)	(3.2.1.1, Table B)	N/I[2]	N/I	CB6.3.3, CB6.3.5(R) (D6, above)	N/I
	D8. Producers should take corrective action to address any contamination at, or after, water uptake from source (e.g. treatment)	(3.2.1.1, Table B)	Criterion 73 (D5, above)	(Criterion 95, Table B)	CB6.3.6 If the risk analysis so requires, have adverse results been acted upon before the next harvest cycle? Compliance: Records are available of corrective actions and/or decisions taken.	N/I
	D9. Producers should control and monitor the effectiveness of any water treatment	N/I	Criterion 73 (D5, above)	(Criterion 95, Table B)	N/I	N/I
	D10. Producers should control and monitor the water temperature	N/I	(Section C5.1, Table B)	(Section G6.1, Table B)	N/I	N/I
	D11. Producers should control and monitor the quality of water in recirculated water/fertigation systems	3.2.2.2 (D1, above) 3.2.1.1.3 Hydroponic water Plants grown in hydroponic systems absorb nutrients and water at varying rates, constantly changing the composition of the re-circulated nutrient solution. Because of this: • Water used in hydroponic culture should be changed frequently, or if recycled, should be treated to minimize microbial and chemical contamination. • Water delivery systems should be maintained and cleaned, as appropriate, to prevent microbial contamination of water.	Criterion 73 (D5, above) Section C5.1.1 (D5, above)	N/I	N/I	N/I
APPLICATION	D12. Producers should base the application of water on the water requirements (and nutrient requirements) of the crops, or specialist advice	N/I	N/I	N/I	CB6.1.1(R) Have systematic methods of prediction been used to calculate the water requirement of the crop? Compliance: Calculations are available and are supported by data records (e.g. rain gauges, drainage trays for substrate, evaporation meters, water tension meters (determining % of moisture in	N/I

Table D: WATER FOR HYDROPONIC GROWING SYSTEMS					
GENERIC CRITERIA	CAC/RCP 53-2003	New Zealand GAP	NZ GAP (GLOBALGAP)	GLOBALG.A.P.[3]	SQF
				the soil) and soil maps). The data can be accumulated on a regional scale. CB6.2.1 Can the producer justify the method of irrigation used in light of water conservation? Compliance: The idea is to avoid wasting water. The irrigation system used is efficient. The producer uses the most efficient irrigation system – as is technically available and financially affordable, and complies with any legislation about local restrictions on water usage. CB6.2.2(R) Is there a water management plan to optimise water usage and reduce waste? Compliance: There must be a written action plan, which aims to optimize water usage on the farm. This can be either an individual plan or a regional activity if the farm is participating in and/or covered by such.	
D13. Producers should minimise contact between the water and the produce	N/I	N/I	N/I	CB6.3.2 (D5, above)	N/I
D14. Producers should maximise the time between final irrigation and harvest (e.g. >48 hours)	N/I	N/I	N/I	CB6.3.2 (D5, above)	N/I
D15. Producers should maintain water delivery systems	3.2.2.2 (D1, above) 3.2.1.1.3 (D11, above)	N/I	N/I	CB9.1 Are equipment sensitive to food safety and the environment (e.g. fertilizer spreaders, plant protection product sprayers, irrigation systems, equipment used for weighing and temperature control) routinely verified and, where applicable, calibrated at least annually? Compliance: The equipment is kept in a good state of repair with documented evidence of up-to-date maintenance sheets for all repairs, oil changes, etc. undertaken. For example: Fertiliser spreader: There must, as a minimum, be documented records stating that the verification of calibration has been carried out by a specialized company, supplier of fertilisation equipment or by the technically responsible person of the farm within the last 12 month. CB9.2(R)	N/I

Table D: WATER FOR HYDROPONIC GROWING SYSTEMS						
GENERIC CRITERIA		CAC/RCP 53-2003	New Zealand GAP	NZ GAP (GLOBALGAP)	GLOBALG.A.P.[3]	SQF
					Is the producer involved in an independent calibration-certification scheme, where available? Compliance: The producer's involvement in a calibration scheme is documented.	
RECORDS	D16. Producers should maintain records of water quality (e.g. *E. coli* concentration, treatments)	(5.7, Table B)	Criterion 73 (D5, above)	(Criterion 95, Table B)	N/I	N/I
RECORDS	D17. Producers should maintain records of water application (e.g. date applied, amount applied, where applied, how applied)	N/I	N/I	N/I	CB5.3.1 Do records of all applications of soil and foliar fertilisers, both organic and inorganic, include the following criteria: Field, orchard or greenhouse reference? Compliance: Records are kept of all fertilizer applications, detailing the geographical area and the name or reference of the field, orchard or greenhouse where the registered product crop is located. Records must also be kept for hydroponic situations and where fertigation is used. CB6.2.3(R) Are records of irrigation/fertigation water usage maintained? Compliance: Records are kept which indicate the date and volume per water meter or per irrigation unit. If the producer works with irrigation programmes, the calculated duration of irrigation and actual quantity of irrigated water should be recorded.	N/I

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK

TABLE E: WATER FOR AGRICULTURAL CHEMICALS

Notes to Table E:
There are no Application criteria in Table E. The application of water is based on the agrichemical requirements of the crop, not on the water requirements.

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK

Table E: WATER FOR AGRICULTURAL CHEMICALS						
GENERIC CRITERIA		CAC/RCP 53-2003	New Zealand GAP	NZ GAP (GLOBALGAP)	GLOBALG.A.P.	SQF
SOURCE	E1. Producers should consider whether the water sources are suitable for their intended use	(3.2.1.1, Table B)	(Section C5.1, Table B)	(Section G6.1, Table B)	(AF1.2.1, AF1.2.2, Table B) FV3.1.1 (E5, below)	N/I
SOURCE	E2. Producers must not use untreated sewage water or any sewage water	N/I	N/I	(Criterion 97, Table B)	N/I	N/I
SOURCE	E3. Producers can use treated sewage water if it meets appropriate standards (e.g. NZWWA guidelines, WHO guidelines)	(3.2.1, Table B)	N/I	N/I	N/I	N/I
QUALITY	E4. Producers should prevent or minimise contamination to their source waters	(3.2.1.1, Table B)	N/I	N/I	N/I	N/I
QUALITY	E5. Producers should evaluate the food safety risks associated with the water	(3.2.1, Table B) 3.2.1.1.2 Water for fertilizers, pest control and other agricultural chemicals Water used for the application of water-soluble fertilizers and agricultural chemicals in the field and indoors should not contain microbial contaminants at levels that may adversely affect the safety of fresh fruits and vegetables. Special attention to the water quality should be considered when using fertilizer and agricultural chemical delivery techniques (e.g. sprayers) that expose the edible portions of fresh fruits and vegetables directly to water especially close to harvest time.	N/I	(Criterion 95, Section G6.1, Table B)	FV3.1.1 Does the risk assessment consider the quality of the water used to make plant protection product mixtures? A written risk assessment is conducted. It includes water source, type of plant protection product (herbicide, insecticide, etc.), application timing (growth stage of the crop), placement of application (edible part of the crop, other parts of the crop, ground between crops, etc.) and corrective action is taken if necessary.	N/I
QUALITY	E6. Producers should test the microbial quality of the water if necessary (or obtain test results from supplier)	(3.2.1.1, Table B)	N/I	N/I	(AF1.2.1, Table B)	N/I
QUALITY	E7. Producers should test the chemical quality of the water if necessary (or obtain test results from supplier)	(3.2.1.1, Table B)	N/I	N/I	N/I	N/I
QUALITY	E8. Producers should take corrective action to address any contamination at, or after, water uptake from source (e.g. treatment)	(3.2.1.1, Table B)	N/I	(Criterion 95, Table B)	FV3.1.1 (E5, above)	N/I
QUALITY	E9. Producers should control and monitor the effectiveness of any water treatment	N/I	N/I	(Criterion 95, Table B)	N/I	N/I
QUALITY	E10. Producers should control and monitor the water temperature	N/I	(Section C5.1, Table B)	(Section G6.1, Table B)	N/I	N/I

