Generic HACCP Models for Food Assurance Programmes

Operational research contract FMA169

FINAL REPORT

Including:

Objective 1 - Stage 1 & 2
International Literature Search Summary Report

Objective 2
HACCP Models Report

Prepared for: **MAF Dairy & Plants**, P O Box 2526, Wellington

Prepared by: **Liz Faulkner,** AgriQuality New Zealand Ltd
Private Bag 14946, Panmure, Auckland
faulknerl@agriquality.co.nz

And:
Stan Bunting, Sandra Walker, Andrew Mill, Michael Breckell, Melanie Dingle, Helen Goodwin, Cherie Wiklund

And:
Beverley Joe

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SECTION A

1. INTRODUCTION TO OBJECTIVES

1.1 Introduction to Objective 1 (Stage 1)

MAF Biosecurity Authority initiated the first project (reference FMA 101), in response to industry feedback that existing quality assurance specifications were causing difficulties. The objective of that project was to review, research and design user-friendly HACCP models acceptable to industry for export plant integrity.

The initial project produced a generic process flow and a Code of Practice for the Export Certification of Plants and Plant products – A Risk Management Programme for Phytosanitary and Food Safety Based on the principles of HACCP.

The objectives of Stage 1 are to:

- Critically review the document produced under contract number FMA 101 - *MAF Plants BioSecurity Code of Practice for the Export Certification of Plants and Plant Products, A Risk Management Programme for Phytosanitary & Food Safety Based on the Principles of HACCP.*

- Identify the gaps within the document relating to:
  - Knowledge about hazards,
  - Application of the HACCP methodology,
  - Validation of CCPs, and
  - Relevance to food safety.

1.2 Results of Objective 1 (Stage 1)

"*MAF Plants Biosecurity Code Of Practice For The Export Certification Of Plants And Plant Products*"

The document attempted to deliver a system to meet food safety, phytosanitary, market access and quality outcomes, whilst trying to introduce the concept of risk management - this was difficult to achieve in one document and has unfortunately resulted in a diluted approach.

The document was based on establishing HACCP models over a range of interrelated market outcomes, not all of which were food safety. It did not adequately address food safety issues in plant products and in particular did not identify scientific data to validate the identification of hazards.

It was recognised that there was a need for a more scientific basis to a number of the HACCP models in the Code of Practice given that internationally there is growing interest and concern in the safety (particularly from the microbiological perspective) of edible plant products.

It is acknowledged that this previous work made valid points creating a good platform to move forward, and it identified further specific work was required to address HACCP in fresh produce. However, any HACCP analysis in the fresh produce industry should not be modelled on the original report. Specific fresh produce food safety issues were not identified. As a result it was not possible to confirm specific hazards and the necessary controls.

1.3 Introduction to Objective 1 (Stage 2)

- Identify critical food safety issues, hazards and desired outcomes from an international literature search. Controls will be covered under Objective Two, and
- Reference other international HACCP requirements for market access and food safety, such as: *Guidance for Industry – Guide to Minimize Microbial Food Safety Hazards for Fresh Fruit and Vegetables – US Department of Health and Human Services – Food and Drug Administration (CFSAN) October 1998.*

The scope of the Literature Search was restricted to export crops, which are primarily intact products including:

- Root crops - potatoes, carrots, onions,
- Fruit crops - apples, kiwifruit, summerfruit, sub-tropicals,
- Seeds/sprouts,
- Leafy green - lettuce, brassicas,
- Glasshouse - tomatoes, capsicums,
- Berryfruit, and
- Organic crops.

2. CRITICAL FOOD SAFETY ISSUES, HAZARDS AND DESIRED OUTCOMES

With the increasing interest globally, of improving the diet and health of consumers, there is increased demand for fresh fruits and vegetables, which will be referred to as fresh produce or Ready To Eat (RTE) fruit and vegetables (O'Brien, 2000).

Meeting this demand has stimulated trade of fresh produce worldwide. This has highlighted the reported incidences of foodborne illnesses related to the consumption of fresh produce particularly produce contaminated with pathogenic organisms. The incidence of foodborne illnesses (FBI) however can fall under the categories of biological contaminants such as microbial pathogens, chemical contaminants, and physical contaminants.

2.1 Trends In Foodborne Illness Outbreaks In Fresh Produce

Beuchat (2000) indicates that outbreaks associated with fruit and vegetables have been documented to increase in recent years as a result of dietary habits and increase of imported food. The Australian Vegetable Industry (2001) also cite a reason for the increase to a change in eating habits particularly an increase in fresh, ready to eat food which are consumed without the traditional "cook and kill" step. Further specific references of outbreaks trends include:

- Minnesota USA 1981-1989 yielded 20% confirmed foodborne illnesses associated with fresh produce increasing to 29% from 1990 – 1998 (Hedberg, 2000),
- Bourquin (1999) describes a significant increase associated with produce. During 1973-1987 fresh produce accounted for 2% of outbreaks compared with five outbreaks in 1987 and 15-20 outbreaks each year currently,
- An FDA survey of imported fresh produce (CFSA N/1) state that the last several years have seen the proportion of foodborne illness associated with fresh fruits and vegetables increase.

Beuchat (2000) states increases in outbreak numbers may be contributed to better reporting and identification of pathogens particularly from public health officials such as the CDC in the USA, Centre for Disease Control and Prevention (Tauxe, 1997) and CDSC in the UK, Communicable Disease Surveillance Centre (O'Brien, 2000).

Tauxe (1997) states, "The epidemiology of foodborne diseases is changing. New pathogens have emerged, and some have spread worldwide". Many pathogens are now known to use fresh produce as the

vehicle or vector. These pathogens may have reservoirs in healthy animals, from which they spread to an increasing variety of foods (Tauxe, 1997).

Bacterial behaviour is changing e.g. acid resistant *Salmonella* (Wessinger et al, 2000). There are more virulent strains of bacteria that continue to be identified, challenging particularly the elderly (School of Public Health, 1999), the young and immunocompromised/weakened immune systems (Hedberg, 2000).

Also, pH, heat and pressure resistant strains are being identified such as those being identified in orange juice (Palop, 2000).

Antibiotic-resistance factors exchanged between microbes make it more difficult to treat many bacterial infections in humans and animals. Thus there is an increasing need to implement preventative procedures rather than elimination practices/techniques for fresh produce (Keen & Osburn, 2000).

Other trends implicated in the increase of foodborne illness outbreaks are associated with practices in the production and preparation of fresh produce; advances in fresh produce industry procedures, better reporting, etc. These are detailed as follows:

2.1.1 Organics

Increasing demand by consumers for "organically grown produce" in developed countries has highlighted foodborne diseases that can potentially contaminate fresh produce by the use of animal manures. Scientific studies have shown that improper use and/or preparation of manures can cause transfer of pathogens present onto crops resulting in human disease. The pathogens of primary concern to humans are *Escherichia coli O157:H7*, *Salmonella*, *Campylobacter* and *Cryptosporidium* (Soil Association, 2000).

A report by the Food Standards Agency (FSA, 2000) indicates organic wastes as fertilisers, may be a potential source of contamination for pathogens. A number of pathogen groups may be found in municipal biosolids in compost both prior to composting and in final product if not properly composted. The most prevalent group is enteric pathogens, i.e. protozoa and helminths (Hay, 1996).

Possible transmission of pathogens to vegetables such as *Salmonella* spp, *Shigella* spp, *E.coli O157:H7*, *Campylobacter* spp and *Listeria monocytogenes* can also occur by manure or sewage

sludge as fertiliser (Little, 1999). A 1992 case in Maine resulted in the death of a woman and child (Nelson, 1997). The deaths were attributed to consumption of contaminated fresh vegetables in the woman's organic garden with *E.coli O157:H7*. The garden was fertilised with raw calf and adult cow manure that were found to be carriers of the disease. Further evidence of four separate outbreaks in 1995 implicated lettuces from organic growers infected by cow manure (Nelson, 1997).

2.1.2 Industry changes

Advances in argonomic practices, processing, preservation, distribution and marketing have resulted in supply all year round and expansion of geographical distribution of many perishable foods. Stanley (1999) states a growth of distribution and consumption of fruit and vegetables of up to 30% per annum. Reasons behind this include better packaging technology giving year-round supply, and production chain advances such as centralised processing with larger batches and increased transport times. Stanley (1999) suggests this results in increased food-handling and potential abuse. International trading of many perishable foods from other countries increases the variety and the availability of out of season produce. International treaties such as NAFTA and GATT have reduced import barriers (Hedberg, 2000).

Altekruse (1997) suggests the trend towards greater distribution of fresh produce from large centralised food processors carry a risk for dispersed outbreaks. An example of this was the multistate outbreak in Canada, which was associated with consumption of Guatemalan raspberries in Canada. The parasite *Cyclospora cayetanensis* that caused the outbreak was only documented previously in North America as cases in overseas travellers (Herwaldt & Ackers, 1997).

2.1.3 Consumption changes

Consumers are increasingly more health conscious and demanding minimally processed foods with longer shelf life as well as convenience (School of Public Health, 1999). Also the perception of "healthy" and "5 plus a day" fruit and vegetables requires there to be a greater range of produce available (Altekruse, 1997). Greater potential hazards exist with the increase in the produce being sold under the label of "organic" which inevitably means greater use of animal manures (Nelson,

1997), which may or may not have been properly managed (Soil Association, 2000).

New foods now eaten raw e.g. bean sprouts may contribute to increased outbreaks. Seed sprouts have emerged as a significant source of foodborne illness and consumption of fresh sprouts has become a public health concern (Powell, 2000). The need also to have ready to use fresh produce is also on the increase, which further increases the potential of FBI's.

2.2 Potential Hazards

2.2.1 Fresh Products Of Particular Concern

Fresh produce exported from New Zealand is primarily exported as "intact product", however some may be exported pre-cut. These types of products carry different areas of concern as described following.

Intact Product

This category comprises of produce whose outer protective layer has not been breached. For example it has not been cut, damaged or bruised. In the case of produce without a protective layer such as skin or peel, the produce remains intact until the point of preparation, e.g. tearing lettuces, cutting capsicums.

Certain fresh fruit and vegetable crops are more susceptible to absorbing microbial pathogens on their tissue surface than other crops. These include strawberry fruit being attacked by *E. coli* 0157:H7 (Yu et al, 2000) and lettuce being contaminated then attacked by *E. coli* 0157:H7 and Hepatitis A (Beuchat, 1999 and Takeuchi & Frank, 2001).

Product not intact

Defined as any product where the intact protective surface/s of the plant have been breached or removed. This can be through cutting, bruising or other damages.

By cutting there are four potential consequences:

1. It can remove the pathogen if present on the outside of the plant but only if carried out in a proper hygienic manner,
2. It can give the pathogen access to the nutrients available on and from the inside of the plant. This can lead to multiplication

of certain pathogens during the storage (except viruses). For example research has shown that *Salmonella* can survive and grow, for the duration of transport and storage preceding ripening on the surfaces and in the core tissues of tomatoes (Zhuang et al, 1995),

3. It can spread the pathogen from contaminated to uncontaminated product as a result of inappropriate hygiene of large batches of the product during processing. Where lettuce has been contaminated with bovine faeces this has lead to outbreaks of *E. coli* 0157:H7 (Beuchat, 1999). Also the case where harvested tomatoes were dumped into a water tank that was inadequately chlorinated resulted in a multistate outbreak of *Salmonella*. Once it was contaminated, the tank served as a source to spread the pathogen to many other tomatoes dumped into it (Hedberg, 2000), and
4. All of the above.

Where fresh produce is damaged during the harvesting, processing and handling of the material, the surface tissue also becomes more susceptible to microbial attack. This has been clearly researched on the bruising of apples where the growth of *Escherichia coli* 0157:H7 is increased on the damaged tissue (Dingman, 2000). Injuries to the wax layer and cuticle and underlying tissues increased bacterial adhesion, growth and multiplication of *Escherichia coli* 0157:H7 on green peppers (Han et al, 2000). Cross contamination by an infected food handler can occur when the product is being processed and human transmitted microbial pathogens such as *Listeria monocytogenes* can infect crops such as lettuce (Beuchat & Bracket, 1990).

2.2.2 Potential Biological Hazards

A number of foodborne diseases will be mentioned throughout this report and key microbial pathogens related to fresh produce will be addressed.

There has been an increased awareness to microbial pathogens associated with fresh produce that can potentially be hazardous to the consumer (Beuchat, 2000). The key countries/regions that have to date focused on foodborne illnesses (FBI's) on fresh produce are the US, EU, Canada, and Australia. Therefore the majority of the international information has been derived from these 4 regions.

The countries where biological foodborne outbreaks have occurred are only recorded if the countries public health departments have

conducted foodborne disease surveillance. The data that is available therefore is skewed towards those organisms that are responsible for the outbreaks that can be readily identified. Organisms that cause severe illness, e.g. Entrovirulent *E. coli* 0157:H7 are more likely to feature in reports than organisms that do not. On the other hand, organisms that cause sporadic cases e.g. *Campylobacter* are less likely to feature than those that cause well-defined outbreaks (O'Brien, 2000).

Comprehensive lists of known foodborne illnesses have been outlined by the American Medical Association, which defines them under the categories of bacterial, viral and parasitic agents (AMA, 2001/a/b/c). These include natural soil borne pathogens, and those derived from animal and human faeces, and waterborne pathogens.

Results on contamination of imported fresh produce have just been completed in the United States, where it was clearly shown that certain crops such as cantaloupes and tomatoes show a high rate of pathogens (*Salmonella* and *Shigella*) on the surfaces of produce which become contaminated during growth (CFSAN/2, 2001).

However, recent statistics from the CDC showed although cases overall of *E. coli* and *Campylobacter* had increased, there was a decrease in the number of *Salmonella* infections, which has decreased by 14.5 to 12.5 per 100,000 people over the past two years (Health News, 1999).

In the UK between 1992-1999, the most commonly identified pathogen identified on the consumption of fresh produce was the small round structured virus (SRSV's) also referred to as Norwalk-like viruses. Other notable pathogens were *Salmonella* spp., *Campylobacter jejuni*, and *Shigella* spp. (O'Brien et al, 2000)

In New Zealand Norwalk-like viruses (NLV's) or small round structure viruses are the most widely recognised cause of outbreaks of food and waterborne viral disease (Greening et al, 1999).

There are an estimated 119,320 episodes of foodborne infectious diseases per year in New Zealand, though total number of cases of all infectious intestinal disease could be as high as 823,000 (Lake et al, 2000). The vehicle of transmission is not clearly defined, i.e. relevance of this data to fresh produce incidence.

In New Zealand some bacteria such *Bacillus cereus* are arguably part of the natural plant flora and many others such as *Listeria monocytogenes* and *Clostridium botulinum* are thought to be resident in associated soil (Stanley, 1999). Contaminated water used in the growing and processing of fresh produce may also pose a threat. The exact mechanism by which seeds or plants become contaminated with the bacterial pathogen is not known. The source of contamination can go back as far as the groundwater used where faecal contamination from distant farms has been isolated (Stanley, 1998).

It is a common perception that most contamination is removed as the water filters through the soil but this does not guarantee that ground-water supplies cannot be contaminated. The pathogenic microbiological risk increases in areas where there may be septic tanks and farmland (UGSG, 1993-1995).

Viruses

No literature has shown outbreaks associated with fresh produce from these viruses in New Zealand.

- Norwalk-like Viruses

  In the UK, the main pathogens involved in outbreaks related to fresh produce in recorded outbreaks from 1992-199 were the Norwalk-like viruses (also known as small round structured viruses - SRSV's), *Salmonella* and *Shigella*. The potential sources of contamination for these pathogens were the use of organic wastes as fertiliser's, use of contaminated irrigation water and contamination of food handlers during harvest and processing (Food Standards Agency, 2000).

  In the USA Norwalk-like viruses were shown to be a frequent cause of outbreaks through foodborne and waterborne infection. It is detailed that salads were implicated in five outbreaks (36%) contaminated by infected food handlers during the preparation of the salad (Hedberg, 2000).

  Another outbreak was associated with green salads served at a restaurant in USA. Again, the contamination occurred by an infected food-handler at the restaurant. In Minnesota during 1981 to 1983 salad items were implicated in 6 out of 12 outbreaks and an infected food handler was the source in five of these six (Hedberg, 2000). From 1984 to 1991 salad items

were implicated in 12 of 39 outbreaks and ill food handlers were identified in 23 of these 39 outbreaks. Another outbreak in the USA involving 1,500 cases was found to be from celery used in a chicken salad. The celery was washed and soaked in water from a hose that had previously been used to unclog food drains after sewage had backed up in the kitchen (Hedberg, 1993).

