Community Recycling Awareness and Participation at Massey University's Turitea Campus

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ABSTRACT

In 1999 Massey University's Turitea campus established a zero waste programme in response to concerns about the practical environmental management of the campus. A key part of this programme was the implementation of a recycling system to ensure valuable resources are not wasted. In order to monitor the effectiveness of this system and identify potential areas of improvement, a recycling and waste audit was conducted across the campus. Of the four trials undertaken three focused on the wider campus community, while the fourth focused on the student hostels. Trial I was conducted as a pilot study during summer school of 2009/10, Trial II during semester two of 2010, Trial III during summer school of 2010/11 and Trial IV during semester one of 2011.

The audit quantified recycling and waste disposal choices made by the campus community. It was found that key issues that impact upon recycling practices include poor signage and inadequate recycling drop-off facilities. Recommendations from the study included an upgrade of recyling infrastructure, a review of the recycling programme, a branding 'make-over' and an information-awareness campaign to raise the campus community's understanding of the role thay can play in a zero waste programme. It is also recommeded that Massey's Wellington and Auckland campuses be included in an institution-wide strategy for zero waste management.

The findings of this research were submitted to Massey University's Sustainablity Steering Group in order that the ideas and information relating to recycling and waste management could be considered along with other institutional sustaianblity issues.

Keywords: zero waste, waste management, recycling management, recycling behaviour, campus sustainability, sustainable university practices.

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ABBREVIATION

ASDC	Awapuni Sustainable Development Centre
DEFRA	Department For Environment, Food and Rural Affairs of England
GBT	Green Bike Trust
ISWM	Integrated Solid Waste Management
MfE	Ministry for the Environment, NZ
MSW	Municipal Solid Waste
MUSA	Massey University Student Association
NZWS	New Zealand Waste Strategy
OECD	Organisation for Economic Co-operation and Development
PNCC	Palmerston North City Council
RFM	Regional Facilities Management
RMA	Resource Management Act
SWAP	Solid Waste Analysis Protocol
USEPA	U.S. Environmental Protection Agency
ZERI	Zero Emissions Research Initiative
ZWA	Zero Waste Academy
ZWIA	Zero Waste International Alliance
ZWNZ Trust	Zero Waste New Zealand Trust

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Continuous growth in waste production combined with sometimes inadequate waste management policies and practices poses a serious issue impacting on both an international and national scale. Over the last few decades, waste has become an increasing concern and is recognised as a threat to the sustainability of our environment, and as having a negative impact on human health (Manga, Forton et al., 2008; Watson, 2009). It has been estimated that across all categories 3000 million tonnes of waste is generated throughout Europe each year (Williams, 2005). In the US, the quantity of municipal solid waste (MSW) generated is estimated to be 230 million tonnes per year and industrial solid waste generation, 400 million tonnes per year (Williams, 2005). In New Zealand in 2006, 3.156 million tonnes of waste was generated to landfill and the majority of this waste is not recycled (Ministry for the Environment (MfE), 2007). In terms of waste generation per capita, New Zealand produced 400kg/capita which is relatively less in comparison to other countries such as Australia (690kg/capita), Switzerland (660kg/capita), Netherlands (600kg/capita), Sweden (470kg/capita) and England (403kg/capita) (OECD, 2007; DEFRA, 2009). However, successive national governments in cooperation with Non-Governmental Organisations (NGOs) have been exploring ways to achieve the goals of the Waste Minimisation Act 2008, which sets "the Government's long-term priorities for waste management and minimisation in New Zealand" (MfE, 2011f).

As key teaching and research organisations who seek to exhibit leadership, "universities have an important role to play in demonstrating environmentally sustainable practices on campus" (ARIES, 2009) and "promoting education and research on environmental impact of sustainability by building students and staff awareness" (UC Santa Barbara, 2008, p. 4). A framework can be a suitable approach to achieve campus sustainability by remedying the limitations of the current environmental management practices in universities. This can ensure increased sustainability through the integration of “three strategies, namely: university Environmental Management System (EMS); public participation and social responsibility; and promoting sustainability in teaching and research” (Alshuwaikhat & Abubakar, 2008). The development of innovative waste management systems are a way of incorporating both the environmental management system of the university with raising awareness of the staff and students about the importance of their participation and acting socially responsibly in order to contribute to campus sustainability.

In relation to environmental sustainability development, Agenda 21 is a UN global action for environmental sustainability globally (UNESA, 1992) that highlights resource conservation, pollution control and waste minimisation as key priorities in the achievement of sustainable development. In synergy with such international policy trends, zero waste has become a worldwide movement seeking environmental sustainability (Kollikkathara et al., 2008; Matete & Trois, 2008). In New Zealand, the national waste strategy, New Zealand Waste Strategy (NZWS) 2002, worked toward the goal of “zero waste and a sustainable New Zealand” and set in place a policy framework for implementing the vision of zero waste (New Zealand Waste Strategy, 2002, p. 3). In 2010 the subsequent NZWS 2010 adopted the twin goals of zero waste minimisation. These goals are “reducing the harmful effects of waste and improving the efficiency of resource use” (New Zealand Waste Strategy, 2010, p. 2).

Zero waste is both a philosophy and practice of reducing waste generation in an optimal way (Zero Waste Inc, n.d). The practice of zero waste can be achieved by maximising recycling, minimising waste, reducing consumption (Clay, Gibson et al., 2007), and ensuring that products are made to be reduced, re-used and recycled back into nature or the productive economy without being discarded or wasted (Clay, Gibson et al., 2007; Matete and Trois, 2008). As a preventive approach, the concept of zero waste is designed to work toward the minimisation of residual disposal to landfill, and increase the initiative of recycling and the re-use of materials in an environmentally sustainable manner (Greyson, 2007; ZWNZ Trust, 1999). The Zero Waste International Alliance (ZWIA) is an international organisation that was established “to promote positive alternatives to landfill and incineration and to raise community awareness of the social and economic benefits to be gained when waste is regarded as a resource base" (ZWIA, 2010). National, regional and local zero waste initiatives are allied with this global vision. The target of zero waste has been taken on by numerous jurisdictions in various countries such as America (California and San Francisco), Canada (Nova Scotia), China (Taiwan), New Zealand, and Australia (South Australia, Victoria, and Western Australia) (Greyson, 2007). In Australia zero waste programmes are initiated by both government institutions and non-profit organisations and incorporate research, education and policy development for national and local sustainability (Zero Waste New Zealand (ZWNZ) Trust, 2011a).

Zero waste targets apply to all sectors of society including government, educational institution, communities, businesses and individuals (Wilson et al., 2003; Suttibak & Nitivattananon, 2008), and can involve both policy development and the creation or modification of waste management practices. In order for widespread behaviour change to take place across all parts of society in relation to sustainable waste management there needs to be collaboration between the various institutions involved. These collaborations typically involve the agencies or businesses that dispose of the waste and the institutions, groups and communities that are producing the waste. An example of this is the collaboration involving Massey University in the Zero Waste Academy (ZWA) for the development of a programme that focuses on both training and research as well as on-campus waste management practices (Massey University, 2003a).The ZWA is a partnered initiative among a number of stakeholders, these being the Zero Waste New Zealand Trust (ZWNZ Trust), the Palmerston North City Council (PNCC), and Massey University.

Massey University's zero waste initiatives are an ongoing commitment, and further monitoring is required to identify waste and recycling volumes and contamination levels, which are indicative of the recycling related awareness and participation of the campus community (Mason, Brooking et al., 2003; Mason, Oberender et al., 2004). Therefore, the Massey University has established the steering group on sustainability with the aim of bringing together academics and professional services from across disciplines and campuses to work on sustainability issues. The Massey University Road to 2020 report, which was updated in 2011, reiterates the aim "to reduce Massey's environmental impact by increasing sustainability practices and behaviour" and to "further integrate sustainability issues into our research and teaching programme" (Massey University, 2011, p. 12). With respect to the effort to increase sustainability practices on campus through zero waste management programme, this research project investigates how to enhance the zero waste management programmes by using waste and recycling audit information alongside the finding of previous research undertaken on campus to design and report on waste and recycling infrastructure changes with a view to increase the awareness and participation of the Turitea campus community. By quantifying levels of contamination in the disposal of waste and recyclables the findings of the waste and recycling audit conducted will directly indicate areas of the current waste management system that need improvement.

During a meeting with Regional Facilities Management (RFM) in February 2011 they expressed interest in auditing the waste and recycling at the student hostels on campus. They were concerned about the volume of waste and recycling produced by the student hostels, and contamination of non-recyclable and recyclable waste due to incorrect disposal. As a result of this interest the student hostels was added into the auditing process as the final trial of this study. A key part of this research was the reporting of the results and findings of this waste and recycling audit and recommendations to RFM.