Table E: WATER FOR AGRICULTURAL CHEMICALS						
GENERIC CRITERIA		**CAC/RCP 53-2003**	**New Zealand GAP**	**NZ GAP (GLOBALGAP)**	**GLOBALG.A.P.**	**SQF**
RECORDS	E11. Producers should maintain records of the quality of the water used for agricultural chemicals (e.g. *E. coli* concentration, treatments)	(5.7, Table B)	N/I	(Criterion 95, Table B)	N/I	N/I

TABLE F: WATER FOR POST-HARVEST PROCESSES

Footnotes for Table F:

1. CAC/RCP 53-2003: Section 4.4.1 (Water supply) of Section 4 in the General Principles of Food Hygiene reads:
   "An adequate supply of potable water with appropriate facilities for its storage, distribution and temperature control, should be available whenever necessary to ensure the safety and suitability of food."
   "Potable water should be as specified in the latest edition of WHO Guidelines for Drinking Water Quality, or water of a higher standard. Non-potable water (for use in, for example, fire control, steam production, refrigeration and other similar purposes where with would not contaminate food), shall have a separate system. Non-potable water systems shall be identified and shall not connect with, or allow reflux into, potable water systems."
2. CAC/RCP 53-2003: Section 5.5 (Water) of the General Principles of Food Hygiene reads:
   "5.1.1 In contact with food
   Only potable water, should be used in food handling and processing, with the following exceptions:
   - For steam production, fire control and other similar purposes not connected with food; and
   - In certain food processes, e.g. chilling, and in food handling areas, provided this does not constitute a hazard to the safety and suitability of food e.g. the use of clean sea water).
     Water recirculated for reuse should be treated and maintained in such a condition that no risk to the safety and suitability of food results from its use. The treatment process should be effectively monitored. Recirculated water which has received no further treatment and water recovered from processing of food by evaporation or drying may be used, provided its use does not constitute a risk to the safety and suitability of food.

   5.5.2 As an ingredient
   Potable water should be used wherever necessary to avoid food contamination.
   5.5.3 Ice and steam
   Ice should be made from water that complies with section 4.4.1. Ice and steam should be produced, handled and stored to protect them from contamination. Steam used in direct contact with food or food contact surfaces should not constitute a threat to the safety and suitability of food."
3. New Zealand GAP: Questions in decision diagram:
   Is the water used for final washing potable? Does Local Authority documentation or water test results show that pathogen levels are acceptable against the DWSNZ2008? (Yes = Risk is not significant)
   ↳ No: Test water for microbiological contamination. Microbial contamination by the indicator organism generic *E. coli* (No = Risk is not significant).
   ↳ Yes: >1 generic *E. coli* in 100 ml water sample (Negative = Risk is not significant)
   ↳ Positive: Remove risk immediately e.g. alternative source or recognised treatment.
   NB: There is also a line of questioning that requires agrichemical levels to be measured against DWSNZ2008 and MRL, but these have not been reproduced here as this study does not consider agrichemical residues.
4. New Zealand GAP (GLOBALG.A.P. Equivalent): Questions in decision diagram:
   Potable source of final wash water? Local Authority documentation or water test result showing pathogen levels acceptable against the DWSNZ2005? (Yes = Risk not significant)
   ↳ No: Test water for microbiological contamination. Microbial contamination by the indicator organism generic *E. coli* (No = Risk not significant).

↳ Yes: >1 generic *E. coli* in 100 ml water sample (Negative = Risk is not significant)
↳ Positive: Remove risk immediately e.g. alternative source or recognised treatment.
NB: There is also a line of questioning that requires agrichemical levels to be measured against DWSNZ2008 and MRL, but these have not been reproduced here as this study does not consider agrichemical residues.

5. New Zealand GAP and New Zealand GAP (GLOBALG.A.P. Equivalent): The decision diagrams also require testing for agrichemicals, but these are not included in this study and have not been recorded in Table F.

Table F: WATER FOR POST-HARVEST PROCESSES						
GENERIC CRITERIA		CAC/RCP 53-2003	New Zealand GAP	NZ GAP (GLOBALGAP)	GLOBALG.A.P.	SQF
SOURCE	F1. Producers should consider whether the water sources are suitable for their intended use	5.2.2.1 Post-harvest water use Water quality management will vary throughout all operations. Packers should follow GMPs to prevent or minimize the potential for the introduction or spread of pathogens in processing water. The quality of water used should be dependent on the stage of the operations. For example, clean water could be used for initial washing stages, whereas water used for final rinses should be of potable quality. 4 Packing establishment: Design and facilities Refer to the *General Principles of Food Hygiene.*[1]	Section D3.1 Water suitability Water quality should be adequate for its intended use. This should include water used for mixing post harvest treatment agrichemicals, wash water, water and ice used in cooling, cleaning and other operations involving contact with the edible part of the produce.	Section H6.1 Water Water quality should be adequate for its intended use. This should include water used for mixing post harvest treatment agrichemicals, wash water, re-circulated wash water, water and ice used in cooling, cleaning and other operations involving contact with the edible part of the produce.	(AF1.2.1, AF1.2.2, Table B)	5.3.1.1 (SQF2000) Adequate supplies of potable water drawn from a known clean source shall be provided for use during processing operations, as an ingredient and for cleaning the premises and equipment.
QUALITY	F2. Producers should prevent or minimise contamination to their source waters	5.2.2.1 (F2, above), and which continues: • Post-harvest systems that use water should be designed in a manner to minimize places where product lodges and dirt builds up.	N/I	N/I	N/I	5.3.2.1 (SQF2000) The delivery of water within the premises shall ensure potable water is not contaminated.
	F3. Producers should evaluate the food safety risks associated with the water	5.2.2.1 (F1, above), which continues: • Recycled water may be used with no further treatment provided its use does not constitute a risk to the safety of fresh fruits and vegetables (e.g. use of water recovered from the final wash for the first wash).	Criterion 73 Sources of water used in the post harvest process shall be evaluated against potential risks of contamination using the decision diagram below and the results of the evaluation documented, actions documented and an assessment of the effectiveness of the actions recorded.[3,5] Section D3.1 Water suitability Evaluation should be carried out at a frequency which allows management of the potential risk, e.g. when the condition of the water source changes, but shall be carried out at least annually. Where a risk has been identified, steps should be taken to ensure the water quality is made adequate for its intended use, for example: • Alternative sources known to be acceptable for human consumption and fit for purpose, • Appropriate chemical of physical treatment of the water, making it fit for purpose, • Good hygiene practice is required for all steps – replacement of the used water and cleaning of equipment.	Criterion 96 Sources of water used in the post harvest process shall be evaluated against potential risks of contamination using the decision diagram below and the results of the evaluation documented. In the absence of any local authority water potability documentation, water shall be tested for potability at least annually against potential risks of contamination. Water and if taken, produce residue test records shall be kept, actions documented and an assessment of the effectiveness of the actions recorded. Where a risk has been identified, steps shall be taken to ensure the water quality is made adequate for its intended use, for example: • Alternative sources known to be acceptable for human consumption and fit for purpose, • Appropriate chemical of physical treatment of the water, making it fit for purpose, • Good hygiene practice is required for all steps – replacement of the used water and cleaning of equipment.[4,5] Section H6.1	N/I	6.9.2.1 (SQF1000) Water quality shall be monitored to verify it complies with the established water microbiological standard or criteria established. A verification schedule shall be prepared indicating the location and frequency of monitoring, which shall be decided by the hazard analysis, best practices within country of production, or applicable legislation.