Norwalk-like viruses (NLV's) are the "most widely recognised causes of outbreaks of food and waterborne viral disease in New Zealand and worldwide" (Greening et al, 1999). During the period July 1997 to June 1999 50 outbreaks of NLV's in New Zealand were reported by public health services, averaging 25 cases per outbreak.

The outbreaks most commonly occurred in restaurants and rest homes and were traced to foodborne (57%) and person to person contact (40.4%) (Greening et al, 1999). The report states the most common method of food contamination was by infected food-handlers and cross-contamination from one food to another. The report does not however detail the type of food associated with the outbreaks.

It is known that consuming food grown in faecally contaminated water can transmit NLV's, including irrigation and wash water, along with consumption of food contaminated by infectious food-handlers, infected surfaces and objects and by direct or aerosol contact from person to person (Greening et al, 1999 and Hedberg, 2000).

Because these viruses can be transmitted through faecal contamination, food grown using inadequately decomposed compost may also transmit NLV's. This may be especially applicable to organically grown crops where composting practices are more common as opposed to other crops where agrichemical application is used for fertilising.

In New Zealand Norwalk-like viruses (NLV's) are present.

- Hepatitis A

  Viruses cannot grow in or on foods but fresh produce may serve as a vehicle of transmission for virus infection mainly through contamination from infected food handlers and use of contaminated water (Beuchat, 2000)

Several fresh produce types have been associated with Hepatitis A in the USA including lettuce, diced tomatoes, raspberries and strawberries (Beuchat, 2000).

Mariam & Cliver (2000) report between 1993 and 1997, Hepatitis A to be ninth in terms of foodborne illnesses in the USA, although a vehicle of transmission is not detailed. In 1997 an outbreak in the USA of Hepatitis A involving 260 cases, was traced to contaminated strawberries distributed as a school lunch programme (Lindsay, 1997).

Mariam & Cliver (2000) states that Hepatitis A virus infects only humans and is shed only in faeces.

In New Zealand Hepatitis A is present.

- Other Viruses

  Rotavirus is associated with faecally contaminated foods such as fruits and salads touched by infected food workers (AMA, 2001/a). Other viruses such as astroviruses, calciviruses, adenoviruses, and parvoviruses) are also associated with faecally contaminated RTE foods contaminated by infected food workers.

  In New Zealand these viruses are present.

Pathogenic microorganisms

- *E.coli* 0157:H7

  Examples of crops susceptible to *E. coli* 0157:H7 include strawberry fruit being attacked by *E. coli* 0157:H7 (Yu et al, 2000) and lettuce being contaminated then attacked by *E. coli* 0157:H7 (Beuchat, 1999 and Takeuchi & Frank, 2001).

  As mentioned earlier, research on the bruising of apples (Dingman, 2000) showed the growth of *E. coli* 0157:H7 is increased on the damaged tissue. Injuries to the wax layer and cuticle and underlying tissues increased bacterial adhesion, growth and multiplication of *E. coli* 0157:H7 on green peppers (Han et al, 2000).

  Lettuce has also been implicated in outbreaks worldwide. Where lettuce has been contaminated with bovine faeces this has lead to outbreaks of *E. coli* 0157:H7 (Beuchat, 1999).

Unpasteurised apple cider has been associated with several outbreaks of *E. coli* 0157:H7 in the USA and Canada. It is thought the contamination has occurred from the use of ground fruit for juicing (i.e. apples) where the fruit's surface and wound's are infected with the organism from contaminated faeces on the ground. However the outbreaks source remains unproven (Dingman, 2000).

As suggested above *E. coli* 0157:H7 outbreak investigations have shown that E.coli is frequently excreted in cattle faeces, which may represent a source of infection. Other animals such as dogs, sheep, lamb, deer, horses and birds have been shown as a source of infection (Orr, 1999).

Orr (1999) suggests fewer *E. coli* 0157:H7 are shed by slaughter-age animals compared with younger cattle. Nelson (1997) also states that for an unknown reason *E. coli* 0157:H7 is carried in calf manure more often than adult cow manure.

The prevalence of *E. coli* 0157:H7 in New Zealand is thought to be quite low however; "there is not a large amount of information available on the status of pathogen carriage or excretion rates of animals in New Zealand" (Ball, 1997). Ball (1997) shows the *E. coli* 0157:H7 was detected in 2 out of 531 faecal specimens in a survey of healthy dairy cattle. The New Zealand Public Health Report (Feb 1999) indicates *E. coli* 0157:H7 was detected in 2 out of 371 faecal specimens from Waikato dairy cows. Other reservoirs are described as horses, sheep and deer however no studies are available in regards to *E.coli* 0157:H7 prevalence in these animals in New Zealand.

The information above highlights organic crops as a potential risk due to contamination from the use of compost prepared from biosolids and the use of cattle for pastoral clean-up. Whilst the industry has several well-known and utilised certification schemes to organic standards, the focus of these standards is "truth of labelling".

Another potential risk is the incidence of *E. coli* 0157:H7 outbreaks associated with sprouts and sprout seeds. Radish sprouts were implicated in the largest outbreak of *E. coli* 0157:H7 in Japan in 1996. " This outbreak affected 6000 people and involved the death of three school children" (O'Brian et al, 2000). The outbreak was attributed to raw

radish sprouts served in school lunches, which were prepared in a central kitchen (O'Brian et al, 2000).

Beuchat et al (2001) details in the USA, 9 out of 11 outbreaks of *E. coli* 0157:H7 between 1988 to 1999 and 2 out of 3 outbreaks between 1996 and 1997 were attributed to alfalfa sprouts. A fourth outbreak in 1998 was linked to clover and alfalfa sprouts.

Information on sprout related pathogenic outbreaks in NZ appear to be non-existent. No information on the New Zealand sprout industry was available; however according to international data there is a perceived risk with this crop, especially seed contamination.

In New Zealand E.coli 157:H7 is present.

- *Salmonella*

  There are several hundred species of *Salmonella* that are pathogenic which can be found in the intestinal tracts of man, animal, bird or rodents and on raw food (Environmental Health, 2001).

  According to Beuchat (2000) Salmonellae have been isolated from many types of fruits and raw vegetables in the USA and outbreaks have been related to tomatoes, bean sprouts, and melons.

  In the USA a number of outbreaks associated with *Salmonella* are recorded, including 2 from contaminated tomatoes, 1 from contaminated cantaloupe, and 12 further outbreaks from contaminated alfalfa and other small seed sprouts (Hedberg, 2000). Hedberg (2000) goes on to describe fresh produce outbreaks caused by *Salmonella* "increased by more then sixfold". O'Brien et al (2000) detail outbreaks associated with watermelons, whole and pre-sliced cantaloupes, and tomatoes.

  Sprouts are of particular concern in regards to this organism. The conditions in which sprouts are grown may support or promote the growth of these organisms. This includes maintaining the seed temperature at 20 to 24°C and in an environment of high moisture (Weissinger et al, 2000). Weissinger et al (2000) states "these conditions are known to support the growth of *Salmonella*".

An outbreak of *Salmonella* in the USA was traced to one lot of contaminated sprout seeds resulting in 133 cases (Weissinger et al, 2000). Another outbreak resulting in 242 cases in the US and Finland was traced to a batch of contaminated seeds traced to a single shipper. Further outbreaks are described in the following table (table 1).

Table 1, Summary of seed sprouts outbreaks

Cases	Location	Type of sprout	Source of contamination
143	UK	Mung	Seed
31	UK	Cress	Seed and/or sprouter
595	Sweden, Finland	Alfalfa	Seed
242	US, Finland	Alfalfa	Seed
133	US, Canada, Denmark	Alfalfa	Seed
~500	US	Alfalfa	Seed and/or sprouter
78	Canada	Alfalfa	Seed
109	US	Alfalfa, mung, other	Seed
52	US	Alfalfa, clover	Seed and/or sprouter
34	US	Alfalfa	Seed and/or sprouter

(Taormina et al, 2000)

Application of untreated sewage sludge and effluents or irrigation water containing untreated sewage to fields and gardens can result in contamination of fruits and vegetables with *Salmonella* (Beuchat, 2000).

Environmental sources of the organism include water, soil, insects, factory surfaces, kitchen surfaces, animal faeces, raw meats, raw poultry, and raw seafoods, to name only a few (The Bad Bug Book, FDA, 2001)

In New Zealand Salmonella is present.

- *Campylobacter*

Altekruse & Cohen (1997), state untreated water is a common source implicated with *Campylobacter jejuni*. It is considered

a leading cause of foodborne illnesses in the USA, and is high amongst young men. It is thought that this may "reflect poor food preparation skills". Illnesses associated with Campylobacter are sporadic and are associated mostly with raw milk and unchlorinated water. AMA (2001/a) also states that foods associated with campylobacter include raw milk, raw or undercooked poultry and contaminated water.

An Auckland Health Report (Auckland Healthcare, 1996) also implicates water as a source for *Campylobacter*, as well as animals and food products of animal origin. They suggest a hazard when there is cross contamination of foods and that possible control or precautions to take include preventing cross-contamination via contaminated surfaces and utensils.

There appears to be no evidence of outbreaks in fresh produce associated with *Campylobacter* in New Zealand and the information detailed above from the international literature search would support this.

In a New Zealand Public Health Report (FSA, 1997), an outbreak of Campylobacteriosis was linked to a water supply at a school camp. The camp was in the Christchurch area and the main link to the outbreak was the back flow of stream water into the water supply. This may pose a risk if contaminated water is used for irrigation and/or wash water for fresh produce.

In New Zealand Campylobacter is present and has been implicated with water.

- *Shigella*

Shigella has been linked to some recent outbreaks in the USA relating to fresh produce. An outbreak in 1986 resulting in 346 cases was identified to be from shredded lettuce and another outbreak in 1992 resulting in 46 cases was related to vegetable salad (Marler et al, 2000). Table 2 details further outbreaks in the USA resulting from *Shigella* and the related produce. Some of these products contain fresh produce such as vegetables but the exact source of the infection is not detailed.

Table 2, *Shigella* incidences

Year	Cases	Source Location
2000	300	Salsa
1992	46	Vegetable salad
1988	30	Cold Sandwiches
1988	3175	Tofu Salad
1986	347	Shredded lettuce

(Marler et al, 2000)

Shigella infections are known to occur from eating contaminated food. Some areas of concern include harvesting vegetables from fields contaminated with sewage or use of faecally contaminated water (such as run-off contamination) and infection of food including fresh produce from flies breeding in infected faeces (Marler et al, 2000).

Information from the CDC indicates that the infection is spread form one infected person to another. *Shigella* can remain present in the diarrheal stools of infected persons for up to a week or two afterwards. Most *Shigella* infections are the result of the bacterium passing from stools or soiled fingers of one person to the mouth of another person (FDA (CDC), 2000).

Shigella infection can therefore be attributed to a lack of basic hygiene and inadequate hand-washing habits, and can also occur when contaminated water is used in processing.

In New Zealand *Shigella* is present.

- *Clostridium botulinum* and *Clostridium perfringens*

  Beuchat (2000) states “Clostridia can be found in soil, raw fruit and vegetables”. Stanley (1999) states that “bacteria such as *Listeria* and Clostridia are resident in New Zealand soils”.

  C. perfringens is mostly associated with outbreaks from inadequately heated or reheated meat products, however the organism can be present in water, soil and dust, and on food contaminated with soil or faeces. McKean (1997) indicates that Clostridial organisms are “capable of living in soil for many years and are resistant to climatic changes, sunlight and drying, and to some disinfectants”.

  C. perfringens bacteria grows anaerobically. The vegetative cell is destroyed through thorough cooking but some spores

may survive these temperatures and during favourable conditions produce a toxin (Sumner & Albrecht, 1995). The Canadian Laboratory Centre for Disease Control (2001) indicates the mode of transmission is through "ingestion of food contaminated with soil or faeces, held under conditions which permit multiplication of the organism (inadequately cooked or reheated meats).

C. botulinum and *C. perfringens* will do no harm until the spores produce a toxin in a low oxygen environment, such as film wrapped packages. It has been documented by Beuchat (2000), that the high rate of respiration of salad vegetables can create an anaerobic environment in these packages, thus favouring the growth of Clostridium. "The bacteria form spores which allow them to survive in a dormant state until exposed to conditions that can support their growth" CDC (2001)

C. botulinum has been linked to coleslaw prepared from contaminated shredded cabbage (Beuchat, 2000). The cabbage was packaged in a sealed plastic bag and was left un-refrigerated. This caused oxygen in the bag to be consumed allowing *C. botulinum* to grow and produce toxin. The cabbage was later used to make the coleslaw resulting in illnesses.

Due to the aerobic nature of fresh fruits and vegetables the potential risk in fresh produce is low, however produce being packed in anaerobic conditions can pose a risk.

Beuchat (2000) notes that the permeability characteristics of packaging minimise the possibility of development of anaerobic conditions that facilitate the growth of this bacteria.

In New Zealand Clostridium botulinum and C. perfringens are present.

- *Listeria monocytogenes*

  According to Beuchat (2000) *L. monocytogenes* has been associated with raw vegetables. It can be isolated from soil, mulches, and other environmental sources. Stanley (1999) states it has been associated with NZ soil.

  Beuchat (2000) reports that surveys of fresh produce have revealed the presence of *L. monocytogenes* on cabbage,

cucumbers, and potatoes in the USA and on ready to eat salads in the U.K. Bean sprouts, sliced cucumbers and leafy vegetables in Malaysia have also shown the presence of *L. monocytogenes*.

L. monocytogenes can also grow on lettuce, tomatoes, asparagus, broccoli, cauliflower and cabbage, and the risk of Listeriosis increases when these vegetables are stored for longer periods before consumption because of their ability to grow at low temperatures (Beuchat, 2000).

The USFDA (2001) conducted a study relating the number of cases of Listeriosis to foods between the years 1970-2000. They summarised results for outbreaks in the USA and outbreaks outside the USA.

The study found that in outbreaks where the source could be specifically identified, there were 205 cases, with vegetables accounting for only 7 (3.4%) of these cases. There were 16 outbreaks and 1030 cases of Listeriosis outside of the USA, and vegetables accounted for only 2 outbreaks (11.8%).

When the data from both inside and outside the USA was collectively summed and each food group was ranked accordingly vegetables ranked as last (compared with dairy products ranking number one, followed by meat products then fish products).

Listeria monocytogenes can grow over a wide range of temperatures (-4 to 37°C – Marler, 2000) and is associated with soil and mulches. Given this, fresh produce that has come into contact with soil and/or mulches and has been stored for any length of time has the potential to be harbouring and/or growing *Listeria*.

However there currently appears to be no evidence linking *Listeria* outbreaks or cases to fresh produce and the microbial ecology of such pathogens is as yet poorly understood (Stanley, 1999).

In New Zealand Listeria monocytogenes is present.

- *Yersinia enterocolitica*

  In the US there is a prevalence of this organism in the soil and water and in animals such as pigs; therefore the organism has potential for entry into the food chain. Poor sanitation and improper sterilization techniques by food handlers cannot be overlooked as contributing to contamination (The Bad Bug Book (FDA), 2000).

  Yersinia enterocolitica is rare unless a breakdown occurs in food processing techniques (The Bad Bug Book (FDA), 2000). The CDC estimates that about 17,000 cases occur annually in the USA but do not state the vehicle of transmission, i.e. number of cases relating to contaminated fresh produce consumption.

  Y. enterocolitica is a far more common disease in Northern Europe, Scandinavia, and Japan. The ability of *Y. enterocolitica* to grow at refrigerated temperatures and its documented presence in produce raises concern about the potential of salad and vegetables to cause illness.

  Seven percent of carrot samples obtained from eating establishments in France were reported to contain serotypes that could cause illness in humans (The Bad Bug Book (FDA), 2000).

  Beuchat (2000) reports in a study, 50% of raw vegetables analysed in the USA contained non-pathogenic strains of *Yersinia*. Incidence was higher on root and leafy vegetables than on tomatoes and cucumbers.

  Sheat et al (1998) details that there is no information on the abundance of Y. enterocolitica in New Zealand waters and there is no other literature supporting the presence of Y. enterocolitica in New Zealand produce.

  In New Zealand Yersinia enterocolitica is present.

Parasites

- *Cyclospora* spp*. & Giardia lamblia*

  Beuchat (2000) indicates the main transmission mode for parasites such as protozoa include surface water consumption, exposure to recreational water contaminated with the parasites, and person-to-person and person-to-animal contact.

  All the parasites require passage through an animal or human host, which may contaminate fresh produce through water contaminated with faeces (such as sewage or irrigation water) and/or poor hygienic practices. Beuchat (2000) describes that contamination may be common in countries with hygienic practices when the practices are compromised, especially water quality.