1.2 Background

In 1999, a zero waste programme was established at Massey University, Palmerston North by the School for Environmental Engineering (Mason, Brooking et al., 2003; Mason, Oberender et al., 2004). The main objective of the established zero waste programme was "to provide a way of responding to the growing interest and concern relating to practical environmental management of the campus" (Mason, Brooking et al., 2003). A secondary objective was to promote ongoing research, education for sustainability (EFS) and more broadly, environmental awareness and responsibility in the campus community. As such, according to Mason, Oberender et al., (2004), the original programme of the study comprised two main projects, 1) original solid waste generation/composting and, 2) recycling/source separation behaviour. Further detailed information regarding these projects can be found in the Literature Review chapter.

In addition to this, since 2002 Massey University has also officially collaborated with the ZWNZ Trust and PNCC to establish the Zero Waste Academy (ZWA). The partnership between Massey University, PNCC, and ZWNZ involved creating a proactive interaction to: "assist PNCC develop an economically and socially viable Zero Waste strategy, a key component of which will be the development of a model resource recovery park. This will provide a working training model for the Zero Waste Academy and position the city as a world-recognized model Zero Waste community." and "make Massey University, Palmerston North campus, the premier tertiary institution in the Asia-Pacific region for Zero Waste research, training and practice." (Massey University, 2003b). The mission statement of ZWA is "to be the facilitator of excellence for training, education and research of zero waste principles and practices" (Hannon, 2009, p. 11).

The ZWA has also proposed the establishment of an ongoing programme with the objective of "promoting an ongoing commitment to demonstrably sound environmental management in the areas of both physical and energy resources, in accordance with the university environmental policy and the university commitment to environmental responsibility in tertiary education" (ZWNZ Trust, 1999). This was an intentionally broader statement than that of the ZWNZ Trust charter, which stated the objective of "working towards the elimination of landfill as a disposal method and the re-use of all materials in an environmentally sustainable manner" (ZWNZ Trust, 1999). The opportunity to eventually establish Massey University at Turitea, Palmerston North as a model "zero waste" campus existed and this aligned with long term goals to implement and continuously improve good environmental management practices in sustainable campus management (Hannon, 2009).

Recycling and proper waste disposal is the responsibility of all members of the campus community, and makes both economic and environmental contributions to a sustainable campus. This research draws upon the previous studies undertaken by Mason, Brooking et al., (2003) and Mason, Oberender et al., (2004) which indicated that there were challenges with regard to the recycling system in the amenities areas and buildings. An additional challenge that had been identified was the presence of international students who are not familiar with the recycling system both on campus and in public areas, as well as the dynamic nature of the student population in general.

Therefore, due to the constantly changing campus population (i.e. student graduates (international and domestic students), moving on into employment, and new students enrolling) on going work is required to grow both an understanding of and participation in the recycling programme so as to improve recycling volumes and minimise the costs associated with contamination. The improvement of recycling infrastructure, such as signage, to provide a simpler and more user friendly system may potentially address these issues.

1.3 Aim

The proposed study will undertake waste and recycling audits in order to provide detailed and up to date information on the performance of the zero waste programmes at Massey University's Turitea Campus, Palmerston North. Given that performance measures such as quantities of recycling vs. waste, and the percentages of contamination in recycling (or conversely the percentage of contamination in waste) are a reflection of staff and student attitude and behaviours toward recycling, and in a broader sense zero waste sustainability, the findings may support improved communication on environmental matters among the university community. The research findings can be used to support the design of future changes in infrastructure and collection system to make this work more effectively.

Therefore, the aim of this study is to analyse the existing recycling program in order to design improvements in campus zero waste management and provide a report which includes key findings and a number of recommendations for RFM.

1.4 Research Questions and Objectives of the Study

In order to achieve the above aim, two research questions are proposed

1. How effective is the existing waste programme system at Massey University?
2. What are the opportunities for redesigning the recycling infrastructure so this is more effective in delivering on the goals of the zero waste programmes at Massey University?

In order to answer these above questions, the following objectives of the study are set:

1. Designing and trialling a suitable waste and recycling audit system for the campus.

2. Identifying the contamination levels in the waste and recycling bins selected for the study.
3. Reporting on the overall quantity of waste disposed of and the general recyclables and organic resources recycled on campus during each trial.
4. Having quantified, then advise Massey University Regional Facilities Management (RFM) on the effectiveness of the existing model for on campus collection and recycling.
5. Develop a set of recommendations for RFM (i.e. infrastructure design considerations, planning and implementation collections and processing) for a redeveloped campus recycling system.
6. Present these recommendations to RFM in way which mirrors a professional context and liaise and respond regarding queries and or follow-up actions.
7. Document this process as a model / pilot for the proposed Massey University 'sustainability internship' in which the campus is utilised as a living laboratory for addressing real world research problems through integrated learning.

1.5 Thesis Structure

Following this first introductory chapter is chapter two, which presents a review of the literature relevant to zero waste management and campus sustainability development. Chapter three presents the methodology used in this research project and describes in detail the location of the recycling and waste audit study, types of bins and other collection equipment and processes that were used in this study. Chapter four presents the results of the research project. In chapter five is the detailed discussion based on the results findings and recommendations. Finally is the conclusion in chapter six.

CHAPTER 2
LITERATURE REVIEW

2.1 Literature Review Outline

In order to conduct this research it was first necessary to create a knowledge base of solid waste and waste management in general, which includes the definitions of relevant terms including different categories of waste. This also provides a context for the development of waste management concepts that include recycling, as this has grown out of the categorisation of different types of waste. The 3 R's or R3 concept (reduce, re-use, recycle) has become a model that is used globally across many countries, and attempts to address waste minimisation through these 3 approaches. Over time this concept has evolved to include other approaches and as such has branched out to R5 and R6, which will also be explained in more detail. Another important concept that has had worldwide application is zero waste. This initiative operates at a global, national and regional levels, and can also be employed at an organisational or institutional level as is the case with Massey University. This is the context within which this research took place. In order to improve current waste management practices it is necessary to conduct waste and recycling audits which can evaluate the performance of recycling programmes. This can also identify areas, such as infrastructure, in which improvements can be made which can potentially enhance the participation of communities in recycling.

2.2 An Overview of Solid Waste and Waste Management

Solid waste is commonly defined as unwanted or unusable substances or materials that are identified as no longer being of value and are thrown out (Annegrete, 2001; OECD, 2002; Environment Waikato Regional Council, 2010). According to Pichtel (2005), solid waste is trash or garbage, refuse, and other discarded solid materials resulting from industry, commercial operations and from community activities. Solid waste is commonly made up of household waste such as plastics, plastic bottles, tins, cans, paper, and glass (Al-Salem, Lettieri et al, 2009; Taufiq, 2010), waste from manufacturing activities, packaging items and discarded electronic devices, as well as garden waste and sewage sludge (Ngoc and Schnitzer, 2009; Taufiq, 2010). Three main categories of waste have been identified which are based on the source of the waste and the level of care that needs to be taken in disposal.

Firstly, the term 'municipal solid waste' (MSW) means all waste materials discarded for disposal by householders and is also known as domestic waste or household waste e.g. kitchen and yard waste (Eriksson, Carlsson Reich et al., 2005). This also includes waste materials generated by commercial and trade business; small business; office buildings and trade institutions such as schools, hospitals, government buildings; and industrial sources (Parizeau, Maclaren et al., 2006; Hristovski, Olson et al., 2007; Hargreaves, Adl et al., 2008). A key characteristic of MSW is that it is highly heterogeneous and includes both durable and nondurable materials (Demirbas, 2011). Durable materials include appliances, and residues from automobile and electronic advices, whilst nondurable materials include paper, food waste, and yard waste (Pichtel, 2005). Nondurable waste typically can be composted and will break down in the short to medium term. By separating these from durable or non-compostable waste they can be managed in a more sustainable way and be diverted from landfill. Additionally appropriate processing and management of nondurable waste such as green waste and food waste can result in the production of compost products, and paper can re-enter the production chain through recycling.

Municipal waste has become a significant environmental problem, particularly in metropolitan cities such as the lower Grande Valley, Texas, Los Angeles, Nova Scotia (Canada), and in Turkey (Chang & Davila, 2008; Phillips, Tudor et al., 2011). The amount of waste generated increases each year and this makes it difficult to create solutions (Gómez, Meneses et al., 2009). An additional challenge is having to identify a solution that will have a minimum impact on the environment (Chowdhury, 2009). The challenge of municipal solid waste management has become a priority for the governments all over the world (Bai & Sutanto, 2002; Lu, Hsiao et al., 2006). As a result, a number of developed countries such as Germany, the United States and Japan, have achieved reductions in the amount of waste going into landfill. The achievement of MSW minimisation is primarily attained by a landfill-based waste management system. Furthermore, there is a move from a landfill-based waste management system to a more integrated one. Integrated waste management is now considered to be the key towards successful MSW treatment (Slater, Frederickson et al., 2007; Chang & Davila, 2008; Zhuang, Wu et al, 2008).