Table F: WATER FOR POST-HARVEST PROCESSES

GENERIC CRITERIA	CAC/RCP 53-2003	New Zealand GAP	NZ GAP (GLOBALGAP)	GLOBALG.A.P.	SQF
			Water The frequency of the evaluation should allow for the management of the potential risk, e.g. when the condition of the water source changes.		
F4. Producers should test the microbial quality of the water if necessary (or obtain test results from supplier)	N/I	Criterion 73 (F3, above), from decision diagram:[3] Test water for microbiological contamination.	Criterion 96 (F3, above), from decision diagram:[4] Test water for microbiological contamination.	(AF1.2.1, Table B) FV5.7.1 Is the source of water used for final product washing potable or declared suitable by the competent authorities? Compliance: The water has been declared suitable by the competent authorities and/or within the last 12 months a water analysis has been carried out at the point of entry into the washing machinery. The levels of the parameters analyzed are within accepted WHO thresholds or are accepted as safe for the food industry by the competent authorities. FV5.7.3 Is the laboratory carrying out the water analysis a suitable one? The water analysis for the product washing is undertaken by a laboratory currently accredited to ISO 17025 or its national equivalent or that can demonstrate via documentation that it is in the process of gaining accreditation. FV5.8.5, CC5.3.6 (F12, below)	5.7.1.5 (SQF1000) Water used in the packing shed or field to wash produce must be potable. Water potability test results must be reviewed and kept on file by the SQF Practitioner. 6.8.3.1 (SQF2000) Microbiological analysis of the water and ice supply shall be conducted to verify the cleanliness of the supply, the monitoring activities and the effectiveness of the treatment measures implemented. 6.8.3.2 (SQF2000) Water and ice shall be analyzed using reference standards and methods. 6.9.2.1 (F3, above)
F5. Producers should test the chemical quality of the water if necessary (or obtain test results from supplier)	N/I	N/I[5]	N/I[5]	FV5.7.1, FV5.7.3 (F4, above) FV5.8.5, CC5.3.6 (F12, below)	5.7.1.5 (F4, above)
F6. Producers should take corrective action to address any contamination at, or after, water uptake from source (e.g. treatment)	5.2.2.1 (F1, above), which continues: • Antimicrobial agents should only be used where absolutely necessary to minimize cross-contamination during post-harvest and where their use is in line with good hygienic practices. The antimicrobial agents levels should be monitored and controlled to ensure that they are maintained at effective concentrations. Application of antimicrobial agents, followed by a wash as necessary, should be done to ensure that chemical residues do not exceed levels as recommended by the Codex Alimentarius Commission.	Section D3.1 (F3, above)	Criterion 96 (F3, above)	N/I	6.9.3.1 (SQF1000) When monitoring shows that water does not meet established criteria or standard, producer will have a corrective action plan developed which could include additional treatment for water, additional sources for water, product identification and disposition or other alternative actions to adequately control the identified hazards.
F7. Producers should control and monitor the effectiveness	5.2.2.1 (F6, above)	Criterion 73 (F3, above)	Criterion 96 (F3, above)	N/I	5.7.5.2 (SQF1000) Flume water treated with chemicals (i.e.

Table F: WATER FOR POST-HARVEST PROCESSES

GENERIC CRITERIA		CAC/RCP 53-2003	New Zealand GAP	NZ GAP (GLOBALGAP)	GLOBALG.A.P.	SQF
	of any water treatment					chlorine, chlorine dioxide, peracetic acid) must be monitored on a pre-determined basis to verify compliance with the target range. Monitoring my include pH, ppm, ORP and/or temperature. 6.8.2.2 (SQF2000) Treated water shall be regularly monitored to ensure it meets the indicators specified. 6.8.3.1 (F4, above)
	F8. Producers should control and monitor the temperature of the water	5.2.2.1 (F1, above), which continues: • Where appropriate, the temperature of the post-harvest water should be controlled and monitored.	Section D3.1 Water suitability The temperature of the water (especially where contact is prolonged e.g. wash water) may contribute to the absorption of microbes and contaminants into the produce, by osmosis and therefore, the water temperature should be as close to that of the produce as possible (or slightly warmer) to help prevent the absorption.	Section H6.1 Water The temperature of the water (especially where contact is prolonged e.g. wash water) may contribute to the absorption of microbes and contaminants into the produce, by osmosis and therefore, the water temperature should be as close to that of the produce as possible (or slightly warmer) to help prevent the absorption.	N/I	5.7.5.2 (F7, above)
	F9. Producers should control and monitor the quality of water in recirculated water systems	5.2.2.1 (F1, above), which continues: • Recycled water should be treated and maintained in conditions that do not constitute a risk to the safety of fresh fruits and vegetables. The treatment process should be effectively monitored and controlled.	N/I	Section H6.1 (F1, above)	FV5.7.2 If water is re-circulated for final product washing, has this water been filtered and are pH, concentration and exposure levels to disinfectant routinely monitored? Compliance: Where water is re-circulated for final produce washing, it is filtered and disinfected, and pH, concentration and exposure levels to disinfectant are routinely monitored. Documented records are maintained. Filtering must be done with an effective system for solids and suspensions that have a documented routine cleaning schedule according to usage rates and water volume. Where recording of automatic filter backwash events and changes in dosage rates by automated sanitizer injectors may be impossible, a written procedure/policy must explain the process.	5.7.5.2 (F7, above)
APPLICATION	F10. Producers should base the application of water on the requirements of the crops, or specialist advice	N/I	N/I	N/I	N/I	N/I
	F11. Producers should minimise contact between water and produce	N/I	N/I	N/I	N/I	N/I
	F12. Producers should use potable water wherever water	5.2.2.1 (F1, above)	Criterion 73 (F3, above), from decision diagram:[3]	Criterion 96 (F3, above), from decision diagram:[4]	FV5.7.1 (F4, above)	5.7.1.5 (F4, above)

Table F: WATER FOR POST-HARVEST PROCESSES						
GENERIC CRITERIA		CAC/RCP 53-2003	New Zealand GAP	NZ GAP (GLOBALGAP)	GLOBALG.A.P.	SQF
	comes into contact with produce, or for any final rinsing steps	5.5 Water used in the packing establishment Refer to the *General Principles of Food Hygiene.*[2]	Is the water used for final washing potable?	Potable source of final wash water?	FV4.1.12 If ice (or water) is used during any operations relating to harvest, is it made with potable water and handled under sanitary conditions to prevent produce contamination? Compliance: Any ice or water used at point of harvest must be made with potable water and handled under sanitary conditions to prevent produce contamination. FV5.8.5, CC5.3.6 Is the source of water used for post-harvest treatments potable or declared suitable by the competent authorities? Compliance: The water has been declared suitable by the competent authorities and/or within the last 12 months a water analysis has been carried out at the point of entry into the washing machinery. The levels of the parameters analyzed are within accepted WHO thresholds or are accepted as safe for the food industry by the competent authorities.	6.9.1.1 (SQF1000) Water used for washing and treating product, cleaning food contact surfaces and mixing sanitizer solutions shall comply with potable water microbiological standards in the country of production. 5.3.1.1 (F1, above) 6.8.1.1 (SQF2000) Water: i. Used for washing, thawing and treating food; ii. Used as an ingredient or food processing aid; iii. For cleaning food contact surfaces; iv. For the manufacture of ice; and v. For the manufacture of steam that will come in contact with food or used to heat water that will come in contact with food shall comply with national or internationally recognized potable water microbiological and quality standards as required.
	F13. Producers should use potable water in cooling systems wherever water comes into contact with produce (e.g. ice, spray coolers)	5.2.2.1 (F1, above), which continues: • Ice should be made from potable water. Ice should be produced, handled and stored to protect it from contamination. 5.2.2.3 Cooling of fresh fruits and vegetables Potable water should be used in cooling systems where water or ice is in direct contact with fresh fruits and vegetables (e.g. hydro cooling, ice cooling). The water quality in these systems should be controlled and maintained.	N/I	N/I	FV4.1.12 (F12, above)	5.3.3.1 (SQF2000) Adequate supplies of ice derived from potable water shall be provided for use during processing operations or as a processing aid or an ingredient. 6.8.1.1 (F12, above) 6.9.4.1 (SQF1000) Ice shall be made from potable water. Producer will verify that any ice used is made from potable water.
	F14. Producers should minimise water on the produce before packing	N/I	N/I	N/I	N/I	N/I
	F15. Producers should maintain water delivery systems	N/I	N/I	N/I	N/I	5.7.4.6 (SQF1000) Hydrocoolers, if used, must be included in a Preventive Maintenance schedule.
RECORDS	F16. Producers should maintain records of water quality (e.g. *E. coli* concentration, treatments)	N/I	Criterion 73 (F3, above)	Criterion 96 (F3, above)	N/I	5.7.1.5 (F4, above)
	F17. Producers should maintain records of water use (e.g. date applied, amount applied, how applied)	N/I	N/I	N/I	N/I	N/I