  Several outbreaks or surveys Beuchat (2000) describes include:

  - *Giardia* on raw sliced vegetables from contaminated food handler,
  - *Cyclospora cayetanensis* on lettuce, raspberries and basil,
  - *Cyclosporidium parvum* linked to unpasteurised apple juice (although no evidence is given in regards to source from the apples), and
  - The presence of cyclosporidium oocysts on lettuce, radish, tomato, cucumber and carrot.

  Dr George Ionas states “there is little or no evidence to suggest that these pathogens are important to public health in New Zealand” (Massey University, 2001).

  In New Zealand Cyclospora spp. & Giardia lamblia are present.

2.2.3 Potential Chemical Hazards

Agrichemicals

Everyone is exposed to small background levels of more persistent chlorinated hydro-carbons when they consume food, and to a

much lesser extent, when they breathe air or have skin contact with dioxin-contaminated materials (Lopipero and Smith, 2001). For the general population, over 90% of exposure to Poly Chlorinated Dibenzo-p-Dioxin and Poly Chlorinated Dibenzo-Furans (PCDD/F's) and Poly Chlorinated Biphenyls (PCB's) is through the diet, with foods of animal origin such a meats, dairy products and fish usually the main source (Lopipero and Smith, 2001).

- Residues in Soil

  Harmful Organochlorines including residues of Dichloro-Diphenyl-Trichloroethane (DDT), and it's primary metabolite Dichloro-Diphenyl-Ethane (DDE), in the soil have declined to low levels in most parts of New Zealand (less than 0.1mg/kg). Levels of 1-5mg/kg are not uncommon on farms in Canterbury where DDT use was high, and where dry land conditions have led to very slow degradation rates (Holland, 1996). Dieldrin has been found in soils where sheep dips were present and has a very low maximum acceptable value (MAV) 0.00003 mg/L (Close, personal communication). It causes concern as it remains in the soil for a long period.

  As with modern insecticides, residues of fungicides are rarely found in the wider environment. An exception is Copper, which accumulates in soils under crops treated with cupric oxide or the hydroxide- a conundrum for "organic" proponents (Holland, 1996).

  While many herbicides are of limited environmental significance due to rapid degradation or strong absorption e.g. Glyphosphate, some herbicides designed for longer-term control, have more mobile and persistent residues with the potential to contaminate the wider environment (Holland, 1996).

  PCDD/F's in our food mainly result from its deposition from air onto pasture and it's uptake by grazing animals, which results in the contamination of animal meat and milk. In fresh produce the application of waste materials, such as sewage sludge, to agricultural land may allow the entry of dioxin-like compounds into food produce (Holland, 1996).

  Smith & Lopipero (2001) detailed concentrations of PCDD/F's and PCB's in New Zealand soils as shown in Table 3.

Table 3, Concentration of PCDD/F's and PCB's in New Zealand Soils[1]

Reference soils	0.17-1.99 PCDD/F's	0.065-0.29 PCB's
Agricultural soils	0.17-9.14 PCDD/F's	0.065-0.15 PCB's
Urban soils	0.54-33.0 PCDD/F's	0.067-1.33 PCB's

Table adapted from (Lopipero and Smith, 1996)

- Residues in Water

  Close (1993) describes that recently low levels of the herbicides Atrazine, Terbutylazine and Simazine have been detected in some wells in South Canterbury.

  Further research has been carried out in New Zealand assessing the pesticide contamination of groundwater (Close, 1993). Samples were taken from 79 wells that were likely to have pesticide contamination. It was found that there were detectable pesticides in 13 wells however no wells had pesticide levels above the maximum acceptable value (MAV) detailed in the NZ Drinking Water Standard 2000.

- Pesticide residues in fresh produce

  In 1999 the US Food & Drug Administration (USFDA) regulatory pesticide-monitoring programme found no violative residues in 99.2% of samples. Fruit and Vegetables accounted for 72.3% of the samples tested (USFDA, 2000b).

  Consistent with other years more vegetables (69.7%) than fruit (38.8%) were found to have no residues. The incidence of residue levels above legal limits was low, i.e. 1.2% on vegetables and 0.6% on fruit samples. The crops that were found to be above USA MRL's were berry fruits, peas, carrots and spinach (USFDA, 2000b).

  In the UK, 71% of the food samples tested in 1999 did not contain any detectable pesticide residues and 27% of samples tested contained pesticide residues below the UK legal limits. This study did not define the proportion of fruit and vegetable samples.

  The same study showed 1.6% of the samples tested were higher than the UK MRL's (UK MAFF, 2000). The report noted "the great majority of the residues detected, including

[1] Data from the Organochlorines Programme. Expressed as nanograms Toxic equivalents per kilogram, dry weight.

those above legal limits, were of no health concern" however two samples were of concern.

The first sample was a pear with high levels of chlormequat (used on pear trees for yield and fruit shape), and the second was a sweet pepper with high levels of methamidophos. Consequences of these levels of residue were cited as mild stomach upsets in toddlers if they ate a whole pear or one third of the pepper in a single sitting.

A combined Department of Health/MAF survey of fruit and vegetables in New Zealand was carried out in 1990/1991 and 1991/1992. Multi-residue analytical techniques were used which can detect a wide range of residues targeting crops most likely to contain residues.

In the 90/91 survey 50% of 741 samples had no significant residues compared with 52% of the 740 samples tested in the 91/92 survey. The survey in 90/91 indicates 46% of samples had residues below set MRL's compared to 43% in the 91/92 survey. Therefore 4% in 90/91 and 5% of samples in 91/92 had residues which either exceeded a set MRL, or which had no set MRL for that pesticide on that particular crop.

Most of the MRL violations were from leafy greens (e.g. lettuce and celery) and were from moderate residues due to unregistered uses of a pesticide approved for other crops rather than uses of banned products or levels exceeding set MRL's. Due to small market volumes of minor crops (e.g. celery), pesticide companies find it uneconomic to register pesticides in New Zealand (MAF/MOH Pesticide Survey, 1992).

The results of the 1997/1998 NZTDS show 59% of samples contained detectable pesticide residues, however none exceeded the NZ Food Regulations Maximum Permissible Proportion (MPP). Unprocessed fruit and vegetables composed 22% of the total food samples (MOH, 2000). It should be noted that the results from this survey measured residues at the point of consumption rather than in the market place or at the farm gate (where compliance with MRLs is required).

The residue of the chemical Benomyl is a good example of where extensive studies have been carried out overseas and in New Zealand on various food products (MOH, 2000). This chemical has been implicated as a potentially carcinogenic pesticide and causing damage to developing foetuses. As a result of conflicting studies, the US Environmental Protection Agency classified Benomyl as a possible human carcinogen (US EPA, 2001).

The results from both the 1997/98 NZTDS and Benomyl Study carried out by the Ministry of Health indicate that fruit and vegetables tested were below the MRL's given for both the Australian and Codex MRL's.

In addition the results from the combined MAF/MOH surveys were in broad agreement with residue monitoring in other countries and confirmed the Department of Health's rankings, which put microbial contamination of food as a much more serious health problem than residues.

Off-label use of chemicals is a potential risk. This practise is reasonably common, particularly for minor crops. Mechanisms could be put in place to assess dietary risk associated with off-label use of chemicals and the registration/approval of such off-label use.

Consideration of research and approvals from other countries could enable a broader spectrum of crop/chemical combinations to be covered e.g. research undertaken by the joint Australia / New Zealand producer based organisation, Crop Protection Approvals Research Pty Ltd.

Heavy Metals

According to McLaughlin (2001), heavy metals that present a risk to fresh fruit and vegetables in New Zealand are lead and mercury that can damage the nervous system, arsenic which is carcinogenic, and cadmium which can damage the kidneys.

- Heavy Metals in Soil

  Of the non-essential trace elements cadmium is the element that presents the greatest risk as the presence of cadmium is in all Phosphatic fertilisers (McLaughlin, 2001). The availability of Cadmium in the soil does not decrease rapidly (e.g. cadmium added to soil 10 years ago "would be almost

available as cadmium added currently"). Another factor to be aware of is that root crops, vegetables, spinach and lettuce accumulate more Cadmium than others (McLaughlin, 2001).

Published data on Cadmium (Cd) levels in New Zealand is scarce, of the information that is available, some studies of the Auckland area show that the levels of Cadmium are low by world standards (0.9 mg Cd per Kg).

McLaughlin (2001) goes on to state levels of other contaminants in fertilisers generally appear to be low or if present, the elements are not taken up to any great extent by plants.

- Heavy Metals in Water

  A cause for concern for heavy metals in water is in the situation of roof catchment systems where corrosion occurs, e.g. galvanised iron, lead-based paints rather than atmospheric deposition.

  A study of contamination of roof-collected rain water in Auckland (Simmons et al, 2001) showed that out of 125 domestic roof-collected water supplies from rural Auckland 14.4% exceeded the NZDWS MAV for lead (0.01mg/L) and 2.4% exceeded that for copper (2mg/L). The properties more likely to have contamination were those with a galvanised iron roof and/or lead-based paint as well as a pH of less than 7.

  The water group from ESR have also completed a study showing that there is the potential for contamination from plumbing materials such as lead, nickel, and copper (AWWARF, 2001).

- Heavy Metals in Fresh Produce

  McLaughlin (2001) suggests cadmium concentrations in crops such as lettuce, potato and onion were compatible to international findings. Accumulation of cadmium was found to be higher in lettuce than potato and onions.

  In a survey of NZ produce in 1995 McLaughlin (2001) summarises that some samples exceeded the maximum permitted concentrations (MPC's) of cadmium.

A wide range of foods were also analysed in the 1997 MOH NZ Total Diet Survey and cadmium levels were found to be very low (generally <0.05mg Cd/kg) (McLaughlin, 2001).

Further New Zealand research or incidences have not been found.

2.2.4 Potential Physical Hazards

In the Food Safety Advice (Sept 2000), Auckland Health Care services report a decline in food safety complaints between July 1999 and June 2000. However, the report also indicates that foreign matter complaints remain a concern and that the proportion of foreign matter complaints have increased over the five-year period from 1995 to 2000. The complaints consisted of materials such as glass, metal, insects and rodents, plastic, sticking plasters, string, hair, stones and other less common items. Whilst the report doesn't show which of these types of hazards were associated with fresh produce, it does state that fruit and vegetables accounted for 14% of complaints which may include other types of complaints such as tainting, spoilage, preparation and technical non-compliance such as labelling.

2.3 Comment on Food Safety Objectives

It has not been possible to identify measurable food safety objectives from the information obtained from the literature search. This highlights the need for further research into food safety issues for fresh produce.

As a result the Food safety objectives used to underpin Section B of this report are described generally as absence for biological and physical hazards. Researchers believe this may not be desirable due to the possible control measures required to achieve absence of some or all of the identified hazards. There is a danger of implementing and maintaining impractical control measures where they are not necessary.

The food safety objectives for residues should be defined as less than the importing country MRLs. However the researchers note that the information obtained from the literature search which has been used to determine the significance of chemical residues, is based on the New Zealand MRLs. Information on compliance with importing country MRLs is not publicly available.

SECTION B

3. INTODUCTION TO OBJECTIVES

3.1 Introduction to Objective Two & HACCP Scope

A generic HACCP plan has been developed for each of the product groups listed in 1.3.

The objectives of the HACCP plan are:

- Product Description for each of the product groups
- Generic Process Flow
- Confirm hazards identified from Objective 1,
- Identify significance of each hazard,
- Identify appropriate control measures,
- Identify appropriate CCP's,
- Seek objective evidence that a CCP is appropriate for the type of food, and will be effective against the hazard,
- Identify critical limits for each CCP,
- Develop specific monitoring plans for each CCP,
- Identify corrective action that is required if a CCP exceeds the critical limits, and
- Define criteria for verification of the HACCP plan.

The scope of this HACCP plan is for the production, packing, storage and distribution of fresh produce i.e fruit and vegetables. The scope of the process flows covered under this HACCP plan is from ground or medium preparation through to planting, harvesting, grading, storage and transportation to the final distribution point in New Zealand (including loading into shipping containers and airfreight containers) as appropriate.

It is important to note that it would be essential during implementation of this HACCP model to ensure the scope is defined for each individual operation. All points throughout the scope described above should be covered by a HACCP plan. This may not mean that all points are in one operation's HACCP plan as they may link into other operation's HACCP plan, e.g. packhouse HACCP plan linking into an exporters HACCP plan.

Because of the lack of information available to determine food safety objectives or product outcomes HACCP application is difficult to achieve in the fresh produce industry. Rather the researchers believe that at this stage it is more appropriate for this industry to apply HACCP principles and good agricultural practices instead of HACCP in its truest sense.

4. PRODUCT DESCRIPTIONS

The following tables describe relevant information about each crop type. Organics can be any of these crops and therefore do not have a separate table. Berryfruits have been included in the fruit crops description.

4.1 Root Crops Product Description

Description:	Potato's, Onions, Carrots
Relevant safety information:	• Predominantly cooked, though some are eaten raw. • Almost always cut and/or peeled. • Grown outdoors in soil.
Packaging:	Various forms including • Paper bags or Hessian sacks (potato's). • Cardboard carton with plastic inners (carrots). • Plastic bags (carrots). • Net bags (onions).
Durability & storage conditions:	Storage conditions range from refrigerated storage to open dry areas.
Method of distribution:	Within New Zealand product can be transported on flat deck un-refrigerated trucks or in enclosed refrigerated or unrefrigerated trucks. Potatoes and onions are often included in a single consignment and transported in un-refrigerated sea containers. Carrots can be distributed at 2 degrees Celcius in sea / air containers.
Expected uses:	Predominantly cooked, though some are eaten raw.
Vulnerable groups of population:	All groups may consume these raw and/or cooked.
Potential for abuse:	Not washed or refrigerated in the home and/or at the distribution centre/retailer.

4.2 Fruit Crops & Berry fruit Product Description

Description:	Apples, summer fruit, kiwifruit, sub-tropicals, berries
Relevant safety information:	• Predominantly eaten raw. • Can be eaten intact or peeled and/or cut. • Grown above ground, outside.
Packaging:	Various forms including • Loose in bins, • Loose in punnets, • Loose in cartons, and/or • Tray packs in cartons.
Durability & storage conditions:	Storage conditions range from refrigerated storage to open dry areas.
Method of distribution:	Within New Zealand product is transported in refrigerated or un-refrigerated enclosed trucks. Generally fruit crops are transported in refrigerated sea containers or palletised in the bulk holds of ships. They can also be transported by air freight (e.g. berries and sub-tropicals). Generally consignments do not consist of more than one product.
Expected uses:	Predominantly eaten raw. May be cooked.
Vulnerable groups of population:	All groups may consume these raw and/or cooked.
Potential for abuse:	Not washed or refrigerated in the home and/or at the distribution centre/retailer.

4.3 Sprouts Product Description

Description:	Sprouts
Relevant safety information:	• Predominantly eaten raw and intact. • Sprouts grown hydroponically.
Packaging:	Various forms including • Packed in sealed plastic bags. • Packed (grown) in punnets.
Durability & storage conditions:	Refrigerated storage.
Method of distribution:	Within New Zealand product is transported in refrigerated enclosed trucks. Product is usually transported in refrigerated airfreight containers.
Expected uses:	Predominantly eaten raw. May be cooked.
Vulnerable groups of population:	All groups may consume these raw and/or cooked.
Potential for abuse:	Not washed or refrigerated in the home and/or at the distribution centre/retailer.

4.4 Glasshouse Crops Product Description

Description:	Tomatoes, Capsicums
Relevant safety information:	• Cooked or eaten raw. • Almost always cut. • Grown above ground, or in soil indoors.
Packaging:	Loose in cartons.
Durability & storage conditions:	Refrigerated storage.
Method of distribution:	Within New Zealand product is transported in refrigerated or un-refrigerated enclosed trucks. It is mainly exported as un-refrigerated airfreight but also some refrigerated sea freight.
Expected uses:	Cooked or eaten raw.
Vulnerable groups of population:	All groups may consume these raw and/or cooked.
Potential for abuse:	Not washed or refrigerated in the home and/or at the distribution centre/retailer.