As waste has become an increasingly important issue, a number of methods and approaches have been undertaken. Sanitary landfill is a method of disposal that involves the isolation of the waste from the environment around it (Thurgood, 1999). This isolation should last as long as it takes for the waste to no longer be a threat biologically, chemically or physically, although the high levels of isolation that may be needed to do this can be costly to implement. As governments and communities have become more aware of sustainability there has been a move away from this method and sustainable waste management has evolved as an approach. Audit Scotland (2007, p. 4) describes sustainable waste management as having "less reliance on landfill and greater amounts of recycling and composting". This approach focuses on a reduction in waste production as the key, followed by re-use, recycling and composting and energy recovery, with landfill disposal as a final option (*ibid.*). A similar approach is Integrated Solid Waste Management (ISWM), which also incorporates waste reduction, recycling and composting, and disposal methods such as landfill and incineration (US EPA, 2002). There are also similarities between these two approaches and zero waste which aims to change behaviour in order to reduce waste, as well as re-use, recycle, recover and rethink.

In comparison, industrial solid waste is produced and can be managed on-site at industrial facilities and generally includes waste generated in any process of industries and manufacturing, including mining (Juhasz, Magesan & Naidu, 2004; Pichtel, 2005). The amount of industrial solid waste produced is approximately four times greater than the amount of municipal solid waste produced (Tammemagi, 1999). It is estimated that 740 million tonnes of waste from the manufacturing industries is generated each year throughout Europe (European Environment Agency, 2003). In the late 1980s, New Zealand generated approximately 300,000 tonnes of industrial waste annually, equivalent to 15 tonnes per US$1 m GDP (OECD, 1991). On the other hand, Australia generates about 20 Million tonnes annually, equivalent to 146 tonnes per US$ 1 m GDP, which is the OECD average. The emission of some aspects of industrial waste began to create concerns in the 1980s and as a result a number of international agreements were developed.

During the 1980s two key international agreements were developed and adopted as concerns increased about specific aspects of hazardous waste disposal and the impact of releasing chlorofluorocarbons into the atmosphere. The first of these, the Montreal Protocol on Substances that Deplete the Ozone Layer was negotiated and signed by 24 countries in 1987 (The Ozone Hole Inc, ND). As of April 2011 the protocol had been ratified by 196 countries. Since creation this protocol has had four major amendments and the most recent of these, the Beijing Amendment has been ratified by 167 countries (UNEP, Ozone Secretariat, 2004). The Montreal Protocol originally required parties to "reduce chlorofluorocarbon (CFC) use to 50% below 1986 levels by 1998 and to freeze halon consumption at 1986 levels from 1992" and the amendments that have taken place have led to the phasing out of these two substances, as well as developing phase-out schedules for additional substances once their detrimental effects on the ozone layer were better understood (MfE, 2011c). In a similar manner the Basel Convention on Control of Transboundary Movements of Hazardous Wastes and their Disposal aims "to both reduce the amount of waste produced by signatories, and regulate the international traffic in hazardous wastes (especially to developing countries)" (MfE, 2011b). It was adopted in 1989 and as of September 2010 had 175 signatory countries. The convention developed the necessary framework to control the transboundary movements and necessary criteria for "environmentally sound management" (ESM) of hazardous wastes, and has since evolved to the stage where the focus is "the full implementation and enforcement of treaty commitments" (UNEP – Secretariat of the Basel Convention, ND). An additional focus is the minimisation of hazardous waste generation which recognises that this is the long term solution to dealing with hazardous waste disposal. The aim of ESM is to "protect human health and the environment by minimising hazardous waste production whenever possible" and uses an "integrated life-cycle approach", which highlights the importance of all aspects from generation to storage, transport, treatment, reuse, recycling, recovery and final disposal (*ibid.*). A final key multilateral environmental agreement that relates to the generation, and therefore disposal of harmful and toxic substances is the Stockholm Convention on Persistent Organic Pollutants (POPs). This is a global treaty which aims "to protect human health and the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have adverse effects to human health or to the environment” (UNEP – Stockholm Convention Secretariat, 2008). This agreement was adopted in 2001 and entered into “force” in 2004, and “requires Parties to take measures to eliminate or reduce the release of POPs into the environment” *(ibid.)*. As more up to date knowledge is discovered about pollutants amendments continue to be made. This convention shares a common goal with the Basel Convention, that of protecting human health and the environment from hazardous chemicals and waste, and so there has been an effort to coordinate the future development of these (*ibid.*). However a number of other types of industrial waste are not included in these agreements and still need to be considered as described below.

The composition of industrial waste varies, depending on the industrial structure of a country or region. It comprises of general rubbish, packaging, food waste, acids, alkalis, oils, solvents, resins, paints, mine spoils and sludge. Examples of an industrial waste stream are coal combustion solids, including ash and flue gas, meat and dairy processing, textiles, clothing and footwear, chemical and petroleum products, and machinery and equipment (Juhasz, Magesan & Naidu, 2004; Pichtel, 2005). Industrial waste may have a high risk of toxicity and be classified as hazardous waste due to containing materials that are actually or potentially hazardous to humans and other living organisms (Hu, Hipel et al., 2009).

Subsequently, hazardous waste is defined as a waste or a combination of waste of a solid, semisolid, liquid, contained gaseous or sludge form, which can pose a substantial present or potential hazard to human health or the environment (Tsai & Chou, 2004). It may cause or contribute to increases in mortality, serious illness and environmental depletion, especially toxic chemical and heavy metal pollutions discharged from factories (Duan, Huang et al., 2008; Hu, Hipel et al., 2009). In some case environmental depletion may result from a discharge to a waterway which would result in a lethal habitat and death of aquatic species such as fish and invertebrates. Hazardous wastes are mostly generated by industrial and commercial sources, or as the by-product of manufacturing processes which can release gasses and particles into the atmosphere (Delgado, Ojeda-Benítez et al., 2007). However cleaning fluids or pesticides used in households can also result in a potential residential source of hazardous waste (*ibid.*).

Consequently, hazardous waste has become one of the most serious environmental issues and is a significant concern for the health of human beings and other organisms (TalInlI, Yamantürk et al., 2005; Hu, Hipel et al., 2009). Furthermore, hazardous waste has created many problems and dangers that have not gone unnoticed. Despite the fact that the problem receives less attention than many other environmental threats some successful solutions to the problem of hazardous have been suggested and implemented. As with air pollution and many other environmental problems, hazardous waste can be controlled through both input and output controls. These controls can include the government increasing regulations on the disposal of hazardous waste to ensure that problems do not occur (Tsai & Chou, 2004). Government measures can also limit the amount of waste industries are allowed to produce, or provide incentives to create less waste. After hazardous waste has been created there are several actions that can be taken. Industries can break down chemical compounds into less dangerous forms, or store waste in ways that protect the environment from being exposed to the waste.

It is important to be aware of the potential contamination problems that can arise from each different type of waste (Lu, Hsiao et al., 2006). For example, industrial wastes such as oil and natural gas refinery by-products, municipal waste, chemical by-products, agricultural waste, and radioactive water used as coolants in nuclear power plants have all been identified as having potential disposal issues (USEPA, 2001). Additionally, when improperly handled and disposed of, hazardous liquid waste poses a serious threat to human health and the environment because of its ability to enter watersheds through the ground water system, and pollute ground water and drinking water. Poorly managed waste disposal could also be a source potential growth of disease-carrying organisms (Kollikkathara, Feng et al., 2009), and result in land scarcity as new landfills need to be created (U.S. Environmental Protection Agency, 2006). While traditional waste management has focused on the disposal aspect it has been recognised that some waste types may in fact be seen in a different way. It is important to consider that this ‘so called waste’ stream is actually made up of potential resources from a wide range of community types (Juhasz, Magesan, & Naidu, 2004), for instance, a significant proportion of waste to landfill in NZ is either compostable or organic waste, and recyclables such as plastics, paper, rubble, concrete, timber (MfE, 2009a).