8 APPENDIX 2: ALIGNMENT OF ASSURANCE PROGRAMMES FOR ORGANIC PRODUCTION

Table 12 (Section 5) presents an alignment of the CAC *Code of Hygienic Practice for Fresh Fruits and Vegetables*, the New Zealand Standard for Organic Production (NZS 8410:2003) and eight assurance programmes against generic criteria, using criterion or section numbers. This Appendix and Appendix 1 support Table 12 by presenting the text of each criterion or section from the documents that were assessed.

This Appendix presents the text from the organic standard and four assurance programmes applicable to organic production:

- NZFSA Official Organic Assurance Programme
- BioGro New Zealand Organic Standards
- AsureQuality Organic Standard
- Demeter New Zealand.

Appendix 1 presents the text from the CAC code and four assurance programmes applicable to conventional production.

The text is summarised in five tables:

Table A:	Natural fertilisers.
Table B:	Water for primary production. The information is relevant to all water used for primary production, irrespective of the purpose of the water (e.g. irrigation, sprays). Tables C and E refer to the information in Table B, where relevant.
Table C:	Water for irrigation (outdoor or indoor non-hydroponic growing systems).
Table E:	Water for agricultural chemicals. This includes water used for mixing or diluting liquid organic preparations, e.g. compost teas, seaweed preparations.
Table F:	Water for post-harvest processes.

There is no Table D (Water for hydroponic growing systems), as can be found in Appendix 1. Organic production prohibits hydroponic systems.

In these tables:

- N/I (Not Included) marks where there is no requirement or recommendation presented in the document for a generic criterion.
- Some of the text may be abbreviated to present only the relevant information (e.g. where a document lists several bullet points, only those relevant to the criterion are presented).
- Where a piece of text from a document aligns against several generic criteria, the document text is only reproduced against one generic criterion; the other relevant generic criteria will contain a reference to the generic criterion where the text has been located.
- Italicised text has been used by the authors of this report for any summaries or commentary.

Furthermore, each table is preceded by any additional information relating to the table including any numbered footnotes relating to the table.

The text presented in Tables A-C, E and F in this Appendix has been extracted from the following documents:

1. New Zealand Standard for Organic Production (NZS8410:2003)

Document reviewed:

- New Zealand Standard Organic Production (NZS8410:2003)

Notes: Within the requirements, the word "shall" refers to practices that are mandatory for compliance with the standard. The word "should" refers to practices that are advised or recommended (these are annotated with an (R) next to the requirement number).

Section 7 of the document addresses landless production systems and contains specific requirements for the production of mushrooms, sprouts, wheat grass and container growing. The specific requirements for mushrooms, sprouts and wheat grass have not been included in the following tables, but the requirements for the more generic group of container grown plants have.

The text in the following tables has been reproduced with the permission of Standards New Zealand. Content has been sourced from NZS 8410:2003 Organic production with permission from Standards New Zealand. NZS 8410:2003 can be purchased from Standards New Zealand at www.standards.co.nz.

2. NZFSA Official Organic Assurance Programme (OOAP NZFSA Standard OP3)

Document reviewed:

- Technical rules for organic production (NZFSA Standard OP3, Appendix two) (Version 7, November 2009).

Notes: Rule 5.1.12 contains specific requirements for the production of mushrooms, which have not been included in the following tables.

Hydroponic production is prohibited (5.1.13), so there are no rules relating to the use of water for hydroponic production (although indoor growing is not prohibited).

Section 8 in the document presents rules for processed foods, which includes the reception, preparation/processing, packaging, labelling, storage and transport of agricultural products. This section applies to horticultural packhouses.

3. BioGro New Zealand Organic Standards

Document reviewed:

- BioGro New Zealand Organic Standards (4 May 2009).

Notes: The Standard contains recommendations and requirements. Recommendations are identified ("Recommendation") in the tables.

The Standard is comprised of several modules. The modules applicable to this study are Module 3 (Certification System), Module 4 (Orchard Production Standard), Module 9 (Crop Production Standard) and Module 13 (Processing Standard). The modules follow the same numbering system, so each requirement in the tables below is followed by "orchard", "crop" or "processing" to identify its origin.

Hydroponic production is prohibited but container-grown crops can be considered for BioGro certification (Module 9, Section 3.7). There are no rules relating specifically to the use of water for container production.

4. AsureQuality Organic Standard

Document reviewed:

- AsureQuality Organic Standard for Primary Producers (Version 4, December 2010).
- AsureQuality Organic Standard for Processors (Version 4, December 2010).

Notes: Hydroponic production is prohibited (4.14.3) but container-grown crops are permitted (4.14.4). There are no rules relating specifically to the use of water for container production.

There are specific requirements for sprout (4.14.1) and mushroom (4.14.2) production, but these requirements are not included in the tables below.

5. Demeter New Zealand (Bio Dynamic Farming and Gardening Association)

Documents reviewed:

- Organic Production Standards for Biodynamic Agriculture (2008).
- Organic Production Standards for Biodynamic Agriculture 2011 (unproofed copy).
- Processing Standards for the use of Demeter, Biodynamic® and related trademarks (Demeter International, revised June 2009).
- Annual Report Form (January 2011).
- The Farm Profile Template for Demeter Certification (January 2011).
- The Management Plant Template for Demeter Certification (January 2011).
- Supplementary Information: Brought-in materials and livestock (February 2009).
- Demeter New Zealand Bulletin No 1 (January 2008).
- Demeter New Zealand Bulletin No 2 (February 2009).

Notes: Sections 3 (How Demeter Certification Works), 4 (Biodynamic Preparations), 5 (Arable and Annual Plant Production), 6 (Orchard and Perennial Plant Production) and 8 (Harvest and Post Harvest Management) of the organic production standards were examined. There were no requirements for water in Section 8, however 8.10.1 states that "Processing shall be according to the requirements of the *Demeter International Processing Standards*". The Processing Standards have requirements for the use of water that are commodity-specific. The standards listed in Table F, below, are from Part B-I (Standards for the certification of DEMETER fruit and vegetable products, including potatoes and potato products), and from Part B-V (Standards for the treatment and processing of DEMETER herbs and spices).

The organic production standards require growers to prepare an annual report, a farm profile and a management plan, and to address any requirements released in a Supplementary Information document and Demeter New Zealand Bulletins (3.4.5, 3.5.2). Compliance with these documents is mandatory for certification, so any relevant content has been included in the following tables.

Hydroponic production is prohibited (Section 1.4, 5.4.10.1 and 6.5.10.1), except for watercress and wasabe. Container growing is also prohibited for crops grown to harvest

(5.4.10.2, 6.5.10.2). Indoor production (production under glass or plastic) is permitted, but only to extend the growing season appropriately (5.4.11, 6.5.11).

The Organic Production Standards require cropping farms to have some livestock (5.4.12), but there are no requirements for preventing contamination from livestock areas into cropping areas.