4.5 Leafy Green Vegetables Product Description

Description:	Lettuce, Brassica
Relevant safety information:	• Can be eaten raw. • Predominantly cut. • Grown outdoors in soil or in Glasshouse culture (soil, hydroponics, rockwool). • There is the possibility of anaerobic respiration in individually wrapped product.
Packaging:	Various forms of packaging including • Heads (20-30 count) in plastic inners in cardboard cartons, • Heads individually wrapped in plastic in cardboard cartons, • Loose leaves in plastic inners in cardboard cartons (lettuce), • Ice packs. Ice packed in and around product in polybins (e.g. broccoli), and/or • Vacuum packed shredded lettuce.
Durability & storage conditions:	Storage conditions range from refrigerated storage to open dry areas.
Method of distribution:	Within New Zealand product is transported in refrigerated or un-refrigerated enclosed trucks. At the point of export leafy vegetables are often in mixed consignments. Usually transported in un-refrigerated airfreight containers.
Expected uses:	Eaten raw or cooked.
Vulnerable groups of population:	All groups may consume these raw and/or cooked.
Potential for abuse:	Not washed or refrigerated in the home and/or at the distribution centre/retailer.

5. PROCESS FLOWS

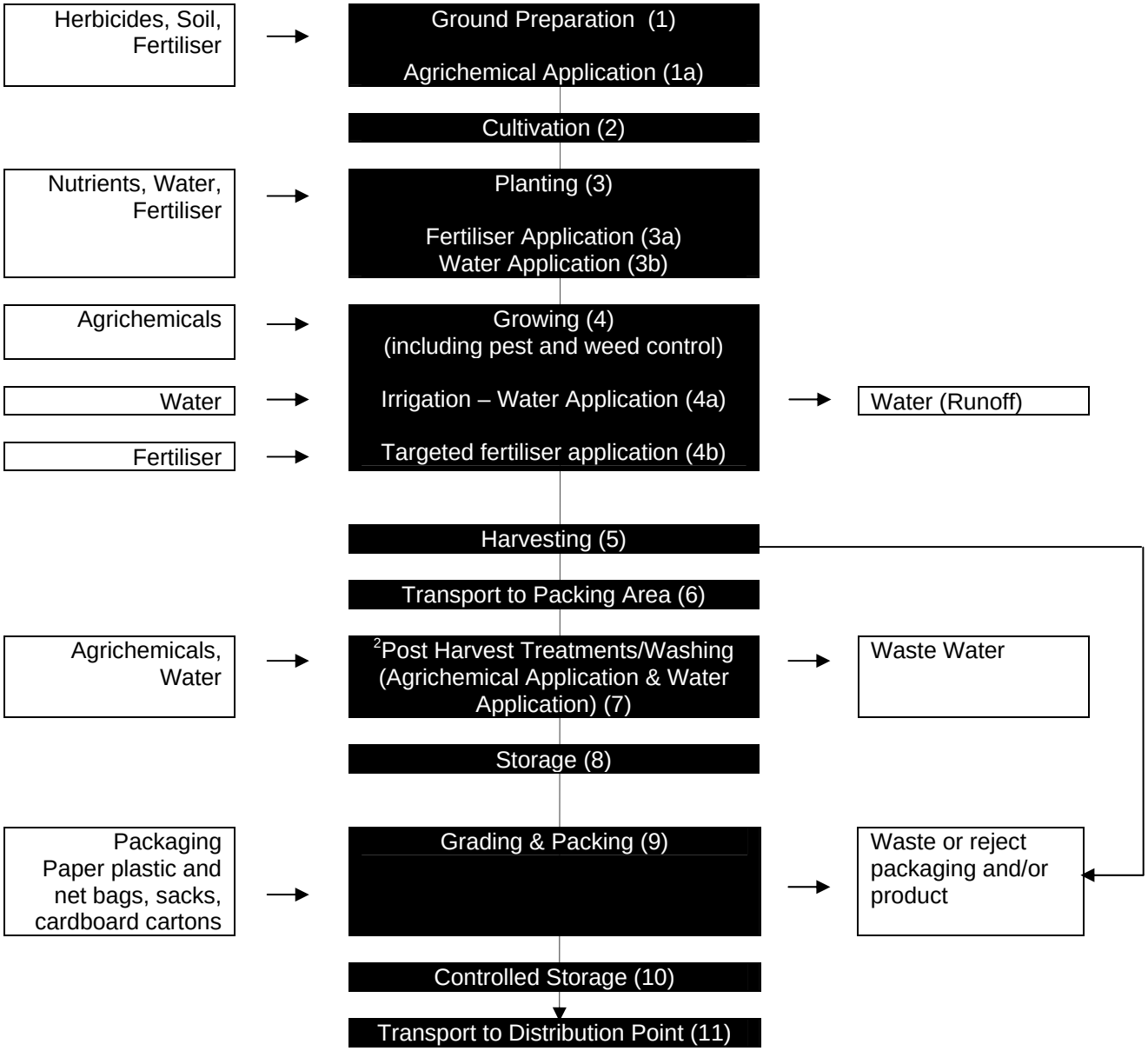
The process flows have been developed in such a way that they can be generically applied in the New Zealand produce industry. These generic process flows were constructed by a combination of consultation with industry groups (those directly involved with carrying out the process) and AgriQuality experience within the various selected crops. This experience coupled with industry consultation gave us a sound platform to formulate the process flows, including inputs and outputs.

It is however important to note that it would be essential during implementation of this HACCP model to ensure the process flows are reviewed against actual operations and modified and made specific where necessary. For example, listing agrichemicals applied.

The process flows are detailed over the next few pages.

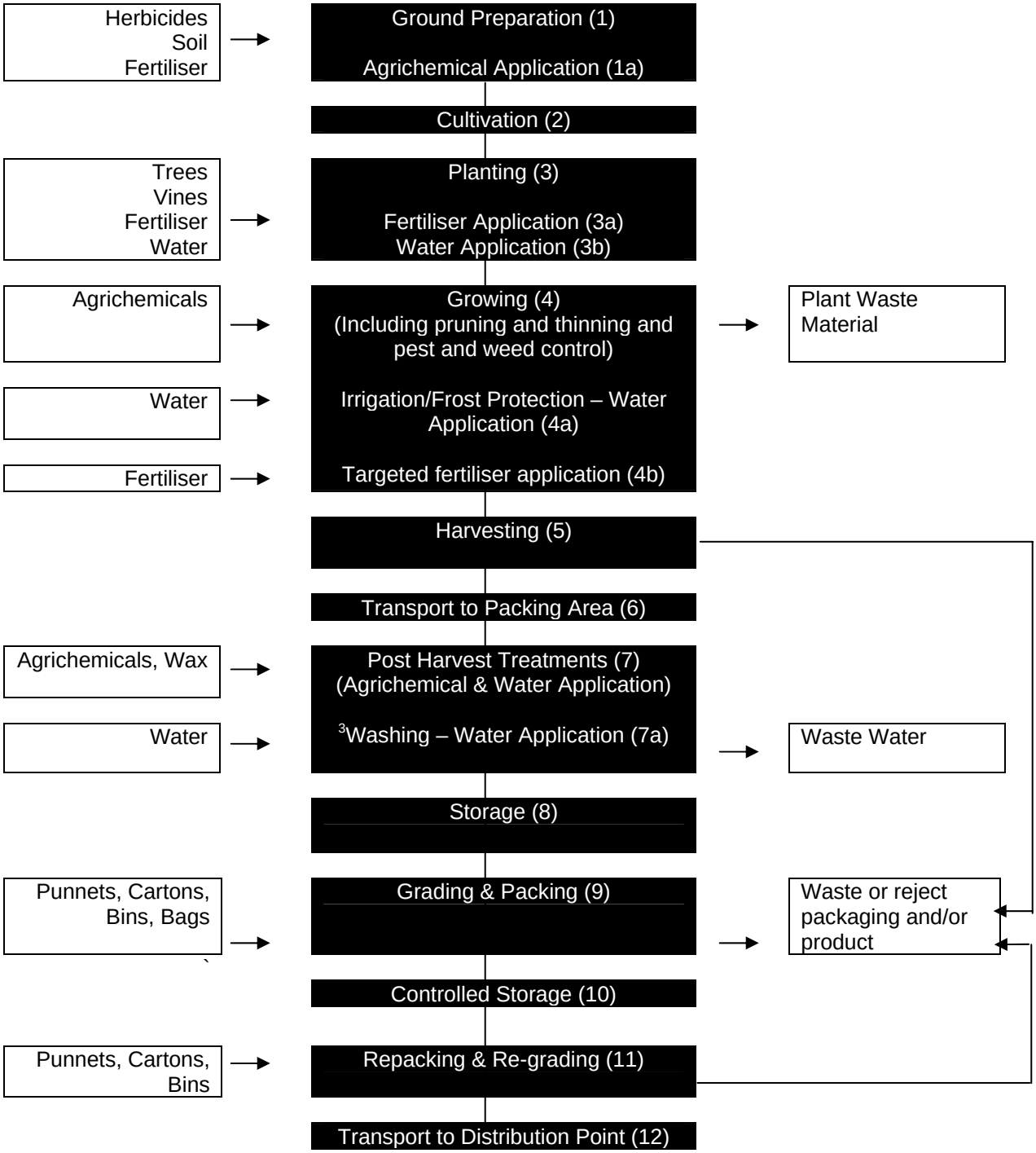
The left hand column in the process flows indicates inputs to the process. The center is the actual process and the right hand column indicates outputs.

Process Flow for Root Crops
(Including potatoes, carrots, and onions)



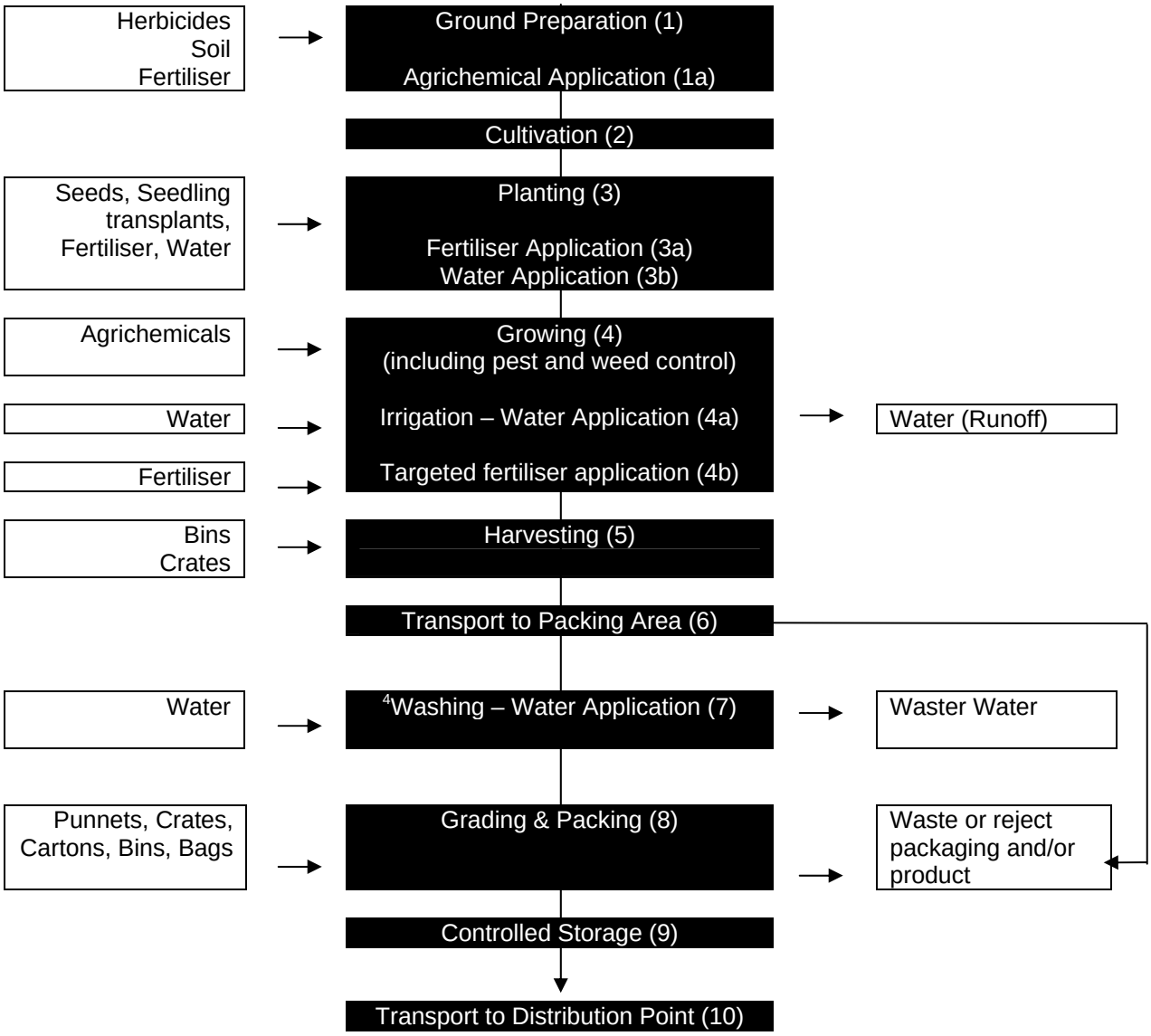
[2] Not all lines are washed and/or have post harvested treatments applied

Process Flow For Fruit Crops and Berry fruit
(Including berry-fruit, summer fruit, sub-tropicals, kiwifruit and apples)



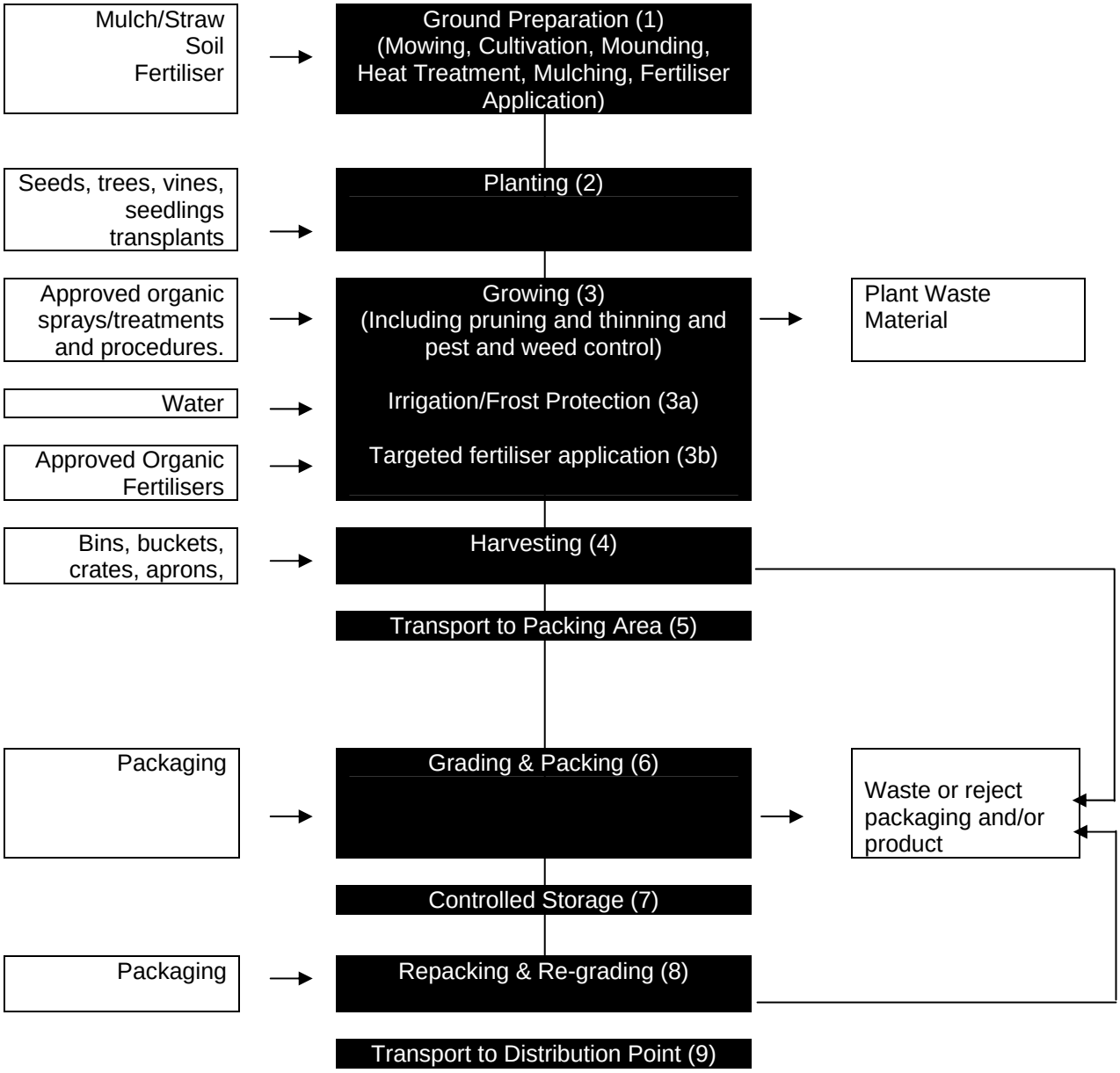
[3] Only applies to some crops e.g. apples