In response to such issues many communities have begun implementing recycling programmes which are an effective way to divert resources from landfill or incineration, and to lessen the residual solid waste which then requires treatment and disposal (Agapitidis & Frantzis, 1998; Bai & Sutanto, 2002; Tinmaz & Demir, 2006). Recycling of resources currently in the waste stream is an option that many municipalities have implemented in recent years. For example, in England, 37.6% of total waste going to landfill has been diverted from landfill through recycling programmes (DEFRA, 2009 as cited in Zhang, Williams et al., 2011). The percentage of waste diversion from landfill in England is still relatively low in comparison with many other countries such as Netherlands, Austria and Belgium; which have achieved more than 50% in some cases (Eurostat, 2009; Zhang, Williams et al., 2011). In New Zealand much progress in recycling has been made since the mid-1990s. The number of territorial authorities providing kerbside collection of recyclable materials has more than quadrupled since 1996, with over 75% of councils providing such services in 2005 (OECD, 2007). This means that the positive benefits of an increase of recycling programmes that can not only reduce facilities required for disposal but conserve energy, cut pollution, and preserve natural resources (Tsai & Chou, 2004) are being more widely felt. Similarly, recycling unused products would save environmental and natural resources as well as minimising greenhouse gas emissions (Hasome, Tachio et al., 2001; Wilson, 2002). Burning and burying our waste results in large releases of carbon dioxide and methane into the ‘commons’ of our atmosphere, thus resulting in an increasing rate of Climate Change; whereas re-using resources is more efficient, and results in fewer greenhouse gas emissions. Re-using the aluminium in drink cans is a great example: recycling avoids the mining of four tonnes of bauxite and overburden for each tonne of new aluminium, and after re-manufacturing the cans the overall outcome is an energy saving of 70-90% (ZWNZ Trust, 2008).

In addition to the recycling programmes mentioned above it is recognised that “gaining a comprehension of what type of waste materials are being disposed of is also very essential to identify priority waste for resource efficiency and waste minimisation programmes” (MFE, 2009b). Because the environmental and health impacts of waste are driven by waste types, better waste composition information can also improve the management of high impact waste types. The waste composition information can directly help develop waste minimisation policies, targeted waste minimisation programmes and improve recycling schemes.

The effectiveness of waste management systems plays an essential role in the minimisation of waste production (Manga, Forton et al., 2008). Waste management is the process of collection, recycling, transport, disposal, and monitoring of waste materials. The term generally correlates with materials generated by human activity, and is commonly undertaken to reduce their effect on health and the environment. Waste management is a complex process because it involves many technologies and disciplines. These include technologies associated with generation (including source reduction), on-site handling and storage, collection, transfer and transportation, processing, and disposal of solid waste (Wei & Huang, 2001; Khoo, 2009; Seadon, 2010). All of these processes have to be carried out within existing legal, social and environmental guidelines that protect the public health and the environment and are aesthetically and economically acceptable (Magrinho, Didelet et al., 2006). To be responsive to public attitudes, the disciplines that must be considered in integrated solid waste management include administrative, financial, legal, planning, environmental and engineering functions (Eichner & Pethig, 2001; Samakovlis, 2004). For a successful integrated solid waste management plan, it is necessary that all the disciplines communicate and interact with each other in a positive interdisciplinary relationship.

The purpose of implementing waste management is to address the adverse impact of waste and to achieve environmental sustainability (Seadon, 2010). Waste management programmes such as recycling are part of the key solution in achieving the goal of zero waste minimisation, as well as raising awareness about behaviour change for sustainable development. Looking at these aspects parts of sustainable waste management it is clear that the single components are not only dependent on technology but to a great deal on human behavioural action. Just like the environmental problems we are suffering from are due to maladaptive human behaviour (Chan, 1998) the solution of these cannot be achieved by technology alone, but needs to include environmentally conscious behaviour.

To sum up, waste is generated by all manner of human activity; that which is produced from the basic functions of our metabolism to the production process of highly sophisticated consumer goods (Van Der Ryn & Cowan, 1996). Consequently, as humanity has found out, waste cannot totally be removed. However, many of the adverse impacts waste has on our environment can be minimised. Commonly what is called waste is actually a combination of readily recyclable resources. Currently our system is only in early stages of evolution to one which maximises, conserves, recovers and recycles. The process of waste minimisation can be achieved in three key ways; namely, Reduce, Re-use and Recycle.

2.3 Reduce, Re-use and Recycle

Waste management is underpinned by the waste hierarchy which has been an evolving concept. The purpose of the waste hierarchy is to extract the most advantageous benefit from products and to generate the minimum amount of waste (meaning that which cannot be avoided being disposed of) (Belkin, 1995; Laustsen, 2007). This hierarchy incorporates R3, R5 and R6 approaches which have built upon each other as research and experience has led to improvements. The primary approach, R3, focused on reduce, re-use and recycle in order to minimise waste going to landfill. Reduction of waste was the first priority, followed by re-use, and then recycling. Firstly, reduce means for the consumer to use fewer products (do without) or to buy products that have less packaging, and for the manufacturer this approach means source reduction. Secondly, re-use means the direct re-use of products, in contrast to the indirect, materials based re-use of recycling. Examples for re-use are second-hand clothes, refillable bottles or the use of printouts as draft paper. Finally, recycle is a process to recover all reusable waste that can be transferred to other beneficial applications. Examples of things that are often recycled are glass, plastic, newspaper, aluminium cans and batteries.

Reduce, re-use and recycle was applied as an appropriate way to minimise the solid waste within households, and consequently contributed significant benefits for communities (Evison & Read, 2001; Matsumoto, 2011). These benefits included the minimisation of the amount of waste materials going into landfill, lessening the pollution that may result from waste disposal, the reduction of material consumption and the recycling and re-use of waste materials contributing to resource conservation by preserving raw materials and energy that manufacturers would otherwise use in producing new products.

Even though recycling is only one of the three R's, nevertheless it is of great importance, which can be seen by the huge amount of research and development dedicated to this approach. Like reduction and re-use, recycling serves the environment in several ways:

- Recycling reduces the solid waste stream, which extends the lifespan of landfill sites (Vencatasawmy et al., 2000; Hassan et al., 2000).
- Recycling saves natural resources and energy, which would otherwise be used in the production of new goods (Vencatasawmy et al., 2000; Hassan et al., 2000; Oskamp, 1995). Because of this recycling helps to lower pollution levels. Manufacturing goods using raw materials normally creates a higher level of pollution than using recycled materials, and incineration also has a higher level of pollutant output than a recycling process (Vencatasawmy et al., 2000; Oskamp, 1995). The lowered levels of pollution can aid in reductions of greenhouse gas emissions and acid rain (Oskamp, 1995).
- Recycling can also create new businesses and the participants can make or save money (Oskamp, 1995).
- The implementation of a suitable solid waste management programme with appropriate recycling methods is vital to the alleviation of the local problems associated with solid waste generation, handling and disposal, environmental conservation and public hygiene (Hasnaian, et al., 2005).

To ensure that the whole recycling concept works the "recycling cycle" has to be closed. This cycle consists of two elements: the recycling of the waste and the purchase of recycled products. This latter part has often been neglected but is crucial for the success of recycling in general (Biswas et al., 2000).

While the waste minimisation process of recycling, reducing and re-using was viewed as one of the more effective, practical and sustainable approaches to combat rising solid waste at local, region, national and international levels this approach was further developed to include new concepts as they evolved. The R5 approach added two concepts to the traditional R3 waste management strategy which can be seen in Figure 1 below. This figure shows the five concepts for waste management in terms of suitability in relation to how sustainable they are, with the least sustainable being at the bottom. Recover or recovery aims to recapture components and move them up the pyramid, and includes the recovery of energy from residual waste that remains, ideally after maximised reduction, re-use and recycling has taken place (Waste Recycling Group Ltd, 2010). The final concept in this approach is the residual disposal or management of waste that remains after the previous concepts have been applied.

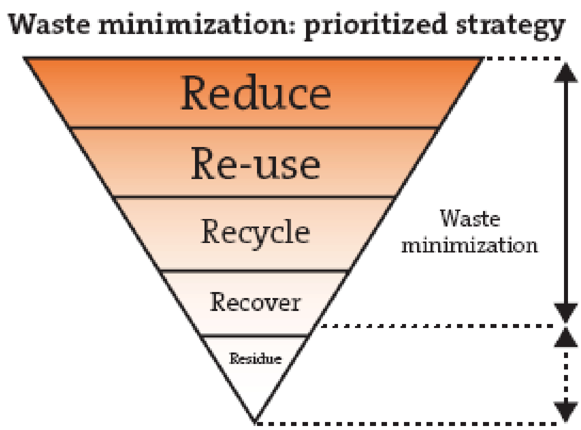

Figure 1, R5 waste hierarchy. Note: from Miswaco Envirocenter, 2004.

Within New Zealand, the government has drawn on internationally recognised waste hierarchies such as R5 in developing national waste management strategies (MfE, 2011b). The Ministry for the Environment has been associated with R5 related projects such as the *Reduce Your Rubbish* campaign which was designed “to raise awareness of New Zealand’s growing waste problem and provide householders with simple actions they can take to reduce their rubbish” (MfE, 2011e). This project has since ended, but MfE now maintains the sustainability.govt.nz website that includes easily accessible information about waste management (MfE, 2009b).