TABLE A: NATURAL FERTILISERS

Footnotes for Table A:

1. NZS8410:2003: Appendix B lists the inputs permitted and the conditions under which they meet the Standard. Table B1 in the appendix lists the materials permitted for soil fertilising, conditioning and growing media (e.g. animal manures, compost from plant material and animals manures, fish products, mulch), and Table B2 lists materials for soil fertilising and conditioning that shall only be used where the need can be justified (e.g. blood and bone). Human sewage sludge (treated or untreated) does not appear on this list and is therefore not permitted for use.
2. NZS8410:2003: Section 5.1, Soil management – soil and fertility. Requirement 5.1.1: Operators shall fulfil the requirements of 4.4.
3. OOAP NZFSA Standard OP3: Section 6 covers the rules of production for animal and animal products and Section 6.7.2 requires that the total amount of manure applied on the holding may not exceed 170 kg of nitrogen per year/hectare of agricultural area used.
4. OOAP NZFSA Standard OP3: Table 1 (Section 13) lists the permitted fertilisers and soil conditioners and the conditions for their use, e.g. farmyard manure is permitted where it does not come from factory farming.
5. AsureQuality: Section 10 contains a list of restricted permitted substances for the production of organic foods and the conditions of use, and Table 1 lists substances for use in crop production.
6. Demeter: Tables 5-1 and 6-1 contain lists of fertilising and soil conditioning materials and amendments, and conditions for their use. There is a requirement for many of the organic fertilisers to be produced on the farm or brought-in from certified biodynamic or organic sources.

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK

Table A: NATURAL FERTILISERS

	GENERIC CRITERIA	NZS 8410	NZFSA OOAP	BioGro	AsureQuality	Demeter
SOURCE	A1. Producers must only use fertilisers certified to, or specified by, a specific programme or standard (e.g. organic standard, Fertmark)	4.1.4 Inputs other than those permitted in Appendix B shall not be used.[1] 7.3.1 Potting compost or other growing media for container growing or planting material shall consist only of those products listed in Table B1.[1]	5.1.4 The fertility and the biological activity of the soil must be maintained or increased, in the first instance, by: • incorporation of animal manure, preferably composted and from organic animal production, within the restrictions of Section 6.7.2, in accordance with the provisions of these Rules. By products from animal farming such as farmyard manure may be used if they come from animal holdings respecting organic animal production principles recognised in New Zealand.[3] • incorporation of other organic material, preferably composted, from holdings producing according to these Rules. Table 1 (Section 13) Fertilisers and soil conditioners. General conditions for all the products: • use in accordance with Sections 5, 6, 7 and 8 of these rules.[4]	3.1.1 (Orchard/Crop) Fertiliser supply Permitted and restricted fertilisers should be obtained from a BioGro certified/approved supplier where available locally. If not, then every effort must be made and documented to ensure that any brought-in materials comply with all requirements of the BioGro standards. 3.1.1 (Orchard/Crop) Liquid fertilizers including vermicast liquids and compost teas Liquid fertilisers may be made on the farm or BioGro certified/approved products may be used. 3.1.3 (Orchard/Crop) Composts and vermicasts Composts and vermicasts may be made on the orchard/farm or purchased from BioGro certified/approved sources. Composts and vermicasts made on the orchard/farm must be made from ingredients sourced from certified properties and/or ingredients selected in compliance with the *BioGro Compost Guide*. 3.1.3 (Orchard/Crop) Mulches Where available, mulch materials must be sourced from certified farms. 3.1.3 (Orchard/Crop) Composts and vermicasts Compost made on the orchard/farm must have been heated, been aerated and mixed, matured sufficiently, and have been produced in compliance with the requirements of the *BioGro Compost Guide*. Vermicasts made from low risk ingredients approved by BioGro do not have to go through a heat process.	4.2.1 The fertility and biological activity of the soil should be maintained or increased, where appropriate, by: (b) Incorporation in the soil of organic material, composted or not, from holdings producing in accordance with the Standard. By-products from livestock farming, such as farmyard manure, may be used if they come from livestock holdings producing in accordance with this Standard. 4.2.2 Substances, as specified in Section 10, Table 1, may be applied only to the extent that adequate nutrition of the crop or soil conditioning are not possible by the methods set out in (4.2.1) above, or, in the case of manures, they are not available from organic farming.[5] 4.2.3 You must not use animal residues and manures from battery poultry systems.	4.4.2 *(Biodynamic preparations)* If preparations are not made on the farm, they shall be from a source approved by Demeter New Zealand and documented as such. 5.4.1.3, 6.5.1.3 All materials used for soil management, amendment or fertilising shall meet the requirements of Table 5-1/Table 6.1.[6] 6.5.1.7 Guidelines for worm farms are under development. In the interim, only material free from contaminants and so documented shall be used.
	A2. Producers must not use untreated human sewage sludge or any human sewage sludge	4.1.4 (A1, above) *(human sewage sludge is not among the list of permitted organic materials in Appendix B)*	Table 1 (A1, above) *(human sewage sludge is not among the list of permitted organic materials in Table 1)*	3.1.3 (Orchard/Crop) Sewage by-products Sewage sludge or bio-solids are prohibited and must not be applied directly, or used as an ingredient in composts. 3.1.3 (Orchard/Crop)	Table 1 (Section 10) Substances for use in crop production Human excrement (including urine) is prohibited.	5.4.14, 6.5.14 Sewage Human waste or sewage (sometimes called "bio-solids"), or composts including it shall not be used, even after treatment.

Table A: NATURAL FERTILISERS

GENERIC CRITERIA		NZS 8410	NZFSA OOAP	BioGro	AsureQuality	Demeter
				Sewage Manures and composts containing human excrement, i.e. faeces and urine, are prohibited, and may not be brought onto the property or used as a compost ingredient.		
	A3. Producers can use treated human sewage sludge if it meets appropriate standards (e.g. NZWWA guidelines, WHO guidelines)	Not applicable *(4.1.4 (A1, above): Human sewage sludge is not among the list of permitted organic materials in Appendix B)*	Not applicable *(Table 1 (A1, above): Human sewage sludge is not among the list of permitted organic materials in Table 1)*	Not applicable *(3.1.3 (A2, above): No human sewage is permitted)*	Not applicable *(Table 1 (A2, above): No human sewage is permitted)*	Not applicable *(5.4.14, 6.5.14 (A2, above): No human sewage is permitted)*
QUALITY	A4. Producers should evaluate the food safety risks associated with the fertiliser	N/I	N/I	N/I	N/I	N/I
QUALITY	A5. Producers should test the microbial quality of the fertiliser if necessary (or obtain test results from supplier)	N/I	N/I	N/I	N/I	N/I
QUALITY	A6. Producers should test the chemical quality of the fertiliser if necessary (or obtain test results from supplier)	4.1.6(R) The occurrence of agrichemical residues and heavy metals in soil inputs should be minimized. Appendix C lists the maximum acceptable levels and requirements for analytical testing. From Appendix C: C2. Heavy metal levels in soils and composts *(the maximum levels in compost (mg/kg) are listed for eight metals)*	N/I	Appendix A Residue levels in certified products, water, soil and composts A4.3 - Heavy metal levels in soils and composts *(Table A3 lists limits for nine heavy metals in soils and composts)*	4.5.2 Heavy metals in compost shall not exceed the following levels: *(levels for eight heavy metals are listed).* Table 1 (Section 10) Substances for use in crop production *(lists limits for heavy metals in composts from organic household refuse and products of animal origin)*	5.4.7.1, 6.5.7.1 Before plant and fish wastes or animal faeces are brought in as manures, compost, composting, bedding or mulching materials, the licensee shall investigate the sources and acceptability and obtain documentary evidence: • that these inputs are free from materials such as heavy metals or pesticides or other contaminants that may cause soil or product contamination or that do not break down in the composting process. Where such evidence cannot be produced to the satisfaction of Demeter NZ, batch residue testing for specific contaminants or other investigations may be required prior to usage. Supplementary information: Soil fertility and conditioning materials *(Requires producers to obtain written statements that products are chemical-free, or detailing what chemicals may be in the products)*
QUALITY	A7. Producers should (or must) use treated fertiliser (e.g. pasteurised, composted)	4.4.1 (also 5.1.1)[2] The quality of the soil shall be shown to be maintained or improved over an appropriate period of time. Means to achieve this may include: • The use of fully composted organic matter derived from selected sources as listed in Table B1 and B2 • Other methods and inputs as listed in Appendix B.[1]	5.1.4 (A1, above)	3.1.3 (Orchard/Crop) Raw manures Wit the exception of a certified property's own dairy or pig effluent from the certified area and certified livestock, raw animal manures must not be applied directly to soils. Raw animal manures (including those from the certified property if collected) must be hot composted before use, refer to BioGro Compost Guide.	N/I	5.4.1.7, 6.5.1.8 Application of fertilising materials of plant or animal origin without prior composting (hot composting or in liquid manures) requires express permission from Demeter New Zealand.