Process Flow for Leafy Greens Vegetables
(Including brassica and lettuce)

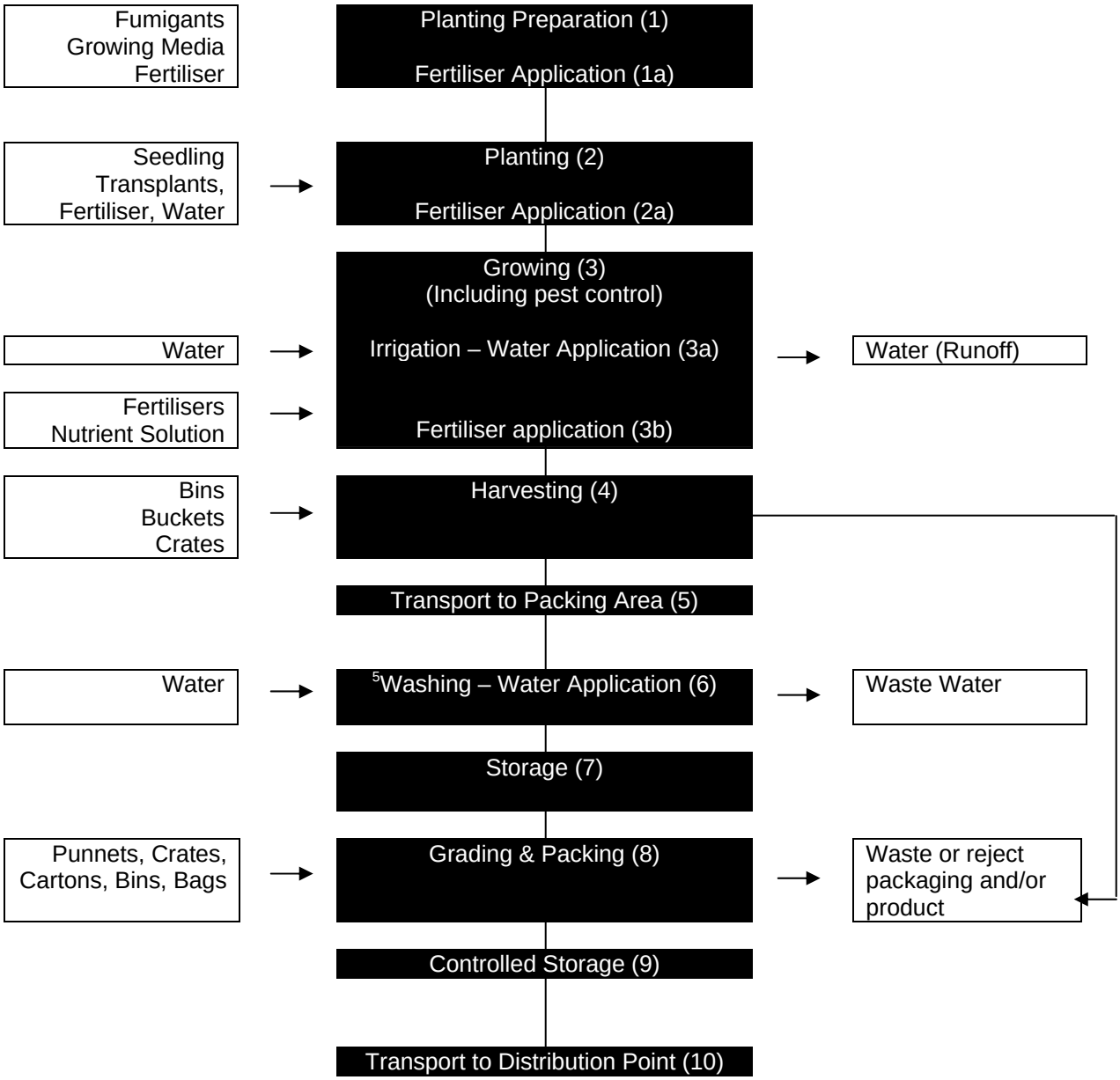


[4] Only applies to some crops

Process Flow For Organics

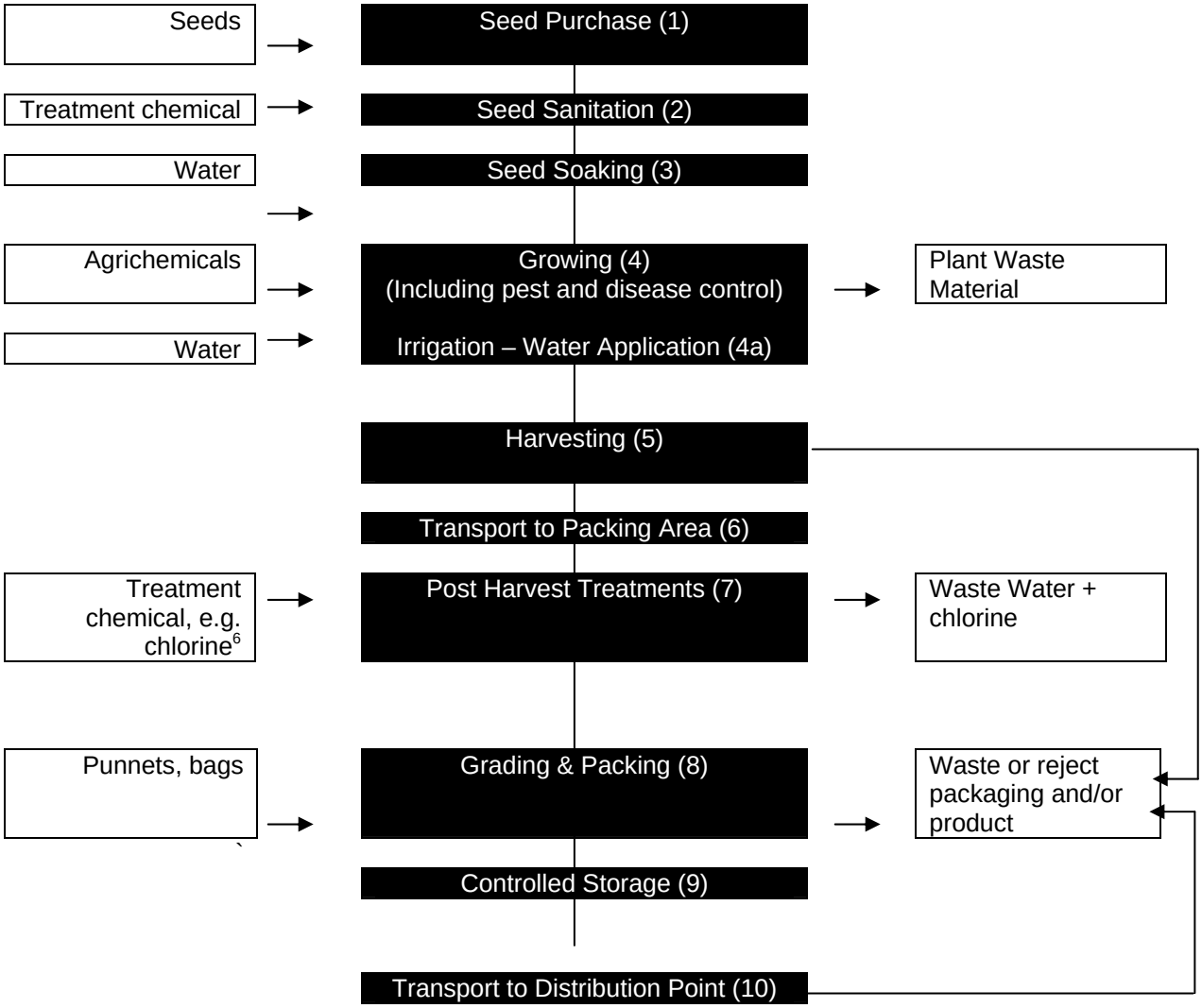


Process Flow for Glasshouse Crops
(Including capsicums and tomato's)



[5] Only applies to some crops

Process Flow For Sprouts



[6] Organic practices do not allow the use of chlorine but do allow other sanitisers such as hydrogen peroxide

6. HAZARD IDENTIFICATION AND ANALYSIS

6.1 Hazard Identification

The following tables indicate the hazards with the potential to occur at each step in the process. The process is based on the process flow diagrams detailed in Section 5.

Hazard identification was undertaken by summarising the information obtained from the literature search, and then detailing at each step the hazards that were reasonably likely to occur.

It is important to note that the identification process details all hazards determined through the literature search to be a potential hazard. During implementation of this generic HACCP plan operators may wish to determine the "actual" hazards in their process and adjust the HACCP plan accordingly.

Some further research/information gathering is required to determine significance of further potential hazards. This has been highlighted accordingly.

Table 4: Root crops hazard identification

Process Step	Potential Hazard Source	Potential Hazard
1 – Ground Preparation	Fertiliser – compost / biosolids	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Listeria* *Clostridium*
	Agrichemical Application e.g Synthesised Fertilisers, herbicides, pesticides	Chemical residues
2 – Cultivation		
3 - Planting	Fertiliser Application	Chemical residues
	Water	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Cyclospora* *Yersinia* *Clostridium* Chemical residues Heavy Metals
	Soils	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Listeria* *Clostridium* *Heavy Metals* *Chemical Residues*
4 – Growing	Water	Refer Step 3
	Agrichemical Application	Refer Step 1
5 – Harvesting	Contact with food-handlers	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Clostridium*
	Equipment and Machinery	Physical
6 – Transport	Dust, Dirt, Rodents, Bird droppings	Refer Step 3
7 – Post-harvest Treatments/washing	Agrichemical Application	Refer Step 1
	Water	Refer Step 3
8 – Storage	Dust, Dirt, Rodents, Bird droppings	Refer Step 3
9 - Grading/Packing	Contact with food-handlers/ equipment	Refer Step 5
10 – Controlled Storage		
11 – Transport		

Table 5: Fruit & berry fruit crops hazard identification

Process Step	Potential Hazard Source	Potential Hazard
1 – Ground Preparation	Fertiliser compost / biosolids	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Listeria* *Clostridium*
	Agrichemical Application e.g Synthesised Fertilisers, herbicides, Pesticides	Chemical residues
2 – Cultivation		
3 – Planting		
	Fertiliser Application	Chemical residues
	Water	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Cyclospora* *Yersinia* *Clostridium* Heavy Metals Chemical residues
	Soils	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Listeria* *Clostridium* Heavy Metals Chemical Residues
4 – Growing	Water	Refer Step 3
	Agrichemical Application	Refer Step 1
5 – Harvesting	Contact with food-handlers	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Clostridium*
6 – Storage	Dust, Dirt, Rodents, Bird Droppings	Refer Step 3
7 – Post-harvest Treatment/washing	Agrichemical Application	Chemical Residues
	Water	Refer Step 3
8 – Storage	Dust, Dirt, Rodents, Bird Droppings	Refer Step 3

Process Step	Potential Hazard Source	Potential Hazard
9 - Grading/Packing	Contact with food-handlers	Refer step 5
10 – Controlled Storage		
11 – Repacking/ Regrading	Contact with food-handlers	Refer Step 5
12 – Transport		

Table 6: Leafy green vegetable crops hazard identification

Process Step	Potential Hazard Source	Potential Hazard
1 – Ground Preparation	Fertiliser - compost / biosolids	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Listeria* *Clostridium*
	Agrichemical Application	Chemical Residues
2 – Cultivation		
3 – Planting		
	Fertiliser Application	Chemical Residues
	Water	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Cyclospora* *Yersinia* *Clostridium* Heavy Metals Chemical residues
	Soils	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Clostridium* Heavy Metals Chemical residues
4 – Growing	Water	Refer Step 3
	Agrichemical Application	Refer Step 1

Process Step	Potential Hazard Source	Potential Hazard
5 – Harvesting	Contact with food-handlers	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Clostridium*
6 – Transport	Dust, Dirt, Rodents, Bird Droppings	Refer Step 3
7 – Washing	Water	Refer Step 3
8 - Grading/Packing	Contact with food-handlers	Refer Step 5
9 – Controlled Storage		
10 – Transport		

Table 7: Organic crops hazard identification

Process Step	Potential Hazard Source	Potential Hazard
1 – Ground Preparation	Fertiliser - compost / biosolids	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Listeria* *Clostridium*
2 – Cultivation		
3 – Planting		
	Fertiliser Application	Refer step 1
	Water	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Cyclospora* *Yersinia* *Clostridium* Heavy Metals Physical
	Soils	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Clostridium*
4 – Growing	Water	Refer Step 3

Process Step	Potential Hazard Source	Potential Hazard
5 – Harvesting	Contact with food-handlers	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Clostridium*
6 – Transport	Physical contamination	Various
7 - Grading/Packing	Contact with food-handlers	Refer Step 5
9 – Controlled Storage	Physical contamination	Various
9 – Regrading & Repacking	Contact with food-handlers	Refer Step 7
10 – Transport		

Table 8: Glasshouse crops hazard identification

Process Step	Potential Hazard Source	Potential Hazard
1 – Planting Preparation	Fertiliser Application	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Listeria* *Clostridium*
2 – Planting	Fertiliser Application	**Refer Step 1**
3 – Growing	Contaminated Water	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Cyclospora* *Yersinia* *Clostridium* Pesticides Heavy Metals Physical
	Fertiliser Application	**Refer Step 1**
4 – Harvesting	Contact with food-handlers	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Clostridium*
5 – Transport	Physical contamination	Various
6 – Washing	Water	Refer Step 3
7 - Storage	Physical contamination	Various
8 - Grading/Packing	Contact with food-handlers	Refer Step 4
9 – Controlled Storage		
10 – Transport		

Table 9: Sprouts hazard identification

Process Step	Potential Hazard Source	Potential Hazard
1 – Seed Purchase	Contaminated Seeds	*E.coli* *Salmonella* *Listeria*
2 – Seed Sanitation	Incorrect application of treatment chemical	**Undetermined as the treatment and chemicals vary**
3 – Seed Soaking	Contaminated Water	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Cyclospora* *Yersinia* *Clostridium* Pesticides Heavy Metals Physical
4 – Growing	Contaminated Water	Refer Step 3
5 – Harvesting	Contact with ill food-handlers	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Clostridium* Various Physical
6 – Transport	Physical contamination	Various
7 – Post-harvest Treatments	Incorrect application of chemical	Refer Step 2
8 - Grading/Packing	Contact with ill food-handlers	Refer Step 5
9 – Controlled Storage	Physical contamination	Various
10 – Transport	Physical contamination	Refer Step 6

6.2 Hazard Analysis & Significance

The hazard analysis was undertaken to determine the hazards most likely to occur at each step of the process by evaluating the information obtained during the literature search and the conditions leading to their presence in fresh produce. The significance of the hazards was determined by considering whether or not their elimination or reduction to acceptable levels was necessary for fresh produce safety. Acceptable limits have been described as the HACCP plan's food safety objectives.

6.2.1 *Biological Hazards*

The biological hazard analysis was undertaken taking into account the following:

1. Likely occurrence of hazard in fresh produce in NZ and internationally,
2. The qualitative and/or quantitative evaluation of the presence of hazards,
3. Multiplication or survival of hazards on fresh produce,
4. Production or persistence of toxins, and
5. Conditions leading to the above including the likely state of the product prior to consumption.

Viruses

- Norwalk-like Viruses

    1. Norwalk-like viruses are known to be a source of outbreaks in New Zealand, however contamination occurred from the food-handler and not the produce itself. Contamination can occur when foods, especially raw foods, are in contact with ill food-handlers and contaminated surfaces. Further contamination may occur from contact with contaminated soil, water or exposure of crops to faecal matter including inadequately decomposed compost,
    2. Unknown,
    3. Cannot grow in or on fresh produce, however fresh produce can serve as a transmission vehicle,
    4. Not available, and
    5. Potential hazard when fresh produce is consumed raw and/or cut or shredded and then the product are eaten raw. This excludes potatoes. Organics crops may also use the practice of stock in fields for “clean-up” increasing risk through faecal contamination.