The most recent development of this approach includes re-think as the sixth ‘R’, as shown in Figure 2 below. This represents the need for meaningful consideration of potential waste during the early stages of production. This may result in product redesign to ensure that any waste can be managed at the top end of the waste hierarchy pyramid. In order for waste minimisation practices such as these to be effective they need to be applied by organisations, institutions and businesses, such as Massey University.

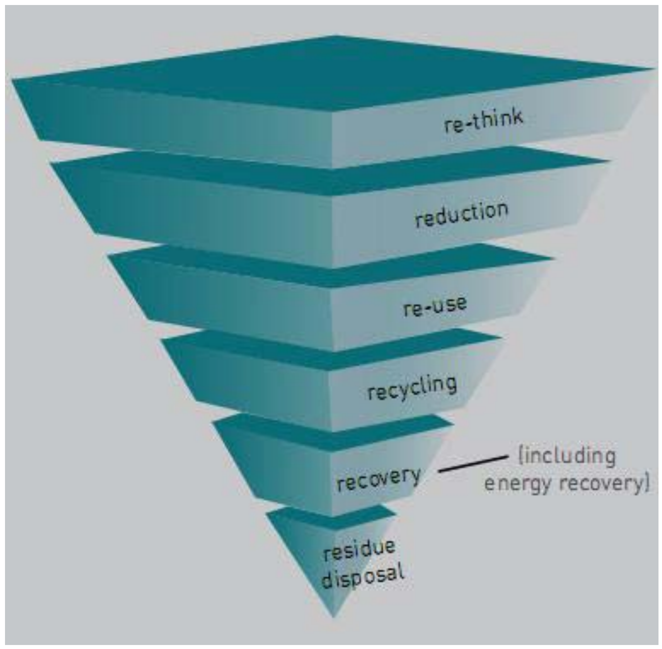

***Figure 2, R6 waste hierarchy. Note: from PNCC, Waste Management and Minimisation Plan*, 2009.**

Massey University's Palmerston North campus is an example of a large organisation which is seeking to improve and enhance awareness "to achieve the attitudinal and behaviour changes necessary to live sustainably" (ARIES, 2009). Universities as part of the higher education system occupy a unique position of leadership and responsibility to promote education as a basis for a more sustainable society and "to integrate sustainable development into education at all levels and all areas of life including communities, the workplace and society in general" (UNDESD, 2011). Accordingly, in this particular case, Massey University has a role to play to create a sustainable environment by preserving the campus environment, which makes a positive contribution to the local community, and assists in achieving the PNCC's target of zero waste minimisation. Massey University's Road To 2020 strategy (2011) emphasises the need for a reduction in environmental impacts through practices and behaviour for sustainability. Recycling programmes and effective waste management lessen impacts in relation to these activities, and integrates learning and behaviour change for sustainability for all people on campus. In addition to this the Massey University Environmental Policy states that it is “committed to the principles of environmental responsibility and sustainable resource management at local, national and international levels” (Massey University, 2002, p. 1). This commitment “involves concerns for natural and developed environments, for the effective use of consumable resources, and the development of best management practices on all of the University’s land holdings” (Massey University, 2002, p. 3). By adopting a waste management strategy that is based on waste hierarchy concepts associated with the R6 approach Massey will be able to achieve this objective.

In addition, for both environmental and economic reasons, recycling and proper waste disposal should be a central concern to all community members. Based on the report by Enzler, et al., (2006), proper labelling and readily available educational materials can play a crucial role in enhancing recycling programmes and may potentially increase the amount of recycling on campus by raising awareness and increasing participation in such programmes. In order to develop and employ effective waste minimisation programmes there needs to be regular monitoring and auditing processes put in place. Universities such as Massey need to ensure this takes place because without accurate knowledge of the performance of the current waste management programme there is little that can be done except to make assumptions about current levels of success.

2.4 Zero waste

Zero waste is an initiative that is applied to encourage and inspire individuals to change old ways of thinking and to reduce the production of waste and to eliminate landfill disposal (Matete & Trois, 2008; Young, Ni et al., 2010). Zero waste is also a strategy for environmental sustainability since waste represents a considerable amount of pollution in the world. The following sections details zero waste at an international scale, zero waste in New Zealand, zero waste in Palmerston North, and zero waste at Massey University.

2.4.1 Zero Waste at the International Scale

Zero waste programmes have contributed to a significant decrease in international waste. It plays a vital role "in achieving the optimality of waste minimisation" (Snyman & Vorster, 2010). A number of countries have committed to establishing zero waste programmes, with the intention to minimise waste production and to achieve environmental sustainability and economic viability. A number of organisations have introduced zero waste programme in various countries.

ZWIA (2009) defines zero waste as being both pragmatic and visionary. It seeks to emulate sustainable natural cycles, where all discarded materials are resources for others to use. Zero waste means designing and managing products and processes to dramatically reduce the volume and eliminate the toxicity of waste, conserve and recover all resources, and not burn or bury them. Implementing zero waste will eliminate all discharges to land and water, or air that may be a threat to planetary, human, animal or plant health.

Zero waste international alliance (ZWIA) is an organisation, spanning the involvement of several countries, in which involves several key individuals and organisations who share the intention of networking and supporting the growing number of zero waste campaigns around the world. ZWIA was established in January 2003 (ZWIA, 2007) and has grown to include international members from a number of representative countries such as the United Kingdom (London), the USA (California), Australia, Canada, Scandinavia, Egypt, Taiwan, India, New Zealand and Italy, as well as a range of companies such as Dupont, Fuji Xerox and Toyota (ZWIA, 2007; Greyson, 2007; Phillips, Tudor et al., 2011). The aim of ZWIA is to develop international standards and benchmarks in waste production and to develop waste minimisation strategies toward zero waste management through initiating and facilitating research and information sharing for the promotion of zero waste, building capacity to effectively implement zero waste and setting standards for the application of zero waste (ZWIA, 2010).

In Australia, a zero waste minimisation strategy was adopted by NSW state government in February 2001. The purpose of adopting this waste minimisation strategy was to reduce waste through collaboration between stakeholders and local communities. The local community provides information with regard to waste management to government; therefore the information given can be used to create an initiative by government to create a policy for a waste minimisation strategy. For instance, Eurobodalla Shire Council was committed to reducing the waste disposed to its landfill site by an average of 10% per year during the period of 2001-2004 (Eurobodalla Shire Council, 2001). Similarly, the council is also committed to reduce the waste disposed to landfill by 90% during the period of 2001-2011. The state of South Australia has also adopted a zero waste strategy which aims to reduce waste to landfill by 25% by 2014 (Zero Waste SA, 2011). This will be achieved through the use of innovative practices and collaboration, education, advocacy and financial incentives.

In addition, in Switzerland, a non-governmental organisation, the Zero Emission Research and Initiative (ZERI) plays a crucial role to reduce waste and pollution to zero in business, municipalities, government agencies, communities and educational institutions. ZERI was established in 1994 by Gunter Pauli, a Belgium entrepreneur (ZERI, 2010). The development of ZERI is meant to promote zero waste solutions. There are a number of countries that have adopted the concept and methodologies of ZERI namely Brazil, Colombia, and Sweden. The concept and method of ZERI has significantly contributed to these countries achieving profitability in their organisations and effectively minimising waste production.

2.4.2 Zero Waste in New Zealand

The zero waste initiative in New Zealand was established in 1997 upon the formation of the Zero Waste New Zealand Trust (ZWNZ Trust) (ZWNZ Trust, 2011k). The focus of the trust is "to support the activities of community organisations, councils, businesses, schools and individuals involved in waste minimisation and recycling" (*ibid.*). Zero waste policies have been adopted by 70% of local councils throughout New Zealand, which are shown by the shaded areas in Figure 3 below, with many aiming for zero waste by 2015 (ZWNZ Trust, 2011d). After ten years of operation in 2007 the Trust divided into two organisations, with the creation of Zero Waste NZ Ltd, a charitable company that operates as a commercial contractor. This company aims to promote the vision of zero waste through a number of core activities: information exchange, networking, collaborating with councils, community groups and businesses, research, advocacy and policy development, providing advice and up skilling individuals through training courses run by the Zero Waste Academy. In 2010 the Zero Waste New Zealand Trust came to an end; however Zero Waste New Zealand Limited continues to operate and has provided consulting services to Counties Power, Deliottes, Kiwi Investment Property Trust, Ngati Whatua O Orakei, Wastebusters Trust Canterbury and the Ministry for the Environment.

Figure 3, Map of zero waste councils in New Zealand. Note: from ZWNZ Trust, 2011.