Table A: NATURAL FERTILISERS							
GENERIC CRITERIA		NZS 8410	NZFSA OOAP	BioGro	AsureQuality	Demeter
				3.1.3 (Orchard/Crop) Industrial by-products Food and textile industry by-products of biodegradable material, i.e. of microbial, plant, or animal origin, free of synthetic additives, may be used provided they are hot composted, refer BioGro Compost Guide.		
APPLICATION	A8. Producers should base the application of natural fertilisers on the nutritional requirements of the soil or crops and the nutritional content of the fertiliser, or specialist advice	N/I	5.1.5 Other organic or mineral fertilisers, listed in Table 1, may exceptionally, be applied, as a complement to the extent that:[4] • adequate nutrition of the crop being rotated or soil conditioning are not possible by the methods set out under 5.1.4 • with regards to the products in Table 1 referring to manure and/or animal excrements: these products may only be used to the extent that, in combination with the animal manure referred to in 5.1.4, the restrictions of Section 6.7.2 are satisfied.[3] The operator shall keep documentary evidence of the need to use these products.	3.1.3 (Orchard/Crop) Soil testing Regular soil testing, as specified below, is required to: i) monitor fertility levels to ensure that the overall fertility of orchard soils is maintained and enhanced; and/or ii) determine whether mineral supplementation is necessary and appropriate; and/or iii) determine the need for restricted fertilisers.	Table 1 (Section 10) Application of substances in Section 10, Table 1 must be based on soil fertility test results and a fertiliser recommendation.[4] *(statement in section 4.2)*	N/I
	A9. Producers should minimise contact between the fertiliser and the produce	N/I	N/I	N/I	N/I	N/I
	A10. Producers should maximise the time between final natural fertiliser application and harvest	N/I	N/I	N/I	N/I	N/I
	A11. Producers should minimise contamination from natural fertilisers applied in adjoining areas	N/I	N/I	N/I	N/I	N/I
	A12. Producers should maintain fertiliser application machinery	N/I	N/I	N/I	N/I	N/I
	A13. Producers should store natural fertilisers away from produce production areas	N/I	N/I	N/I	N/I	N/I
RECORDS	A14. Producers should maintain records of fertiliser source (e.g. name of supplier, type of product such as manure or vermicast)	4.1.1 Operators shall follow an organic management plan that identifies how they will develop and maintain the organic integrity of their operation in accordance with this Standard. See Appendix A for details of organic management plans. Operators shall keep sufficient records of all activities as would be required for a third party to	9.1.6 Plant production records must be compiled in the form of a register and kept available to the TPA at all times as the address of the holding. Such records shall provide at least the following information: • Fertiliser: date of application, type and amount, parcels concerned • Purchase of farm inputs: date, origin,	8.4 (Certification system) Record keeping All records relating to production, inputs and sales may be requested and must be available during the audit. Documents for verification of compliance must be kept for a minimum of five years including, but not limited to: a. Primary producers – affidavit, maps, inputs used, records such as spray	4.11.4 You must keep written and/or documentary accounts, which enable AsureQuality to trace the origin, nature and quantities of all raw materials bought, and the use of such materials.	3.15.2 Contents of the primary record The following details must be recorded with special care: a) details of all production and use of biodynamic preparations b) details of the use of all other brought-in or own produced materials, whether considered to be benign or not. These must include material, rate of use, time

Table A: NATURAL FERTILISERS							
GENERIC CRITERIA		NZS 8410	NZFSA OOAP	BioGro	AsureQuality	Demeter
		verify that they have conformed to this Standard and their management plans. Appendix A A3. Record keeping • Written and or documentary accounts to enable traceability of the origin, nature and quantities of all raw materials bought and the use of such materials. 4.4.3 (also 5.1.1)[2] Detailed records shall be kept of the nutrient inputs including source, technical characteristics, certification status (if any), amount and use.	type, amount purchased and the use of the products.	diaries and production data, soil residue tests and DDT tests, production records, reconciliation data.		of use, crop or animal applied to, location, area affected; c) full details of the bringing-in of any materials or livestock, including certificates of origin or supplier statements as set out in the most recent technical bulletin Procedures for Brought-in Materials and Livestock; 5.4.7.4, 6.5.7.4 Documentation to show that the particular batch is a BioGro approved input shall satisfy the requirements of 5.4.7.1/6.5.7.1 and 5.4.7.3/6.5.7.3 above. Annual report (4. Biodynamic field spray preparations, composts and liquid manures spread) Record type, where from, where used, whether prepped, rate applied, when applied. Annual report (7. Brought-in manures, fertilizers & composting & mulch materials) Record material, amount, where from, whether BioGro approved, how much used, where used, when used, amount left. Annual report (8. Composts and liquid manures made) Record type, how much made, date maturing completed, observations, observations of final quality, brought-in materials used, how much left in stock at end of period. Supplementary information: Soil fertility and conditioning materials *(Requires producers to obtain written statements on the source of some products, or the certification of the supplier)*
	A15. Producers should maintain records of fertiliser quality (e.g. *E. coli* or lead concentration)	4.4.3 (A14, above)	N/I	N/I	N/I	5.4.7.1, 6.5.7.1 (A6, above) 6.5.1.7 (A1, above) Annual report (8) (A14, above) Supplementary information: Soil fertility and conditioning materials (A6, above)
	A16. Producers should maintain	4.1.1 (A14, above)	9.1.6 (A14, above)	N/I	4.11.4 (A14, above)	3.15.2 (A14, above)

Table A: NATURAL FERTILISERS						
GENERIC CRITERIA		NZS 8410	NZFSA OOAP	BioGro	AsureQuality	Demeter
	records of fertiliser application (e.g. date applied, amount applied, where applied, how applied)	4.4.3 (A14, above) 4.4.4 (also 5.1.1)[2] Mulching materials, if applied to the soil, do not have to be composted prior to use, but their use shall be documented. Mulching materials shall not contain substances prohibited by this Standard.				Annual report (4) (A14, above) Annual report (7) (A14, above)
	A17. Producers should maintain records of the operator who applied the fertiliser (e.g. contact details, qualifications/training)	N/I	N/I	N/I	N/I	N/I

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK

TABLE B: WATER FOR PRIMARY PRODUCTION

Notes to Table B:
There are no Application criteria in Table B. The application of water is covered separately in tables C and F.

Footnotes for Table B:

1. AsureQuality: 4.5.5 (Section 4.5 Contamination control) reads "In the case of reasonable suspicion of contamination the certification body shall make sure that an analysis of the relevant products and possible sources of pollution (soil, water, air and inputs) shall take place to determine the level of contamination and take measures accordingly". The "measures" may or may not include addressing contamination at the water source. 4.5.5 was considered too generic to apply directly to criteria B8 when compared with the requirements of other programmes (e.g. CAC/RCP 53-2003).