- Hepatitis A

    1. Information only links Hepatitis A with some crops some such as berries, lettuce and tomatoes. No information links Hepatitis A to fresh produce in New Zealand. Contamination can occur when foods, especially raw foods, are in contact with from ill food-handlers and contaminated surfaces. Further contamination may occur

from contact with contaminated soil, water or exposure of crops to faecal matter including inadequately decomposed compost,
2. Unknown,
3. Cannot grow in or on fresh produce, however fresh produce can serve as a transmission vehicle,
4. Not available, and
5. Potential hazard when fresh produce is consumed raw and/or cut or shredded and then the product are eaten raw. This excludes potatoes. Organics crops may also use the practice of stock in fields for “clean-up” increasing risk through faecal contamination

Pathogens

- *E. coli* 0157:H7

1. There have been no documented outbreaks from *E. coli* 0157:H7 in fresh produce in New Zealand. Outbreaks internationally have been documented, including apple juice and lettuce. Contamination may occur with contact with contaminated soil, water or exposure of crops to faecal matter including inadequately decomposed compost,
2. Unknown,
3. Growth is increased on damaged tissue such as injuries to wax layer or cuticle and underlying tissues,
4. Unknown, and
5. Potential hazard when fresh produce is consumed raw and/or cut or shredded and then the product are eaten raw. This excludes potatoes. Organics crops may also use the practice of stock in fields for “clean-up” increasing risk through faecal contamination.

- *Salmonella*

1. *Salmonella* is present in New Zealand, however the link between the presence and contamination of fresh produce is unknown. Contamination may occur with contact with contaminated soil, water or exposure of crops to faecal matter including inadequately decomposed compost. *Salmonella* may also be transmitted through contamination from ill food-handlers and contaminated surfaces,
2. Unknown,
3. Growing conditions for sprouts may support or promote the growth of *Salmonella*,

4. Unknown, and
5. Potential hazard when fresh produce is consumed raw and/or cut or shredded and then the product are eaten raw. This excludes potatoes. Organics crops may also use the practice of stock in fields for “clean-up” increasing risk through faecal contamination.

- *Campylobacter*

1. *Campylobacter* appears to be associated mainly with unpasteurised milk, poultry and untreated water (especially unchlorinated water). In this regard, fresh produce contamination risk would be present in the use of untreated water in crop production and/or processing when water is likely to come into contact with the product, for example crop production close to the ground and overhead irrigation. Cross contamination from contaminated milk, meat, surfaces and utensils are also a potential source,
2. Unknown,
3. Unknown,
4. Unknown, and
5. Potential hazard when fresh produce contaminated with *Campylobacter* is consumed raw and/or cut or shredded and then the product are eaten raw. This excludes potatoes.

- *Shigella*

1. *Shigella* contamination in fresh produce can occur through faecal contamination, both through contaminated waterways and in the field. A lack of basic hygiene and hand-washing habits can also cause contamination by cross-contamination from people,
2. Unknown,
3. Unknown,
4. Unknown, and
5. Potential hazard when contaminated fresh produce is consumed raw and/or cut or shredded and then the product are eaten raw. This excludes potatoes.

- *Listeria*

1. *Listeria* is present in New Zealand soils. The link between the presence in soils and contamination of fresh produce is unknown however, fresh produce that has come into

contact with contaminated soil and/or mulches and has been stored for any length of time has the potential to be harbouring and/or growing *Listeria*,
2. Unknown,
3. Information collated indicates that *Listeria monocytogenes* can grow on fresh produce. *Listeria monocytogenes* can grow over a wide range of temperatures (-4 to 37°C – Marler, 2000) and potential risk when contaminated produce is stored for long periods,
4. Unknown, and
5. Potential hazard when contaminated fresh produce is consumed raw and/or cut or shredded and then the product are eaten raw. This excludes potatoes.

- *Clostridium botulinum, Clostridium perfringens & Yersinia enterocolitica*

  1. Clostridia are found in soil and are known to produce a toxin under anaerobic conditions. It can also be present through faecal contamination. *Y. enterocolitica* is found in soil and water, however the prevalence of *Y. enterocolitica* in New Zealand waters is unknown. The link between the presence of these organisms in soils and/or water and contamination of fresh produce is unknown. Contamination may occur when produce comes into contact with soil and a further risk of Clostridia when fresh produce is subsequently placed under anaerobic conditions, e.g. individually wrapped lettuces,
  2. Unknown,
  3. *Yersinia enterocolitica* has the ability to grow at refrigerated temperatures,
  4. *Clostridium botulinum* is not harmful until it produces a toxin in a low oxygen environment, and
  5. When produce is held in a low oxygen environment such as vacuum packaging, the rate of respiration can create anaerobic conditions favouring the growth of *Clostridium botulinum*. May be an issue for further processed glass house crops.

  Further research into *Y. enterocolitica* presence in water is required to ascertain the significance of this hazard and the necessity for controls.

Parasites

1. *Giardia* is present in New Zealand water. The presence of *Giardia* on raw produce may occur when produce comes into contact with contaminated animal or human faeces, sewage, untreated sewage in water and primary or secondary municipal sludge,
2. Unknown,
3. Unknown,
4. Unknown, and
5. Potential hazard when contaminated fresh produce is consumed raw and/or cut or shredded and then the product are eaten raw. This excludes potatoes.

Due to the uncertainty of health risk in regards to *Cyclospora cayetanensis* further research is necessary to determine its significance and necessity for control.

6.2.2 Chemical Hazards

The chemical hazard analysis was undertaken taking into account the following:

1. Likely occurrence of hazard in fresh produce,
2. The qualitative and/or quantitative evaluation of the presence of hazards,
3. Ability to remain above acceptable levels and be absorbed (i.e. persistence), and
4. Conditions leading to the above.

The food safety objectives for residues have been defined as the New Zealand MRL's however this may need to be reviewed on implementation as exporters are required to comply with the importing country MRL's. Food safety objectives for heavy metals in water are defined as the MAV outlined in the NZDWS. Food safety objectives for heavy metals in soil are undetermined.

Agrichemical Residues

- Residues in the Soil

    1. Can occur when land with unacceptable levels of residues is used for growing certain crops,
    2. Research has shown that there are areas in New Zealand known to have higher levels of residues from past use (e.g. land used as petrol stations, sheep dipping areas, etc),

3. The uptake of these residues into produce is unknown, and
4. Undetermined.

Further investigation or information gathering is required to determine if the is a significant hazard and whether or not crops are at risk through uptake of soil residues.

If the hazard is significant planting restrictions may need to be applied. This may include researching "target soil levels" from international requirements. Controls may be based on these after the relevance of the international requirements to New Zealand has been determined.

- Residues in Fresh Produce

1. The hazard is likely to occur if manufacturers instructions are not followed including withholding periods,
2. The 1997/1998 NZTDC found no samples above Food Regulation limits (MRL's). According to this survey, "the pesticide residues found in the survey are unlikely to have any adverse health implications for the New Zealand population",
3. Undetermined, and
4. The use of agrichemicals outside the condition of registration (commonly known as off-label chemical use) - often a result of agrichemicals not being registered for specific crop/chemical combinations.

The studies mentioned in this report indicate the number of residues exceeding MRL's has fallen. [7]Assuming the results of the 1997/1998 survey are the same for export and domestic produce (the samples are selected domestically) the survey suggests that the industry may have already addressed the issue of exceeding MRL's. This may have been done through industry programmes such as NZAET/Fresh Produce QA Programme for the domestic market, and Zespri, ENZA, Avocado, Summerfruit, Strawberry, and Persimmon export programmes.

Off-label chemical use is still a potential risk and classed as a significant hazard. For economic reasons this practise is reasonably common, particularly for minor crops.

[7] For the purposes of this study it has been assumed that the same spray programmes have been applied to both export and local market product. Domestic produce is usually grade off from export crops therefore has gone through the same production system. Individual export programme results may confirm this assumption, however these were unavailable during this study.

Mechanisms could be put in place to assess dietary risk associated with off-label use of chemicals and the registration/approval of such off-label use. Consideration of research and approvals from other countries could enable a broader spectrum of crop/chemical combinations to be covered e.g. research undertaken by the joint Australia/New Zealand producer based organisation, Crop Protection Approvals Research Pty. Ltd.

Heavy Metals

- Heavy Metals in Water

    1. There seems to be only a potential risk with heavy metals in water when water is sourced from contaminated sites, especially roof catchment systems where corrosion occurs and where corrosion occurs from plumbing materials,
    2. Some studies (as described above in the literature search) have determined the presence of heavy metals such as lead, copper and nickel in water,
    3. Undetermined, and
    4. It appears to be unacceptable to rely on council water supplies as potable water because there may be potential sources of contamination between treatment point and point of use.

- Heavy Metals in soil

    1. Can occur when land with unacceptable levels of heavy metals is used for growing certain crops,
    2. Surveys within New Zealand on cadmium in fresh produce have provided contradictory information,
    3. Cadmium in soil poses a risk due to it's uptake and degradation rate, and
    4. Undetermined.

    Due to inadequate information the significance of this hazard is undetermined.

6.2.3 Physical Hazards

The physical hazard analysis was undertaken taking into account the following:

1. Likely occurrence of hazard in fresh produce,

2. The qualitative and/or quantitative evaluation of the presence of hazards,
3. Persistence of physical contaminants, and
4. Conditions leading to the above.

Food safety objectives for physical hazards have been defined as absent or present.

1. According to the survey detailed in the literature search 14% of food safety complaints were associated with fresh produce (although not all necessarily physical hazards),
2. Undetermined due to the diversity of the industry,
3. It is likely that physical hazards will remain if they are present, and
4. All steps in the process can potentially produce physical hazards, e.g. stones, glass, metal, insects, rodents, plastic, sticking plasters, string, and hair.

6.2.4 Examples of Further Research/Information Required

There are a number of areas where further research or more information is required before a potential hazard can be determined as significant or not. These include:

1. The presence of *Y. enterocolitica* in New Zealand waters,
2. The level of health risk associated with *Cyclospora cayetanensis*,
3. The uptake of residues in soil by plants and any conditions leading to the presence of heavy metals,
4. Information for determining hazard significance for heavy metals in soil such as likely occurrence, evaluation, persistence and conditions leading to the above.

7. CONTROL MEASURES

Control measures are actions or activities that can be used to prevent, eliminate or reduce a hazard to acceptable levels.

The following information details the control measures for each significant hazard. Identified control measures may already be addressed by current Good Agricultural Practices (GAP's).

With the implementation of this HACCP plan each operation should review the control measure and determine whether or not it is fully in place in their operation. Where control is not carried out as described the operator should determine the gaps and implement as necessary. They should also review their practices against additional GAP and where necessary implement appropriate procedures/practices.

It is noted for some crops control measures are undetermined, as the significance of potential hazards has not been identified. These would need to be addressed during implementation.

Table 10: Root crops control measures

Process Step	Potential Hazard Source	Potential Hazard	Control Measure
1 – Ground Preparation	Fertiliser (inadequately decomposed compost)	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Listeria* *Clostridium*	Manures, biosolids and other fertilisers are certified or sourced from reputable supplier 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).
	Incorrect Agrichemical Application	Pesticides	Agrichemicals are not used outside condition of registration[8] and rate of application as per manufacturer's instructions are followed
2 – Cultivation			
3 – Planting			
	Incorrect Fertiliser Application	Pesticides As above	As above, in addition withholding periods are followed before planting for agrichemicals
	Contaminated Water	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Cyclospora* *Yersinia* *Clostridium* Pesticides Heavy Metals	Refer water control as 5.1 below
	Contaminated Soils	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Clostridium*	Time between manure, biosolids or other natural fertiliser is appropriate and these are not applied to the top of crops, this includes length of time between the land use of stock and planting
4 – Growing	Contaminated Water	Refer Step 3	Refer Step 3
	Incorrect Agrichemical Application	Refer Step 1	Refer Step 1

[8] It is noted that not all crop/chemical combinations are registered therefore using chemicals outside the terms of registration may occur. There is a possibility of a chemical hazard level being exceeded (for low levels of residue) due to there being no MRL's determined for that specific crop/chemical combination. As mentioned earlier in this report Mechanisms could be put in place to assess dietary risk associated with off-label use of chemicals and the registration/approval of such off-label use. Consideration of research and approvals from other countries could enable a broader spectrum of crop/chemical combinations to be covered e.g. research undertaken by the joint Australia/New Zealand producer based organisation, Crop Protection Approvals Research Pty. Ltd.

Process Step	Potential Hazard Source	Potential Hazard	Control Measure
5 – Harvesting	Contact with ill food-handlers	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Clostridium*	As below for food-handlers (Step 9), in addition field equipment is maintained and clean. Packaging materials (i.e. paper bags, hessian sacks, cardboard cartons, plastic inners, plastic and net bags) are maintained and clean and inspected before use. Food -handlers conduct their work in such a manner that reduces the opportunity for potential contamination from physical objects such as sticking plasters, wood, metal, glass, etc
6 – Transport	Physical contamination	Various	Transport vehicles are soundly constructed, clean and inspected before use
7 – Post-harvest Treatments/washing	Incorrect Agrichemical Application	Refer Step 1	Refer Step 1
	Contaminated Water	Refer Step 3	Refer Step 1
8 – Storage	Physical contamination	Various	Storage facilities are built in a manner to avoid access by pests and reduce the opportunity for physical contamination and inspected before use
9 - Grading/Packing	Contact with ill food-handlers/contaminated equipment	Refer Step 5	Food handlers do not come to work when suffering from symptoms of a communicable disease (e.g. nausea, abdominal cramps, vomiting, diarrhoea). Food handlers maintain an appropriate degree of personal cleanliness including that cuts and wounds are covered and hands are washed and sanitised where applicable. Amenities provided for food handlers are kept in a good state of repair, clean and well-stocked
10 – Controlled Storage	Physical contamination	Refer Step 8	Refer Step 8
11 – Transport	Physical contamination	Refer Step 6	Refer Step 6

Table 11: Fruit & berry fruit crops control measures

Process Step	Potential Hazard Source	Potential Hazard	Control Measure
1 – Ground Preparation	Fertiliser (inadequately decomposed compost)	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Listeria* *Clostridium*	Manures, biosolids and other fertilisers are certified or sourced from reputable supplier 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).
	Incorrect Agrichemical Application	Pesticides	Agrichemicals are not used outside condition of registration[9] and rate of application as per manufacturer's instructions are followed
2 – Cultivation			
3 – Planting	Contact with ill food-handlers	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Clostridium*	Food handlers do not come to work when suffering from symptoms of a communicable disease (e.g. nausea, abdominal cramps, vomiting, diarrhoea). Food handlers maintain an appropriate degree of personal cleanliness including that cuts and wounds are covered and hands are washed and sanitised where applicable. Amenities provided for food handlers are kept in a good state of repair, clean and well-stocked
	Incorrect Fertiliser Application	As above Step 1 (agrichemicals & fertiliser)	As above (step 1), in addition withholding periods are followed before planting for agrichemicals
	Contaminated Water	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Cyclospora* *Yersinia* *Clostridium* Pesticides Heavy Metals	Refer water control as follows

[9] Refer to footnote 9

Process Step	Potential Hazard Source	Potential Hazard	Control Measure
	Contaminated Soils	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Clostridium*	Time between manure, biosolids or other natural fertiliser is appropriate and these are not applied to the top of crops, this includes length of time between land use of stock and planting
4 – Growing	Contaminated Water	Refer Step 3	Refer Step 3
	Incorrect Agrichemical Application	Pesticides	Refer Step 1
5 – Harvesting	Contact with ill food-handlers	Refer Step 3 Various Physical	As above for food-handlers (step 3), in addition field equipment is maintained and clean. Packaging materials (i.e. bins, Punnets, cartons and tray packs) are maintained and clean and inspected before use. Food -handlers conduct their work in such a manner that reduces the opportunity for potential contamination from physical objects such as sticking plasters, wood, metal, glass, etc
6 – Storage	Physical contamination	Various	Storage facilities are built in a manner to avoid access by pests and reduce the opportunity for physical contamination and inspected before use
7 – Post-harvest Treatment/washing	Incorrect Agrichemical Application	Pesticides	Refer Step 1
	Contaminated Water	Refer Step 3	Refer Step 3
8 – Storage	Physical contamination	Refer Step 6	Refer Step 6
9 - Grading/Packing	Contact with ill food-handlers	Refer above Step 5	As above for food-handlers (step 5), in addition product contact surfaces are maintained and clean and inspected before use
10 – Controlled Storage	Physical contamination	Refer Step 6	Refer Step 6
11 – Repacking/ Regrading	Contact with ill food-handlers	Refer above Step 5	As above Step 9
12 – Transport	Physical contamination	Various	Transport vehicles are soundly constructed and clean and inspected before use

Table 12: Leafy green vegetable crops control measures

Process Step	Potential Hazard Source	Potential Hazard	Control Measure
1 – Ground Preparation	Fertiliser (inadequately decomposed compost)	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Listeria* *Clostridium*	Manures, biosolids and other fertilisers are certified or sourced from reputable supplier 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).
	Incorrect Agrichemical Application	Pesticides	Agrichemicals are not used outside condition of registration[10] and rate of application as per manufacturer's instructions are followed
2 – Cultivation			
3 – Planting	Contact with ill food-handlers	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Clostridium*	Food handlers do not come to work when suffering from symptoms of a communicable disease (e.g. nausea, abdominal cramps, vomiting, diarrhoea). Food handlers maintain an appropriate degree of personal cleanliness including that cuts and wounds are covered and hands are washed and sanitised where applicable. Amenities provided for food handlers a kept in a good state of repair, clean and well-stocked
	Incorrect Fertiliser Application	Pesticides, also Refer step 1	As above (step 1), in addition withholding periods are followed before planting for agrichemicals
	Contaminated Water	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Cyclospora* *Yersinia* *Clostridium* Pesticides Heavy Metals Physical	Refer water control as follows

[10] Refer to footnote 9.