Furthermore, a number of businesses in NZ also have adopted a zero waste strategy including Fonterra, Ricoh group NZ, Fuji Xerox and Toyota NZ, Palmerston North (ZWNZ Trust, 2011h). Additionally the New Zealand Business Council for Sustainable Development (NZBCSD) promotes zero waste, and focuses specifically on achieving zero solid waste in industry (NZBCSD, 2011). For businesses the initial interest in zero waste may simply be about ensuring that the production of waste is decreased in order to increase profits. This can take place by reductions in disposal costs, increasing value from lower inputs of materials and energy, and maximising the amount of product per unit of raw material and reducing the cost of production (ZWNZ Trust, 2011b). This may also lead to businesses aiming to address broader sustainability issues which can lead to responsible employers that attract a committed workforce, strong community, improved supplier and regulatory relationships and increasing competitiveness through innovation (*ibid.*).

Fonterra established the 'Eco-Efficiency Programme' in 2003 and aimed to reduce the volume of rubbish it sends to the country's landfills by 75% over the 18 months period. The new programme has been very successful, reducing the volume of waste going to landfill by 85% - a saving of up to 800 tonnes a year (ZWNZ Trust, 2011f). Similarly, Ricoh offer a take back service for old photocopier machines and toner cartridges. In its day-to-day operations Ricoh collects as many materials for recycling as possible including obsolete machines, aluminium, toner cartridges, polyethylene plastic, paper and cardboard (ZWNZ Trust, 2011h). When cardboard is mixed with other materials and sent to landfill, it ends up costing a business approximately $400 per tonne. However, when it is recycled, then it will only cost the business $40 per tonne. Furthermore, it costs around $1000 to dump a tonne of screwed up paper (in rubbish bags), compared with $40-60 per tonne to recycle flat paper. High waste paper producers (or users) can earn $60-100 per tonne through recycling.

In addition, Fuji Xerox also runs a successful in-house recycling programme that staff willingly participate in (ZWNZ Trust, 2011h), which collects copy and print cartridges for recycling. In addition to this they are aiming to decrease waste in the initial design phase of their products by including recyclability, energy savings, long life, low emissions and developing high-speed duplexing copying functions, as well as producing recycled paper. In addition, the team at Toyota's National Customer Centre in Palmerston North has the goal of being one of the first zero waste businesses in the Manawatu (*ibid.*). Non-recyclable waste from the Centre's $60M turnover national parts warehouse has reduced 25% in the past year due to continuous improvement activities.

Furthermore, there has also been collaboration between the ZWNZ Trust and local government as is shown by the adoption of a zero waste strategy by the Far North District Council in 1999 (ZWNZ Trust, 2011e). This was one of the first ten councils to adopt a zero waste philosophy in New Zealand. The Far North District Council has taken an extra step in the zero waste approach by involving two local community based businesses in their waste management system. Firstly Clean Stream Northland (CSN) as one of the 4 waste contractors for the district (Far North District Council, 2011), and this company is a joint venture between the Community Business and Environment Centre (CBEC) and Te Runanga o Te Rarawa, which is the tribal council that represents the interests of 23 local Maori marae (iwi/hapu) (CBEC, 2011a). CSN operates 10 refuse transfer stations for the Far North District Council and work in partnership with them to achieve a target of zero waste to landfill. They do this by "providing quality cost effective waste reduction services, and educating [their] communities on how [they] can reduce waste to landfill" (*ibid.*). Their approach aligns to a R5 concept (reduce, re-use, recycle, recovery, landfill), and in January 2010 the community was recycling 53% of its waste by tonnes and 78% by volume. The "current waste reduction target for [this network of] recycling/refuse transfer stations operated by CSN is 75% in tonnes" (*ibid.*).

In addition to this CBEC Recycling and Refuse services operates a kerb side recycling and refuse service across some district areas such as Kaitaia, Ahipara, Awanui, Waipapakauri and Te Hapua (CBEC, 2011b). In addition to kerb side recycling they offer commercial level recycling and rubbish services throughout the Far North. This company was first established in 1989 and operates the Kaitaia recycling centre along with a network of drop off centres, which are recognised as a model of community led waste reduction and resource recovery *(ibid.*). For Kaitaia this has resulted in currently 61% of their waste going through the recycling centre and approximately 250,000 cubic metres of waste being diverted from landfill over 13 years (ZWNZ Trust, 2011c). While local and corporate initiatives have been increasing to reduce waste and increase sustainability, at a higher level the New Zealand government has also shown concern for waste production and reduction.

In response to an increase in waste production, the New Zealand government has established legislation in order to manage and minimise waste issues in the country.

The Waste Minimisation Act 2008 "encourages a reduction in the amount of waste we generate and dispose of in New Zealand and aims to lessen the environmental harm of waste" and "also aims to benefit our economy by encouraging better use of materials throughout the product life cycle, promoting domestic reprocessing of recovered materials and providing more employment" (MFE, 2011a). It plays a key role in achieving waste minimisation towards zero waste management strategy through a range of methods. The Act will establish a levy on all waste disposed of in landfills, develop product stewardship schemes, clarify the roles and responsibilities of territorial authorities, allow for the creation of regulations to improve information and reporting on waste and waste minimisation and establish a board which can give independent advice to the Minister for the Environment (*ibid.*). The waste strategy is set to increase the effectiveness of the re-use, reduce and recycle concept as well as increasing environmental awareness. It also demonstrates the government's commitment to reducing the waste stream and the local government's aspiration for more effective and efficient waste management and minimisation of waste production.

Previously the NZ Waste Strategy 2002 aimed to "achieve the vision towards zero waste and a sustainable New Zealand" through four strategic action programmes and 30 national targets including waste minimisation, organics, construction and demolition wastes, hazardous wastes and waste disposal. It meant to achieve environmental sustainability, social wellbeing and economic viability. However the 2010 Waste Strategy considered these goals to be ambitious and revised the aim to enable a more flexible approach to waste management and minimisation through the two goals of reducing harm and improving efficiency. The message of reduce, re-use, recycle is consistent with the second of these goals which highlights resource efficiency in both production and consumption. While this strategy focuses strongly on reduce, re-use, recycle there is also evidence of rethink being promoted in the production of packaging (MfE, 2011d). This provides a vision for the shaping of a best practice waste minimisation strategy in New Zealand.

Due to the increase in waste production every year, waste has become a primary concern with regards to environmental impacts in New Zealand. Accordingly, the increasing awareness of the environmental effects of producing a significant amount of waste has driven stakeholders (national government, local government, and politicians) to address the issue by creating a new methodology of solid waste management in order to improve environmental standards. In New Zealand, the Waste Analysis Protocol (WAP) which was developed in 1992 was used as an approach to address the waste problem. After a full review in 2000, this was transformed to the Solid Waste Analysis Protocol (SWAP) which has been developed as an effective way to collect waste data and address the issues.

The primary reason of transforming the WAP to SWAP was to facilitate the collection of consistent and reliable waste data by providing a methodology that can be used nationally. However, the original or core methodology of WAP is still retained in the new methodology of SWAP. The primary purpose of applying SWAP with regard to solid waste management is to assist territorial authorities in their waste management planning. It assists regional council by providing quantified data that can be used in the development of appropriate objectives and practices for waste management at the regional level, as well as assisting regional councils and territorial authorities in fulfilling their monitoring obligations under section 35 of the Resource Management Act 1991 (RMA). The 2008 Waste Minimisation Act highlighted the need for improved data collection and reporting on waste in order to improve waste minimisation practices at a national level.

SWAP is designed to obtain superior, detailed information from the results of waste management projects. The method is suitable for a small user with limited needs and resources, but it is also for large users with broader needs and resources in order to achieve an accurate result across a range of contexts. This makes it an applicable analysis framework for a range of situations and organisations, such as Massey University. The key components of the protocol are the use of a clear classification system, and statistical principles, and analysis in trial design and data analyses to guide survey designers in how to obtain the best result for the survey or investigation, and to provide users of the information with an indication of the accuracy of the information.

Furthermore, the SWAP analysis plays an essential role in conducting solid waste audits by providing a framework which can be promoted for use at both regional and national levels. A key part of this is the establishment of a precise classification system. According to the Ministry for the Environment (2002), there are 12 classifications which were used in the waste audit conducted for this research. This classification is intended to be utilised as a method for the survey protocol as well as for categorising waste in waste audits. The SWAP classification system formed the basis for parts of the waste and recycling audit carried out at Massey University for this research. This meant that waste production of each classification type was able to be quantified, and contamination levels in the disposal of recyclables and non-recyclables were able to be measured. The following, Figure 4 is the waste classification system designed by the Ministry for the Environment (*ibid*.).