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK

Table B: WATER FOR PRIMARY PRODUCTION

	GENERIC CRITERIA	NZS 8410	NZFSA OOAP	BioGro	AsureQuality	Demeter
SOURCE	B1. Producers should consider whether the water sources are suitable for their intended use	4.5.2 Water shall be adequately assessed to ensure appropriateness for use.	N/I	N/I	N/I	Farm profile template (2.5 Water) Give details of all water sources used. Include: Details of contamination risks and resulting water quality.
	B2. Producers must not use untreated sewage water or any sewage water	N/I	N/I	N/I	N/I	5.4.14, 6.5.14 Sewage Human waste or sewage (sometimes called "bio-solids"), or composts including it shall not be used, even after treatment.
	B3. Producers can use treated sewage water if it meets appropriate standards (e.g. NZWWA guidelines, WHO guidelines)	N/I	N/I	N/I	N/I	Not applicable *(5.4.14, 6.5.14 (A2, above): No human sewage is permitted)*
QUALITY	B4. Producers should prevent or minimise contamination to their source waters	4.5.1 The quality of water passing through an organic production unit and of ground water shall be maintained as much as practicable. Effluent management, manuring, nutrient budgeting, cultivation, stock access to streams and irrigation shall be managed using best practice to minimize adverse affects on water quality such as elevated levels of nutrients, suspended solids and microbial pathogens.	N/I	N/I	N/I	Management plan (3.5 Pollution prevention) How do you minimise any risk from pollution sources on the property? Include: Contamination of water (e.g. through dairy effluent) Describe any changes planned, possible or necessary and give your reasons.
	B5. Producers should evaluate the food safety risks associated with the water	N/I	N/I	N/I	N/I	N/I
	B6. Producers should test the microbial quality of the water if necessary (or obtain test results from supplier)	N/I	N/I	N/I	N/I	N/I
	B7. Producers should test the chemical quality of the water if necessary (or obtain test results from supplier)	N/I	N/I	N/I	N/I	N/I
	B8. Producers should take corrective action to address any contamination at, or after, water uptake from source (e.g. treatment)	N/I	N/I	N/I	N/I[1]	N/I
	B9. Producers should control and monitor the effectiveness of any water treatment	N/I	N/I	N/I	N/I	N/I
	B10. Producers should control and monitor the water temperature	N/I	N/I	N/I	N/I	N/I

Table B: WATER FOR PRIMARY PRODUCTION						
GENERIC CRITERIA		**NZS 8410**	**NZFSA OOAP**	**BioGro**	**AsureQuality**	**Demeter**
RECORDS	B11. Producers should maintain records of water quality (e.g. *E. coli* concentration, treatments)	N/I	N/I	N/I	N/I	N/I

TABLE C: WATER FOR IRRIGATION (OUTDOOR OR INDOOR NON-HYDROPONIC SYSTEMS)

Footnotes for Table C:

1. BioGro: Table A2 in Appendix A lists examples of the maximum permitted levels of heavy metals in water. Appendix B lists permitted, restricted and prohibited materials and practices.
2. AsureQuality: There are general standards for soil and water conservation (4.6.1) but these do not specifically relate water use to the requirements of the crop or soil.
3. Demeter: Producers are only required to test water for residues if a new irrigation system is proposed or has been recently added (3.12.2).
4. Demeter: There is a requirement in the Management Plan for producers to document how they minimise water usage on the farm, including irrigation policies, systems and practices. This does not specifically require producers to relate water use to the requirements of the crop or soil.

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK

Table C: WATER FOR IRRIGATION (OUTDOOR OR INDOOR NON-HYDROPONIC SYSTEMS)						
GENERIC CRITERIA		**NZS 8410**	**NZFSA OOAP**	**BioGro**	**AsureQuality**	**Demeter**
SOURCE	C1. Producers should consider whether the water sources are suitable for their intended use	(4.5.2, Table B)	N/I	3.2.2 (Orchard/Crop) a. Water sources should be chosen to ensure adequate supplies of uncontaminated water, and where necessary water purity tests should be carried out. Appendix B Permitted, Restricted, and Prohibited Materials and Practices B1.11 - Water Water used for irrigation and stock watering must be of appropriate quality.	N/I	(Farm profile template (2.5), Table B)
	C2. Producers must not use untreated sewage water or any sewage water	N/I	N/I	N/I	N/I	(5.4.14, 6.5.14, Table B)
	C3. Producers can use treated sewage water if it meets appropriate standards (e.g. NZWWA guidelines, WHO guidelines)	N/I	N/I	N/I	N/I	Not applicable *(5.4.14, 6.5.14, Table B)*
QUALITY	C4. Producers should prevent or minimise contamination to their source waters	(4.5.1, Table B)	N/I	N/I	N/I	(Management plan (3.5), Table B)
	C5. Producers should evaluate the food safety risks associated with the water	N/I	N/I	N/I	N/I	N/I
	C6. Producers should test the microbial quality of the water if necessary (or obtain test results from supplier)	N/I	N/I	N/I	N/I	N/I
	C7. Producers should test the chemical quality of the water if necessary (or obtain test results from supplier)	N/I	N/I	3.2.2 (C1, above) Appendix A, Table A2[1] 3.2.3 (Orchard/Crop) Water source purity Where there is potential contamination, e.g. the catchment area includes conventional horticulture, then proof must be provided annually that irrigation water is not contaminated with any restricted or prohibited materials.[1]	N/I	N/I[3]
	C8. Producers should take corrective action to address any contamination at, or after, water uptake from source (e.g. treatment)	N/I	N/I	N/I	N/I	N/I
	C9. Producers should control and monitor the effectiveness of any water treatment	N/I	N/I	N/I	N/I	N/I
	C10. Producers should control and monitor the water temperature	N/I	N/I	N/I	N/I	N/I

Table C: WATER FOR IRRIGATION (OUTDOOR OR INDOOR NON-HYDROPONIC SYSTEMS)

GENERIC CRITERIA		NZS 8410	NZFSA OOAP	BioGro	AsureQuality	Demeter
APPLICATION	C11. Producers should base the application of water on the water requirements of the soil or crops, or specialist advice	4.5.1 Harvested water shall be used efficiently by carefully matching water usage to crop of pasture requirements, the use of water budgets and the adoption of efficient irrigation practices and systems. Harvesting of water is required to be in accordance with regional council requirements.	N/I	3.2.3 (Orchard/Crop) (c) Optimal watering Irrigation systems must be efficient and effective in supplying orchard/farm needs. Soil and orchards/farms must not exhibit signs of excessive irrigation, namely over-watering, leaching or waterlogging. (d) Monitoring water Optimum water use strategies must be demonstrated and supported by an appropriate method of monitoring. Appendix B, B1.11 Optimum application rates should be used for irrigation	N/I[2]	N/I[4]
	C12. Producers should minimise contact between the water and the produce	N/I	N/I	N/I	N/I	N/I
	C13. Producers should maximise the time between final irrigation and harvest (e.g. >48 hours)	N/I	N/I	N/I	N/I	N/I
	C14. Producers should maintain water delivery systems	N/I	N/I	Appendix B, B1.11 All equipment, such as pipes, troughs etc., maintained to avoid problems such as wastage, leaching of soil nutrients, soil structural damage and soil erosion.	N/I	N/I
RECORDS	C15. Producers should maintain records of water quality (e.g. *E. coli* concentration, treatments)	N/I	N/I	N/I	N/I	N/I
	C16. Producers should maintain records of water application (e.g. date applied, amount applied, where applied, how applied)	N/I	N/I	N/I	N/I	N/I

TABLE E: WATER FOR AGRICULTURAL CHEMICALS

Notes to Table E:
There are no Application criteria in Table E. The application of water is based on the agrichemical requirements of the crop, not on the water requirements.

Footnotes for Table E:
1. Demeter: The Management Plan (4.1 Spray preparations) requires producers to outline their policies for use of the biodynamic spray preparations. This includes recording the water source. However, it does not specifically require the grower to assess the suitability of this water source.