Process Step	Potential Hazard Source	Potential Hazard	Control Measure
	Contaminated Soils	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Clostridium*	Time between manure, biosolids or other natural fertiliser is appropriate and these are not applied to the top of crops, this includes length of time between land use of stock and planting
4 – Growing	Contaminated Water	Refer Step 3	Refer Step 3
	Incorrect Agrichemical Application	Refer Step 1	Refer Step 1
5 – Harvesting	Contact with ill food-handlers	Refer Step 3 Various physical	As above for food-handlers (step 3), in addition field equipment is maintained and clean. Packaging materials (i.e. plastic inners, cardboard cartons) are maintained and clean and inspected before use. Food - handlers conduct their work in such a manner that reduces the opportunity for potential contamination from physical objects such as sticking plasters, wood, metal, glass, etc
6 – Transport	Physical contamination	Various	Transport vehicles are soundly constructed and clean and inspected before use
7 – Washing	Contaminated Water	Refer Step 3	Refer Step 3
8 - Grading/Packing	Contact with ill food-handlers	Refer Step 5	As above for food-handlers (step 5), in addition product contact surfaces are maintained and clean and inspected before use
9 – Controlled Storage	Physical contamination	Various	Storage facilities are built in a manner to avoid access by pests and reduce opportunity for physical contamination and inspected before use
10 – Transport	Physical contamination	Refer Step 6	Refer Step 6

Table 13: Organic crops control measures

Process Step	Potential Hazard Source	Potential Hazard	Control Measure
1 – Ground Preparation	Fertiliser (inadequately decomposed compost)	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Listeria* *Clostridium*	Manures, biosolids and other fertilisers are certified or sourced from reputable supplier 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).
2 – Cultivation			
3 – Planting	Contact with ill food-handlers	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Clostridium*	Food handlers do not come to work when suffering from symptoms of a communicable disease (e.g. nausea, abdominal cramps, vomiting, diarrhoea). Food handlers maintain an appropriate degree of personal cleanliness including that cuts and wounds are covered and hands are washed and sanitised where applicable. Amenities provided for food handlers a kept in a good state of repair, clean and well-stocked
	Incorrect Fertiliser Application	Refer step 1	Refer Step 1
	Contaminated Water	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Cyclospora* *Yersinia* *Clostridium* Pesticides Heavy Metals Physical	Refer water control as follows
	Contaminated Soils	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Clostridium*	Time between manure, biosolids or other natural fertiliser is appropriate and these are not applied to the top of crops, this includes length of time between land use of stock and planting
4 – Growing	Contaminated Water	Refer Step 3	Refer Step 3

Process Step	Potential Hazard Source	Potential Hazard	Control Measure
5 – Harvesting	Contact with ill food-handlers	Refer Step 3 Various physical	As above for food-handlers (step 3), in addition field equipment is maintained and clean. Packaging materials (i.e. various) are maintained and clean and inspected before use. Food - handlers conduct their work in such a manner that reduces the opportunity for potential contamination from physical objects such as sticking plasters, wood, metal, glass, etc
6 – Transport	Physical contamination	Various	Transport vehicles are soundly constructed and clean and inspected before use
7 - Grading/Packing	Contact with ill food-handlers	Refer Step 5	As above for food-handlers (step 5), in addition product contact surfaces are maintained and clean and inspected before use
9 – Controlled Storage	Physical contamination	Various	Storage facilities are built in a manner to avoid access by pests and reduce opportunity for physical contamination and inspected before use
9 – Regrading & Repacking	Contact with ill food-handlers	Refer Step 7	Refer Step 7
10 – Transport	Physical contamination	Refer Step 6	Refer Step 6

Table 14: Glasshouse crops control measures

Process Step	Potential Hazard Source	Potential Hazard	Control Measure
1 – Planting Preparation	Incorrect Fertiliser Application	**Undetermined, the type of fertiliser used is unknown**	**Undetermined**
2 – Planting	Contact with ill food-handlers	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Clostridium*	Food handlers do not come to work when suffering from symptoms of a communicable disease (e.g. nausea, abdominal cramps, vomiting, diarrhoea). Food handlers maintain an appropriate degree of personal cleanliness including that cuts and wounds are covered and hands are washed and sanitised where applicable. Amenities provided for food handlers a kept in a good state of repair, clean and well-stocked
	Incorrect Fertiliser Application	**Undetermined, the type of fertiliser used is unknown**	**Undetermined**
	Contaminated Soil/Growing Medium	**Undetermined**	**Undetermined**
3 – Growing	Contaminated Water	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Cyclospora* *Yersinia* *Clostridium* Pesticides Heavy Metals Physical	Refer water control as follows
	Incorrect Fertiliser Application	**Undetermined, the type of fertiliser used is unknown**	**Undetermined**

Process Step	Potential Hazard Source	Potential Hazard	Control Measure
4 – Harvesting	Contact with ill food-handlers	Refer Step 2 Various physical	As above for food-handlers (step 2), in addition field equipment is maintained and clean. Packaging materials (i.e. cartons) are maintained and clean and inspected before use. Food - handlers conduct their work in such a manner that reduces the opportunity for potential contamination from physical objects such as sticking plasters, wood, metal, glass, etc
5 – Transport	Physical contamination	Various	Transport vehicles are soundly constructed and clean and inspected before use
6 – Washing	Contaminated Water	Refer Step 3	Refer Step 3
7 - Storage	Physical contamination	Various	Storage facilities are built in a manner to avoid access by pests and reduce opportunity for physical contamination and inspected before use
8 - Grading/Packing	Contact with ill food-handlers	Refer Step 4	Refer Step 4
9 – Controlled Storage	Physical contamination	Refer Step 7	Refer Step 7
10 – Transport	Physical contamination	Refer Step 5	Refer Step 5

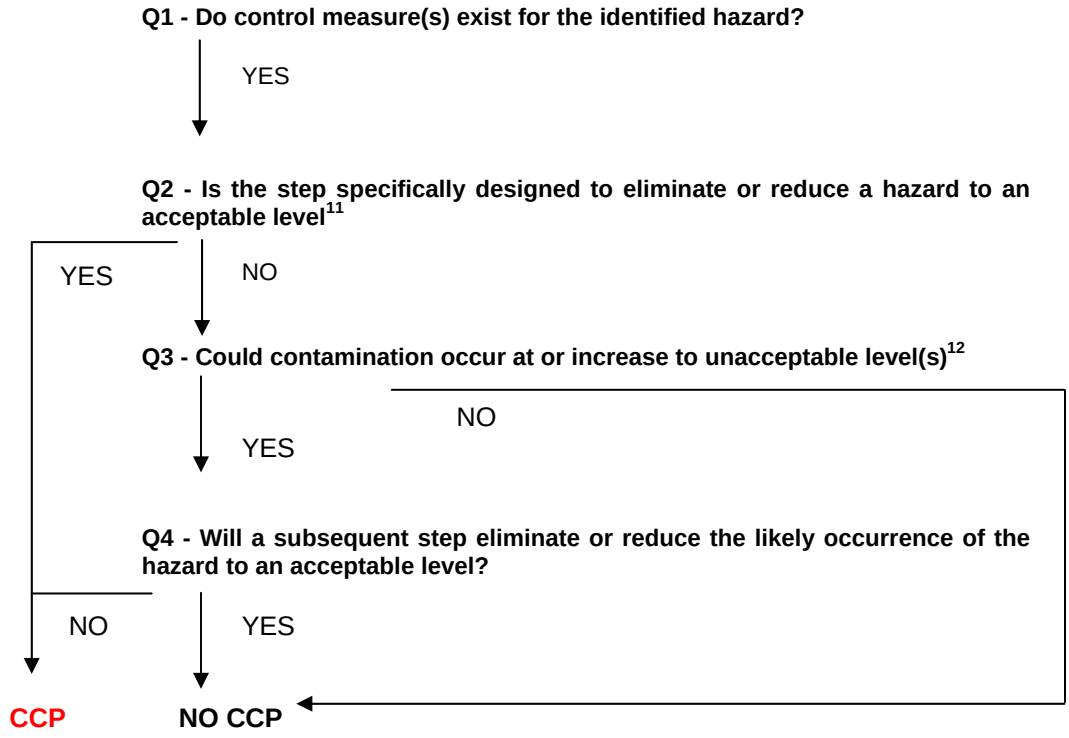
Table 15: Sprouts control measures

Process Step	Potential Hazard Source	Potential Hazard	Control Measures
1 – Seed Purchase	Contaminated Seeds	*E.coli* *Salmonella* *Listeria*	Seeds are purchased from reputable suppliers and grown under good agricultural practices. Seeds are stored in closed and sealed containers in a clean dry area.
2 – Seed Sanitation	Incorrect application of treatment chemical	**Undetermined as the treatment and chemicals vary**	**Undetermined**
3 – Seed Soaking	Contaminated Water	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Cyclospora* *Yersinia* *Clostridium* Pesticides Heavy Metals Physical	Refer Water control as follows

Process Step	Potential Hazard Source	Potential Hazard	Control Measures
4 – Growing	Contaminated Water	Refer Step 3	Refer Step 3
5 – Harvesting	Contact with ill food-handlers	Norwalk-like Viruses Hepatitis A *E. coli* O157:H7 *Salmonella* *Campylobacter* *Shigella* *Giardia* *Listeria* *Clostridium* Various Physical	Food handlers do not come to work when suffering from symptoms of a communicable disease (e.g. nausea, abdominal cramps, vomiting, diarrhoea). Food handlers maintain an appropriate degree of personal cleanliness including that cuts and wounds are covered and hands are washed and sanitised where applicable. Amenities provided for food handlers a kept in a good state of repair, clean and well-stocked. Equipment is maintained and clean. Packaging materials (i.e. Punnets & plastic bags) are maintained and clean and inspected before use. Food -handlers conduct their work in such a manner that reduces the opportunity for potential contamination from physical objects
6 – Transport	Physical contamination	Various	Transport vehicles are soundly constructed and clean and inspected before use
7 – Post-harvest Treatments	Incorrect application of chemical	Refer Step 2	Refer Step 2
8 - Grading/Packing	Contact with ill food-handlers	Refer Step 5	Refer Step 5
9 – Controlled Storage	Physical contamination	Various	Storage facilities are built in a manner to avoid access by pests and reduce opportunity for physical contamination and inspected before use
10 – Transport	Physical contamination	Refer Step 6	Refer Step 6

8. CCP DETERMINATION

A CCP is a step at which control can be applied and is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level. The information collated during the hazard analysis allows for the identification of a CCP. To assist in the decision making process of determining CCP's a CCP Decision Tree was used. The decision tree is as follows.



NOTE: For the steps involving water, it is recommended that control is addressed by the individual operator for their specific operation using good agricultural practices as described in 7.2.

[11] Acceptable and unacceptable levels need to be defined within the overall objectives in identifying the CCPs of the HACCP plan

[12] This Question is answered with the assumption that the control measures are in place as described and effective

Table 16: Root crops CCP determination

Process Step	Potential Hazard Source	Q1	Q2	Q3	Q4	CCP (Y/N)
1 – Ground Preparation	Fertiliser (inadequately decomposed compost)	Yes	No	No		No
	Incorrect Agrichemical Application	Yes	No	Yes	No	**Yes**
2 – Cultivation						
3 – Planting	Contact with ill food-handlers	Yes	No	No		
	Incorrect Fertiliser Application	Yes	No	Yes	No	**Yes**
	Contaminated Soils	Yes	No	No		No
4 – Growing	Incorrect Agrichemical Application	Yes	No	Yes	No	**Yes**
5 – Harvesting	Contact with ill food-handlers	Yes	No	No		No
6 – Transport	Physical contamination	Yes	No	No		No
7 – Post-harvest Treatments/washing	Incorrect Agrichemical Application	Yes	No	Yes	No	**Yes**
8 – Storage	Physical contamination	Yes	No	No		No
9 - Grading/Packing	Contact with ill food-handlers	Yes	No	No		No
10 – Controlled Storage	Physical contamination	Yes	No	No		No
11 – Transport	Physical contamination	Yes	No	No		No

1, 3, 4 & 7 – Residue levels can become unacceptable where chemicals are used outside registration, which as indicated previously does occur (refer footnote 9). Note for Step 3 fertiliser may be natural or agrichemical, CCP is based on agrichemical.

Table 17: Fruit & berry fruit crops CCP determination

Process Step	Potential Hazard Source	Q1	Q2	Q3	Q4	CCP Y/N
1 – Ground Preparation	Fertiliser (inadequately decomposed compost)	Yes	No	No		No
	Incorrect Agrichemical Application	Yes	No	Yes	No	**Yes**
2 – Cultivation						
3 – Planting	Contact with ill food-handlers	Yes	No	No		
	Incorrect Fertiliser Application	Yes	No	Yes	No	**Yes**
	Contaminated Soils	Yes	No	No		No
4 – Growing	Incorrect Agrichemical Application	Yes	No	Yes	No	**Yes**
5 – Harvesting	Contact with ill food-handlers	Yes	No	No		No
6 – Storage	Physical contamination	Yes	No	No		No
7 – Post-harvest Treatments/washing	Incorrect Agrichemical Application	Yes	No	Yes	No	**Yes**
8 – Storage	Physical contamination	Yes	No	No		No
9 - Grading/Packing	Contact with ill food-handlers	Yes	No	No		No

Process Step	Potential Hazard Source	Q1	Q2	Q3	Q4	CCP Y/N
10 – Controlled Storage	Physical contamination	Yes	No	No		No
11 – Repacking/Regrading	Contact with ill food-handlers	Yes	No	No		No
12 – Transport	Physical contamination	Yes	No	No		No

Steps 1, 3, 4 & 7 – Residue levels can become unacceptable where chemicals are used outside registration, which as indicated previously does occur (refer footnote 9). Note for Step 3 fertiliser may be natural or agrichemical, CCP is based on agrichemical.

Table 18: Leafy green vegetable crops CCP determination

Process Step	Potential Hazard Source	Q1	Q2	Q3	Q4	CCP Y/N
1 – Ground Preparation	Fertiliser (inadequately decomposed compost)	Yes	No	No		No
	Incorrect Agrichemical Application	Yes	No	Yes - 1	No	**Yes**
2 – Cultivation						
3 – Planting	Contact with ill food-handlers	Yes	No	No		
	Incorrect Fertiliser Application	Yes	No	Yes	No	**Yes**
	Contaminated Soils	Yes	No	No		No
4 – Growing	Incorrect Agrichemical Application	Yes	No	Yes	No	**Yes**
5 – Harvesting	Contact with ill food-handlers	Yes	No	No		No
6 – Transport	Physical contamination	Yes	No	No		No
7 – Washing						
8 - Grading/Packing	Contact with ill food-handlers	Yes	No	No		No
9 – Controlled Storage	Physical contamination	Yes	No	No		No
10 – Transport	Physical contamination	Yes	No	No		No

Steps 1, 3 & 4 – Residue levels can become unacceptable where chemicals are used outside registration, which as indicated previously does occur (refer footnote 9). Note for Step 3 fertiliser can be natural or agrichemical, CCP is based on agrichemical.