Primary Classifications	Secondary Classifications	Examples
1. Paper	- Paper (excluding newsprint and magazines)	e.g. Photocopy paper
	- Paper (Newsprint)	e.g. Newspapers
	- Paper (magazines and printed materials)	e.g. Advertising Brochures
	- Paper board (corrugated cardboard)	
	- Paper Board (including cereal and shoe boxes)	
	- Paper Board (Liquid cartons and multi materials)	e.g. waxed cartons, foil lined cartons
2. Plastics	- PET-Code 1	e.g. Soft drink bottles
	- PET-Code 2	e.g. Milk bottles, retail bags
	- PVC-Code 3	e.g. Cups, shower curtains, binders
	- LDPE-Code 4	e.g. retail carry bags
	- PP-Code 5	
	- PS-Code 6	e.g. Foam meat trays, foam cups
	- Multi Material-Code 7	
3. Putrescibles	- Putrescibles (excluding garden)	e.g. Food scraps, dead animals
	- Putrescibles (garden)	e.g. Grass clipping, weeds, trees
4. Ferrous Metals	- Ferrous (excluding Steel cans)	e.g. Car body, roofing iron, appliance
	- Ferrous (Steel cans)	e.g. Baked bean can, soap can
5. Non-Ferrous Metals	- Non-Ferrous (excluding aluminium cans)	e.g. Copper pipe, aluminium windows.
	- Non Ferrous (Aluminium cans)	e.g. soft drink cans
6. Glass	- Glass (brown bottles)	
	- Glass (Clear bottles)	
	- Glass (Green bottles)	
	- Glass (Jars)	e.g. Jam jar, gherkin jar)
	- Glass (Excluding bottles and jars)	e.g. Window glass
7. Textiles	- Non-Leather	e.g. Carpet, curtains
	- Leather	

8. Nappies & Sanitary	- None	e.g. Disposable nappies, sanitary napkins
9. Rubble, Concrete, etc	- Rubble and rocks	e.g. Including bricks
	- Concrete	
	- Plasterboard	e.g. Gib board
	- Fibre Cement products	e.g. Hard planks, shakes
	- Fibreglass	
	- Soil/Clay	e.g. Topsoil sand
	- Other	
10. Timber	- Length and pieces	e.g. Farming timber, boards, sawn timber
	- Pallets and crates	
	- Fabricated	e.g. joinery, beds, cabinet
	- Sheets	e.g. plywood, particle board, MDF
	- Sawdust/shavings	
	- Debris/other	
11. Rubber	- Tyres	
	- Rubber products	e.g. Rubber pipes, mats
12. Potentially Hazardous	- Household hazardous	e.g. Cleaning agents, aerosol, wax products, glues, cosmetics, medicines, batteries, lighters, paint and ink, agrichemicals
	- Special and treated waste	
	- Medical waste	e.g. prescriptions medicines, animal remedies
	- Untreated hazardous waste	
	- Debris/others	e.g. Contaminated soil

Figure 4, SWAP analysis. Note: from MfE, 2008.

2.4.3 Zero Waste in Palmerston North

In 2000, Palmerston North City Council officially adopted a zero waste policy (ZWNZ Trust, 2011i). Prior to this, from the early 1990s a range of strategies had been created to achieve a reduction in waste. These focused on management of the landfill and the waste going in to it. During this time recycling centres were also established and a number of community based programmes began, such as a green waste depot, education about composting, a locally designed vermicomposting bin that was distributed to the regional educational institutions, and in 1995 a weekly kerbside recycle system was implemented (*ibid.*). A collaboration also developed between PNCC and Massey University, as these two organisations were both increasingly focusing on the zero waste approach as a waste management strategy.

In 2002 this collaboration was formalised by the launch of the Zero Waste Academy, and the signing of a Memorandum of Understanding (MoU) between PNCC, the Zero Waste New Zealand Trust and Massey University (ZWNZ Trust, 2011i). The Zero Waste Academy project aimed to "link the leadership and vision of Zero Waste New Zealand Trust with the experience and expertise of Massey University and the practical implementation of Palmerston North City Council's Zero Waste policy" (ZWA, 2002, p. 1). The two key objectives of this project were to "assist Palmerston North City develop an economically and socially viable Zero Waste strategy, a key component of which will be the development of a model resource recovery park" and to "make Massey University, Palmerston North campus, the premier tertiary institution in the Asia-Pacific region for Zero Waste research, training and practice" (*ibid.*).

In December 2005 the PNCC adopted the Waste Minimisation Plan which was updated in 2009 to reflect changing perspectives about waste both nationally and locally (PNCC, 2009). The purpose of adopting the Waste Minimisation Plan was to improve the system of waste management by recognising the role of the private sector in generating and handling waste, and minimising the amount of waste disposed of into landfill. It is also intended to respond to the requirements of the Waste Minimisation Act 2008. In addition to Waste Minimisation Act 2008, PNCC has also developed the plan in accordance with relevant government policy, namely the Local Government Act 2002, and the New Zealand Waste Strategy 2002.

By implementing the Waste Minimisation Plan, PNCC has committed to achieve 75% diversion of waste that is currently buried in landfill and clean-fills by 2015 (PNCC, 2009). PNCC's commitment to waste minimisation is fundamentally based on the vision and guiding principles of the Waste Management and Minimisation Plan 2009. The vision of this plan is to achieve "effective progress towards zero waste and a sustainable Palmerston North" (PNCC, 2009, p. 2). The guiding principles provide a framework for the waste minimisation plan, and include developing a strategic approach to waste minimisation, collaborating with those who want to work in the best interests of the community, and implementing systems that are affordable, cost effective, and resilient, and achieving environmental excellence (PNCC, 2009).

The Waste Management and Minimisation Plan highlighted the significance of the fact that 84% of the Palmerston North's waste was collected by the private sector, and so was out of direct control of PNCC. This indicates that the collaboration between PNCC and the private sector has to be developed in depth in order to achieve the optimal result of diverting waste from landfill. Therefore, a key approach for minimising waste entering the landfill for PNCC is to work collaboratively with the private sector to design and monitor a new best practice approach to waste minimisation in Palmerston North.

Within Palmerston North two transfer stations are currently in operation by private enterprises and are located at Matthew Avenue and Malden Street. These provide various waste collection and disposal services including both recycling activities and landfill operations (PNCC, 2009). A concern when waste disposal is controlled by the private sector is that their approach may not be consistent with PNCC's, and the local vision for waste management may not be met. PNCC, on the other hand, provides a weekly kerbside recycling and rubbish bag collection service primarily aimed at residential areas. PNCC also operates two recycling centres at Awapuni Sustainable Development Centre (ASDC-PNCC) and Ferguson Street, plus a transfer station in Ashhurst. The Awapuni Sustainable Development Centre processes both recycling and green waste. PNCC has an "immediate focus to provide an improved recycling collection system, provide facilities to process recyclables, and provide economic green and organic waste facilities" (PNCC, 2009, p. 5). The plan also aims to use an

R6 approach to sustainable waste management by situating residents' contribution as high up the waste hierarchy as possible (ibid.).

In order to implement the Waste Minimisation and Management Plan in Palmerston North, PNCC introduced a new residential kerbside recycling collection service on 5th July 2010 (PNCC, n.d.a). In this service, all residentially rated properties received a 240 litre wheelie bin for recycling plastic, paper, cardboard, and tins and a 45 litre recycling crate for glass collection (See Figure 5), with each bin being collected on a fortnightly rotation. When compared to the previous system this mades household recycling more user friendly, as official bins were not provided and the use of plastic bags was common. In this new system the household is only responsible for sorting glass from the other recyclables, and the provision of a sturdy bin could potentially result in less glass breakages.

Figure 5, the new collection of recycling bins in Palmerston North. Note: from PNCC, 2010.

2.4.4 Zero waste at Massey

As the major educational facility in Palmerston North, Massey University, Turitea Campus has an important role to play in Zero waste minimisation within the region. They have been identified as one of the key private sector organisations that PNCC needs to collaborate with on zero waste initiatives. This has already taken place through the launch of the Zero Waste Academy, as outlined on page 31. Prior to this collaboration, in December 1999, a Zero waste programme was established at Massey by the School of the Environment (Mason, Brooking et al., 2003; Mason, Oberender et al., 2004). The zero waste initiative was a response to student concerns over environmental management issues such as recycling facilities on Massey's Turitea Campus (Mason, Brooking et al., 2003). This led to discussions which included concerned staff and students and eventually disseminated to a PNCC staff member, which led to the discovery of the Zero Waste NZ Trust. Following on from this a funding grant was obtained which was used to conduct an initial study into organic residuals, the findings of which were published in 2003.

This research was conducted by two students and supervised by an academic staff member. The primary objective of Mason, Brooking, Oberander et al.'s initial study was to assess the quantity of waste produced and the production patterns of solid residuals at Massey University (*ibid.*). It was recommended that a formal environmental management system needed to be introduced. As a result of this research an on-campus composting facility was designed (Zero Waste New Zealand Trust, 2011j). In addition to this a related project was initiated that focused on the improvement of solid waste recycling and source separation.