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK

Table E: WATER FOR AGRICULTURAL CHEMICALS							
	GENERIC CRITERIA	NZS 8410	NZFSA OOAP	BioGro	AsureQuality	Demeter
SOURCE	E1. Producers should consider whether the water sources are suitable for their intended use	(4.5.2, Table B)	N/I	N/I	N/I	(Farm profile template (2.5), Table B)[1]
SOURCE	E2. Producers must not use untreated sewage water or any sewage water	N/I	N/I	N/I	N/I	(5.4.14, 6.5.14, Table B)
SOURCE	E3. Producers can use treated sewage water if it meets appropriate standards (e.g. NZWWA guidelines, WHO guidelines)	N/I	N/I	N/I	N/I	Not applicable (5.4.14, 6.5.14, Table B)
QUALITY	E4. Producers should prevent or minimise contamination to their source waters	(4.5.1, Table B)	N/I	N/I	N/I	(Management plan (3.5), Table B)
QUALITY	E5. Producers should evaluate the food safety risks associated with the water	N/I	N/I	N/I	N/I	N/I
QUALITY	E6. Producers should test the microbial quality of the water if necessary (or obtain test results from supplier)	N/I	N/I	N/I	N/I	N/I
QUALITY	E7. Producers should test the chemical quality of the water if necessary (or obtain test results from supplier)	N/I	N/I	N/I	N/I	N/I
QUALITY	E8. Producers should take corrective action to address any contamination at, or after, water uptake from source (e.g. treatment)	N/I	N/I	N/I	N/I	N/I
QUALITY	E9. Producers should control and monitor the effectiveness of any water treatment	N/I	N/I	N/I	N/I	N/I
QUALITY	E10. Producers should control and monitor the water temperature	N/I	N/I	N/I	N/I	N/I
RECORDS	E11. Producers should maintain records of the quality of the water used for agricultural chemicals (e.g. *E. coli* concentration, treatments)	N/I	N/I	N/I	N/I	N/I

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK

TABLE F: WATER FOR POST-HARVEST PROCESSES

Footnotes for Table F:

1. OOAP NZFSA Standard OP3: Drinking water is a permitted additive to organic processed food in Table 4.1, and water is a permitted processing aid for preparation of foodstuffs of plant origin in Table 4.2. According to the definitions presented in Section 3, water used for rinsing or cooling produce (where the water or ice comes into direct contact with the produce) is a food additive, and processing aids are also considered food additives. This rationale has been applied when including Rules 8.2.2 and 9.1.6 in Table F, although only the quality of the water used as an additive has been specified ("drinking water").

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK

Table F: WATER FOR POST-HARVEST PROCESSES						
	GENERIC CRITERIA	NZS 8410	NZFSA OOAP	BioGro	AsureQuality	Demeter
SOURCE	F1. Producers should consider whether the water sources are suitable for their intended use	N/I	N/I	N/I	N/I	(Farm profile template (2.5), Table B)
QUALITY	F2. Producers should prevent or minimise contamination to their source waters	N/I	N/I	N/I	N/I	(Management plan (3.5), Table B)
	F3. Producers should evaluate the food safety risks associated with the water	N/I	N/I	N/I	N/I	N/I
	F4. Producers should test the microbial quality of the water if necessary (or obtain test results from supplier)	N/I	N/I	4.2.2 (Processing) Water used must be potable. Evidence of water potability is required by BioGro.	N/I	N/I
	F5. Producers should test the chemical quality of the water if necessary (or obtain test results from supplier)	N/I	N/I	4.2.2 (F4, above)	N/I	N/I
	F6. Producers should take corrective action to address any contamination at, or after, water uptake from source (e.g. treatment)	N/I	N/I	N/I	N/I	N/I
	F7. Producers should control and monitor the effectiveness of any water treatment	N/I	N/I	N/I	N/I	N/I
	F8. Producers should control and monitor the temperature of the water	N/I	N/I	N/I	N/I	N/I
	F9. Producers should control and monitor the quality of water in recirculated water systems	N/I	N/I	N/I	N/I	N/I
APPLICATION	F10. Producers should base the application of water on the requirements of the crops, or specialist advice	N/I	N/I	N/I	N/I	N/I
	F11. Producers should minimise contact between water and produce	N/I	N/I	N/I	N/I	N/I
	F12. Producers should use potable water wherever water comes into contact with produce, or for any final rinsing steps	10.4.1 The use of additives and processing aids listed in Appendix E should be restricted to the following circumstances: (a) They are indispensable for ensuring the safety of the food; (b) They are essential to prepare or preserve food; (c) They minimize the physical or mechanical effects on a product; or (d) They are required by legislation. The use of such substances should therefore be restricted to where there is	8.2.2 The following conditions shall apply to the composition of organic processed food: b. only additives, processing aids, flavourings, water, salt, preparations of micro-organisms and enzymes, minerals, trace elements, vitamins, as well as amino acids and other micronutrients in foodstuffs for particular nutritional uses may be used, and only in so far as they have been authorised for use in organic production. Permitted materials are	3.6.3 (Orchard/Crop) Washing water Water used for washing produce must be of potable quality. 4.2.2 (F4, above). Appendix C: Allowed ingredients of non-agricultural origin, additives, and processing aids Requirement C1.1 Allowed ingredients of non-agricultural origin	6.2.1 Organically derived ingredients must be used if available. Non-organic ingredients may be used in the preparation of processed organic products where such ingredients: Are additives and processing aids, which appear in Table 3 and are in compliance with the specific conditions. 6.2.7 (ingredients) Water must be potable	1.3.1.1 (Part B-I, fruit and vegetables) Washing of fruit Preliminary washing can be with tap water. Final cleaning of the fruit must be done with pure drinking water. 2.3.1.1 (Part B-I, fruit and vegetables) Washing Preliminary washing can be done with tap water. Final cleaning must be done with pure drinking water. 1 (Part B-V, herbs and spices)

Table F: WATER FOR POST-HARVEST PROCESSES							
GENERIC CRITERIA		NZS 8410	NZFSA OOAP	BioGro	AsureQuality	Demeter
		a demonstrated technological need. From Appendix E: Processing inputs. Table E1 – Substances permitted as food additives, including carriers Potable water: Potable water shall be used where the water comes into contact with a food product.	listed in Table 4.1 and Table 4.2.[1]	Water: Must be potable.	6.6.2 Only water and substances that appear in Table 3 as processing aids may be used after harvest as cleaners or disinfectants in direct contact with organic food. Table 3 (Section 10): Combined tables of ingredients, additives and sanitisers Water and steam – potable water only.	Harvest If cleaning is required, water of drinking quality, without any additives, is to be used. This cleaning water must be removed from the herbs and spices as completely as possible before further processing.
	F13. Producers should use potable water in cooling systems wherever water comes into contact with produce (e.g. ice, spray coolers)	10.4.1 and Table E1 (F12, above)	8.2.2 (F12, above)	4.2.2 (F4, above), Appendix C (F12, above)	Table 3 (F12, above)	N/I
	F14. Producers should minimise water on the produce before packing	N/I	N/I	N/I	N/I	1 (Part B-V, herbs and spices) (F12, above)
	F15. Producers should maintain water delivery systems	N/I	N/I	N/I	N/I	N/I
RECORDS	F16. Producers should maintain records of water quality (e.g. *E. coli* concentration, treatments)	N/I	9.1.6 Plant production records must be compiled in the form of a register and kept available to the TPA at all times as the address of the holding. Where the unit itself processes its own agricultural produce, the accounts must contain information on the origin, nature and quantities of ingredients, additives and manufacturing aids delivered to the unit and the composition of the processed products.[1]	4.2.2 (F4, above)	N/I	N/I
RECORDS	F17. Producers should maintain records of water use (e.g. date applied, amount applied, how applied)	N/I	9.1.6 (F16, above)	N/I	N/I	N/I