Table 19: Organic crops CCP determination

Process Step	Potential Hazard Source	Q1	Q2	Q3	Q4	CCP Y/N
1 – Ground Preparation	Fertiliser (inadequately decomposed compost)	Yes	No	No		No
2 – Planting	Contact with ill food-handlers	Yes	No	No		No
	Fertiliser (inadequately decomposed compost)	Yes	No	No		No
	Contaminated Soils	Yes	No	No		No
	Fertiliser (inadequately decomposed compost)	Yes	No	No		No
4 – Harvesting	Contact with ill food-handlers	Yes	No	No		No
5 – Transport	Physical contamination	Yes	No	No		No
6 - Grading/Packing	Contact with ill food-handlers	Yes	No	No		No

Process Step	Potential Hazard Source	Q1	Q2	Q3	Q4	CCP Y/N
7 – Controlled Storage	Physical contamination	Yes	No	No		No
8 – Regrading & Repacking	Contact with ill food-handlers	Yes	No	No		No
9 – Transport	Physical contamination	Yes	No	No		No

Table 20: Glasshouse crops CCP determination

Process Step	Potential Hazard Source	Q1	Q2	Q3	Q4	CCP Y/N
1 – Planting Preparation	Incorrect Fertiliser Application	Yes	No	No		No
2 – Planting	Contact with ill food-handlers	Yes	No	No		No
	Incorrect Fertiliser Application	Yes	No	Yes		**Yes**
	Contaminated Soil/Growing Medium	Yes	No	No		No
3 – Growing	Incorrect Fertiliser Application	Yes	No	Yes		**Yes**
4 – Harvesting	Contact with ill food-handlers	Yes	No	No		No
5 – Transport	Physical contamination	Yes	No	No		No
6 – Washing						
7 – Storage	Physical contamination	Yes	No	No		No
8 - Grading/Packing	Contact with ill food-handlers	Yes	No	No		No
9 – Controlled Storage	Physical contamination	Yes	No	No		No
10 – Transport	Physical contamination	Yes	No	No		No

.

Table 21: Sprouts CCP determination

Process Step	Potential Hazard Source	Q1	Q2	Q3	Q4	CCP Y/N
1 – Seed Purchase	Contaminated Seeds	Yes	No	No		No
2 – Seed Sanitation	Incorrect application of treatment chemical	Yes	Yes			**Yes**
3 – Seed Soaking						
4 – Growing						
5 – Harvesting	Contact with ill food-handlers	Yes	No	No		No
6 – Transport	Physical contamination	Yes	No	No		No
7 – Post-harvest Treatments	Incorrect application of treatment chemical	Yes	Yes			**Yes**
8 - Grading/Packing	Contact with ill food-handlers	Yes	No	No		No

Process Step	Potential Hazard Source	Q1	Q2	Q3	Q4	CCP Y/N
9 – Controlled Storage	Physical contamination	Yes	No	No		No
10 – Transport	Physical contamination	Yes	No	No		No

Steps 2, 3 – Residue levels can become unacceptable where chemicals are used outside registration, which as indicated previously does occur (refer footnote 8). Step 7 – Treatments are specifically designed to eliminate potential microbiological hazards.

8.1 Critical Limits, Monitoring & Corrective Action

In most cases, controls other than CCP's will be within existing job or task instructions rather than documented in the form of the table included in this section.

For each CCP critical limits, monitoring and corrective action need to be determined (an example for agrichemical application has been provided in the following table). Critical limits are the criteria that separate acceptability from unacceptability. These differ from the food safety objectives described in the hazard analysis section.

The critical limits need to be determined based on scientific data so that the potential hazard will be controlled by the CCP and meet the food safety objectives (e.g. MRL's for residues).

The monitoring procedures are a planned sequence of observations or measurements of control parameters to assess whether a CCP is under control. For the purpose of this generic HACCP plan the record keeping has not been recorded, however an example for agrichemical application has been provided in the following table. Record keeping will vary from operation to operation and therefore should be implemented by each operator on implementation of this plan.

The corrective action requirements are actions to be taken when the results of the monitoring at the CCP indicate that the critical limits have been breached. These should be such that the process will be adjusted to maintain control and prevent non-compliance against the food safety objectives (i.e. MRL's for residues).

The following table describes critical limits, monitoring and corrective action that as an example for agrichemical application. A template for a HACCP Summary Worksheet has been included as Appendix One. The worksheet provides a concise format for documenting critical limits, monitoring and corrective actions. It also includes verification, which is described in Section 9.

Table 22: Documented procedures for Agrichemical CCP

Critical limits	
Parameters being checked	Chemical residues
Target level for each parameter	Importing country MRL for specific chemical
Monitoring procedures	
Responsibility for monitoring	Operator
What is going to be done	Application and harvesting according to recommendations and Growsafe certified
Monitoring method, sampling regime etc	Measuring correct quantities of chemicals to manufacturers instructions, and Determine the length time between application during ground preparation, planting, growing and harvest
Monitoring frequency	For every application
How the observations are to be recorded	Maintenance of spray diary
Corrective action procedures	
Responsibility for taking corrective action	Operator
How is control restored	Do not apply chemical, don't/delay plant(ing) and/or harvest(ing)
How is control and disposition of non-conforming product managed	As above
Action taken to prevent the problem from happening again	Refer to manufacturers instructions
Escalating response is available if preventative action fails	Re-training
How the above actions are to be recorded	Component of spray diary

8.2 Water Control Measure Description

It has been recognised that water can be a source of biological hazards. The hazards have been determined to be mostly of faecal origin; therefore the appropriate degree of control would be such to ensure the water source is not contaminated with faecal matter. Further contamination may occur with chemical and physical hazards.

Due to the diversity of water sources operators need to take responsibility for the water source used within their operation. In order to take responsibility, operators need to be aware of potential hazards and controls associated with **their** water supply; therefore it is recommended a water management programme be developed and implemented in each operation/facility using a HACCP approach.

The following has been developed based on the recommendations from the draft "Guide to Production of Safe Food in the Australian Vegetable Industry" and the Codex Alimentarius Commission proposed draft "Code of Hygienic Practice for the Primary Production and Packing of Fresh Fruit and Vegetables".

Requirements

- A process flow of water systems from the source of water to point of use. Point of use may be at the irrigation point or use in a washing step (e.g. "dump tank"), grading, or use in application of fertilisers or agrichemicals. The process flow should describe both systems should these two activities occur in the one operation. To ensure a comprehensive process flow and hazard analysis the operator would be required to understand where the water used in the operation comes from and the potential for the water to be contaminated with hazards (this may be determined through testing) including:
  - Biological hazards introduced through faecal matter (e.g. from bird life and/or possums) in roof catchment systems and/or contamination from dead animals, either on the roof or in storage areas, or through run-off or improper maintenance or drainage from staff amenities,
  - Hazards introduced through adjacent operations such as land fills, stock farms, etc,
  - Hazards introduced through sewage leakage into ground water systems (if not a secure source),
  - Hazards discharged or leached from a contaminated site in surface water, contamination of surface waters with wild animals and bird life and/or their biosolids, leachates from and wastewater and/or raw sewage,

  - Hazards from contamination from stock grazing near waterways, discharges of sewege, abattoir, or farm effluent or urban runoff,
  - Hazards introduced through contaminants washed into source water during irrigation or heavy rainfall, e.g. heavy metals,
  - Hazards that may be introduced post treatment (e.g. from treatment at council water supplies to point of use at farm/operation), hazards associated with inadequately controlled dump tanks, etc,
- CCP determination. Note the quality of water required for primary production and that used for irrigation and harvesting may vary. If treatment was determined necessity this should be such to ensure water is fit for purpose. The irrigation system and the crop type may also generate different requirements, for example exposure of edible portion especially close to harvest time, physical characteristics of the crop such as crevices rough surfaces, etc, and whether or not post treatment occurs after the point of water use. Water used in hydroponic systems may have further requirements such as frequency of change and maintenance and cleanliness of the water delivery system,
- For any CCP's determined identify the critical limits,
- Inspection and testing at source and/or point of use and the frequency of such inspection and/or testing. Monitoring requirements would need to be established for each hazard (for each CCP the monitoring should be such as to determine the difference between acceptability and unacceptability). The Drinking Water Standards of New Zealand, 2000 may provide useful guidance in this area,
- Corrective action on inspection and testing results or CCP monitoring results, and
- Verification requirements.

Please note the Ministry for the Environment is currently carrying out a study to look at what pathogens are in New Zealand waters and developing methodologies for estimating pathogen levels at any stream site in New Zealand. There is also a focus on the sources of contamination, environmental factors and microbiological indicators, and the findings of this study may assist operators in the development of waste management programmes.

It is also noted that the Ministry of Health have published a draft report titled "Draft Public Health Risk Management Plans – Raw Water" that may also be useful in determining the requirements of a water management programme.

9. VERIFICATION OF HACCP PLAN

Verification is the application of methods, procedures, tests and other evaluations, in addition to monitoring, to determine compliance with the HACCP plan's food safety objectives and control measures. Verification of the HACCP plan does not just focus on CCP's, operators should note that it covers their whole operation.

For the control measures one of the main methods of verification is through audit and testing. Examples of this are:

a. Internal audits by a competent staff member,
b. Third-party audits of each operation such as those carried out by auditors for industry export programmes,
c. Third-party audits of product and service suppliers to determine safe practices are being followed, e.g. packaging, equipment, transporters, stores,
d. Obtaining a Certificate of Analysis (COA) from suppliers of manure, biosolids and other natural fertilisers to demonstrate the absence or control of potential hazards,
e. Reviewing results of refresher training for food and packaging handlers to determine ongoing awareness and compliance with appropriate safe food procedures,
f. Testing of fresh produce for biological and chemical hazards,
g. Visual inspection of fresh produce for physical hazards, and
h. Visual monitoring of food-handlers practices.

For each CCP verification activities in addition to the activities described above should be described as in the following table e.g. for AgriChemicals

Table 23: Example of Verification Activities

Responsibility for validation / revalidation	Operator/System Manager/Quality Manager
How validation is to be done	Via spray diary, training records, customer feedback records
Responsibility for ongoing operator verification	Operator/System Manager/Quality Manager
When is ongoing operator verification to be carried out	Periodically
How is ongoing operator verification to be done	Internal audit, review operation, review records, and sampling & testing
What follow up action is to be taken if non-compliance occurs	Identify and adequately control affected product and modify system to control CCP
How the above activities are recorded	Operator verification report

10. INTERNATIONAL HACCP REQUIREMENTS

(For Market Access And Food Safety)

Recent foodborne illnesses in both the United Stated and in Europe of imported fresh produce have raised concerns about microbial safety hazards associated with agricultural and manufacturing practices for the production of fresh produce (CFSAN/2 2001). Both the CDC and CDSC in their respective countries are required to carry out prevalence surveys to assess the potential hazards of microbial contamination on fresh produce and the extent of the contamination on specific fruit and vegetables.

a) In the past 5 years Hazard Analysis and Critical Control Points (HACCP) programmes have been extended to the on-farm environment as a way to reduce risks associated with produce before they enter the process environment or the raw fresh produce market. However, as recognised by the USFDA, true on farm HACCP specifications are unachievable for produce because there are no Critical Control Point's (CCP's) such as pasteurisation than can be applied (Powell, 1999).

b) A baseline of current agricultural practices needed to be established by the US Department of Agriculture (USFDA) to develop an educational outreach program. The National Agricultural Statistics Survey (NASS) was assigned to establish this baseline and conduct a survey every two years. The concern of lack of NASS expertise prompted a pilot study prior to the 14 State 2000 Fruit and Vegetable Agricultural Survey (Garren 2000). The content of the produce information will concentrate on the impact of agricultural practices on microbial food safety hazards for fresh produce. Information gathered will be available in mid-2001 (Garren 2000).

c) It is clear that the objectives to achieve Good Agricultural Practices (GAP's), Good Handling and Hygiene Practices (GHP's), Good Manufacturing Practices (GMP's) and HACCP programmes are essential to ensuring the safety of produce to the consumer. Countries that are most proactive in achieving this are still in the process of establishing the so-call baselines (USA, EU, Canada, Australia).

d) The outline of GAP's has been outlined and summarised in a number of guidelines available to commercial producers in various countries. The key to all the guidelines is based on prevention rather than elimination of foodborne diseases. There are reasonable steps that a grower can take to reduce the risk that pathogens will contaminate the food produced on the farm (Cornell University, 2000).

e) Food safety is a product of many environmental, cultural and socio-economic factors. Epidemiological methods of foodborne disease

surveillance are needed to detect outbreaks, identify their causes and assess the effectiveness of control measures. Risk management necessarily follows the process of risk assessment. These are principles behind HACCP systems for protecting the safety of foods (US Dept. Health and Human Services 1998).

10.1 Guides To Minimising Food Safety Hazards

The Guide to Minimise Microbial Food Safety Hazards for Fresh Fruits and Vegetables (GMMFSH for FFV) was a response to the 1997 President's Food Safety Initiative - Initiative to Ensure the Safety of Imported and Domestic Fruits and vegetables. The guide addresses microbial food safety hazards and good agricultural and management practices (GAP's and GMP's) common to the growing, harvesting, washing, sorting, packing, and transporting of most fruits and vegetables sold to consumers in an unprocessed or minimally processed (raw) form. This is a voluntary science-based guidance for both domestic and foreign fresh producers (US Dept. of Health and Human Services, 1998).

Relevant guidelines that have also been adopted or in the process of being developed include:

- USA - University of Florida. A Model HACCP Plan for Small-Scale, Fresh Squeezed (Not Pasteurised) Citrus Juice Operations. This has been adopted from a safety standpoint where the highest concern is the contamination of pathogen *Salmonella* spp. and *Escherichia coli* O157: H7. (Schmidt et al, 1997),

- USA - Microbiological Safety Evaluations and Recommendations on Sprouted Seeds. US Food and Drug Administration (Adopted 28th May 1999),

- "Guidance for Industry: Reducing Microbial Food Safety Hazards for Sprouted Seeds" (Dept. of Health and Human Services 1999),

- USA - Microbial Food Safety Considerations for Glasshouse Vegetable Production. Two major outbreaks in raw tomatoes with *Salmonella javiana* and Hepatitis A further prompted investigations into the source of contamination (Ruiz & Powell, 1998),

- Australia - A Guide to Production of Safe Food in the Australian Vegetable Industry (draft 21/2/01). This guide covers primary production, harvesting, packaging, storage and transport of whole fresh produce. It does not cover minimally processed vegetables as these are dealt with in the Food Safety Guidelines for the Australian Fresh Cut Produce Industry (Australia Vegetable Industry 2001 draft),

- The Guide to MMFSH for FFV aimed developing the most appropriate good agricultural practices (GAP's) and good management practices (GMP's) for your operation. Prevention is favoured over reliance on corrective actions (US Dept. of Health and Human Services 1998). The guidelines have some of the procedures outlines in the Codex Alimentarius Commission - Code of Practice (COP) under CAC/RCP 44-95 (FAO of the UNWHO 1995),

- The Codex Alimentarius Commission proposed draft code of hygienic practice for the primary production, harvesting and packaging of fresh fruits and vegetables (Step 3) July 2000,

- 2000/0178 (COD) Proposal for a Regulation Of The European Parliament And Of The Council on the hygiene of foodstuffs,

- The Codex Alimentarius Commission proposed draft code of hygienic practice for pre-cut fruits and vegetables (Step 3) July 2000,

- The Codex Alimentarius Commission proposed draft guidelines for the utilization of Quality Assurance Systems to meet requirements in relation to food (Step 3),

- NZ Fresh Produce Quality Assurance Approved Supplier Programme, this covers through the supply chain and not just the primary producer, and

- EUREP GAP – Euro Retailer Produce Working Group protocol and checklist for Fresh Produce (November 1999).

11. MISCELLANEOUS POTENTIAL HAZARDS

11.1 Genetically Modified Organism's (GMO's)

One of the issues facing the fresh produce producer and retail industries is GMO's. The question is, are we giving the consumer protection or are we simply being protectionists? (Hennessy, 2000).

In a Food Safety consumer survey conducted in the US, topping the list of concerns was that of bacterial contamination (94%), but GMO's was listed 6th (67%) on the list.

Research is being carried out to establish if GMO plants are more susceptible to microbial pathogenic organisms, among other comparative studies with conventionally produced crops.

11.2 Nutrients and Nutraceuticals

With growing consumer awareness of improving health, evidence has accumulated that foods provide not only nutrients (vitamins, minerals, protein, carbohydrate and fat) but also a host of non-nutrient components that may or may not confer health benefits (Borchers et at, 2000).

Investigations into the activities of plant foods or extracts have been impeded by several factors. The exact chemical composition of a plant can vary considerably with the method of growing, harvesting, processing and storage. The potential hazard of commercial production of certain fruit and vegetable under this basis is producers are adding non-regulatory or unproven products on to their crops.

This can lead to changes in composition of a plant and lead to potentially hazardous residues to humans, which may not be able to be tested readily.

A simple example is that of the excessive use of nitrogen during the growing of the produce that can result in nitrate rich soils and water sources (Pedianet, 2001). This can be a potentially lethal on infants younger than 6 months, where the consumer may not be aware they are purchasing nitrate rich fruit and vegetables (natural or amended in production).

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