Mason, Oberender and Brooking (2004) assessed the effectiveness of source separation at Massey and investigated the potential for the re-use of resource residuals on Turitea campus. The study was conducted in and around the kitchen, cafeteria and concourse areas and aimed to assess the quantities and production patterns of solid residuals these areas. The research objectives were "to assess the effectiveness of source separation practise and to investigate the potential for resource residuals re-use and re-cycling both on and off campus" (Mason et al., 2004). This research identified that a recycling problem existed in the amenities buildings; a problem that was associated with human activities including eating, drinking and socialising. The key recommendation was that improved and ongoing education and training was required to improve recycling behaviours in these areas.

Consequently, there was further study of campus community attitudes toward environmental awareness (Kelly, Mason, Leiss & Ganesh, 2006). This study conducted a survey using written questionnaire, which was mailed to a random sample of 1400 staff and students. The response to that survey demonstrated the existence of different attitudes among the university community when it came to environmental issues and that many were still uncertain when it came to recycling. The major difficulty appeared to be distinguishing between what could and could not be recycled, and it was suggested that better signage would address part of this issue. Additionally there was support for the concourse based recycling system to be extended to the remainder of campus.

In 2008, Massey University Student Association (MUSA) conducted another survey of 152 students to identify the percentage of the university community which was regularly recycling, and using the bins provided in appropriate manner. This survey asked participants to rate their own environmental awareness and Massey's environmental sustainability, as well as quantifying the awareness of recycling on campus, the use levels of recycling facilities, and the satisfaction level regarding the current recycling facilities. The results of the MUSA survey indicated that: 59.9% of participants rated Massey's environmental sustainability as good or better, 97.4% of students were aware of the university's recycling and 89.5% of those surveyed were using the recycling facilities, and 61.2% were happy or very happy with the current facilities. In addition to this the opportunity was provided for participants to name one thing they would like to see Massey do to improve environmental sustainability on campus. The top three results were more recycling bins (39), addition of composting bins (11) and increased promotion of recycling for a sustainable campus (11).

Lastly, there was a further report on the university's waste problem by Hannon (2005), as the co-ordinator of Zero Waste Academy. This report focused on documenting the current and future initiatives of Massey University's practical zero waste program. Current initiatives included the expansion of the recycling wheelie bin to a total of 26 clusters across campus, a staff/common room plastics and cans recycling system, with the potential for organic and biodegradable waste to be added, supporting local PNCC product development project regarding a Organic/Renewable vs. Plastic Sanitary disposal system trial, and the development and utilisation of an ongoing waste audit that incorporates innovative methodologies and contributes to monitoring of the zero waste programme.

In summary, previous studies found that there was an existing focus in and around the kitchen/cafeteria and concourse areas; that a recycling problem existed in the amenities buildings; there were question concerning effectiveness of source separation of waste and the behaviour of the campus community in relation to recycling programs. Further, many on campus were still uncertain when it came to what could be recycled and what could not be. Finally, due to some lateral thinking there was a suggestion that the deciding factor in participation by the campus community in the zero waste programmes was bin type and its colour. Clearly, there were still questions unanswered regarding the efficiency of the current zero waste programs on Massey's Turitea campus. However, without accurate knowledge of the performance of the current Massey waste management programme there is little that can be done except to make assumptions about how the current programme may be improved and developed.

2.5 Recycling Behaviour

Recycling only takes place when somebody makes a choice to put any given materials in a recycling bin instead of a waste bin. While infrastructure design in zero waste programmes may ensure that there is access to a user friendly recycling bin the provision of facilities such as this can be described as a hardware element and is just a part of the zero waste challenge. A key dimension of zero waste is what people know, understand and believe, and how they choose to act. These elements can be thought as human software which is as important as the recycling hardware previously described. There is a relationship between recycling behaviour and waste audits as they are a method that can provide an insight into how well the human recycling software is working by quantifying the correct and incorrect recycling and waste choices people are making.

In recent years the increasing amount of waste produced in communities and households has become a major concern in many countries and a number of initiatives have aimed to address this. A key focus for this has been to increase participation in recycling programmes across the community through effective system and facilities design. The range of techniques employed relate to the community and individuals' triggers for behaviour change. A study carried out in the UK analysed behavioural and attitude changes towards recycling in an area of central London (Thomas, Yoxon, Slater & Leaman, 2004). This research had similar findings to other studies carried out in the UK in that time or space constraints, the lack of convenient facilities and not considering their actions to be of worth can outweigh a person's desire to participate in recycling. More specifically, the key reason that people gave for increased recycling behaviour was the improvement of facilities for recycling (*ibid.*). An example of this would be the addition of extra recycling bins, to increase the locations where recycling can take place. Other key motivators for behaviour change was that recycling was considered common behaviour, and that recycling fitted in with everyday routines and became a habit (*ibid.*). A final factor identified was that the person had the right information to be able to participate in the recycling programme. While these need to be considered at the operational level there are also examples of initiatives that have been implemented at a policy based or strategic level which focus on improving recycling behaviour.

A country may have a number of strategic documents that could operate bilaterally, with neighbouring nations, as well as nationally within that country. The vision for waste management in England was established by the Department for Environment, Food and Rural Affairs (DEFRA) 2007 Waste Strategy for England. The underlying strategy from this report was for central government to take a role in enabling each sector, within society to share responsibility for reducing its own waste (DEFRA, 2007). This aimed to encourage action by all individuals and to increase the numbers of people participating in recycling. This strategy identified a number of activities that will contribute to a change in recycling behaviour including extending the campaign for recycling, increasing the amount of recycling bins available in public spaces, and promoting the reduction of waste and increase of recycling in schools. It is important to include the two key factors of behavioural change these being encouragement and engagement as these are necessary to generate and sustain a transformation in public behaviour. The encouragement factor is important to attain higher participation and is most effective when there is active enforcement, increased education, and financial incentives. Similarly, the engagement factor activities, such as education, consultation, and awareness raising and providing information, have been found to enhance recycling performance and be essential to recycling scheme success.

In addition to this the Waste and Resource Action Programme (WRAP) works across the United Kingdom and aims to "help the UK Governments to meet their national and international commitments and build the green economy" and "to support resource efficiency in the UK so that householders, businesses and the public sector save money and make better use of resources" (WRAP, 2011). Since the programme began in 2000 it has helped to increase the size of the recycling and reprocessing sector which has quadrupled between 2000 and 2008, and this has resulted in over 120 million tonnes of waste being diverted from landfill and over 20 million tonnes of CO2 equivalent greenhouse gases saved. This contributes to achieving WRAP's vision which is "a world without waste, where resources are used sustainably" (*ibid.*). In addition to this the European Union (EU) Directive came into force in 2010 and establishes a legislative framework which sets EU-wide targets for reuse and recycling 50% of household waste and for reuse, recycling and recovery of 70% of construction and demolition waste by 2020 (DEFRA, 2008). In order to meet these targets it will be necessary for behaviour change and increased participation across society. In addition to creating behaviour change around recycling and waste disposal it is essential to monitor recycling programmes for example through waste audit process.

Therefore approaches to achieving behaviour change with respect to the increasing performance of recycling programmes have to be effectively designed in order to increase community participation. This may include employing a range of techniques that relate to the communities' triggers for behaviour change. For instance in England, the general awareness of potential techniques has shifted towards economic incentives in which financial penalty will be given for not recycling, however the opportunity to implement this technique has not yet been taken up by any of the local authorities (DEFRA, 2009). Additionally it is essential to encourage people to comprehend more about the full range of recyclable and non-recyclable materials in order to increase participation rates and support recycling programmes.

Recycling engages a complex chain of behaviour from many parties, namely producers, manufactures, and consumers (Begum, Siwar et al. 2009; Watson 2009). Concerns about the role of the consumer in recycling for the most part focus the return of recyclable materials into the system, which is dependant in part on the recycling behaviours that take place. A better understanding of recycling behaviours will help aid design and improve the effectiveness of any recycling programme (Sidique, Lupi et al. 2010). In order to reduce the amount of waste entering landfills, recycling and waste reduction programmes such as source reduction, kerbside recycling, and drop off recycling programmes should be implemented. Application of these practical systems can contribute to the achievement of zero waste goals, as well as fulfilling components of broad spectrum sustainability programmes.

By implementing recycling programmes universities can be leaders in waste minimisation, while also demonstrating the outcomes of these programmes with regards to behaviour change in recycling which contribute to campus sustainability. Two examples of universities that have done this are Monash University, in Melbourne and the Australian National University (ANU), in Canberra. At Monash a wide range of environmental initiatives have been developed, which includes recycling, in an attempt to reduce environmental impacts by “reducing, reusing and recycling valuable resources, and reducing waste sent to landfill” (Monash University, 2009). Similarly ANU established ANUgreen environmental program in 1999 under the ANU environmental policy (ANU, 2011). This aims to reduce the university’s environmental impact and a key aspect of this has been the development of a comprehensive waste minimisation plan that focuses on R3 practices.

At Massey University, where this research took place, behaviour change has played a key role in developing a zero waste programme, for which the participation of the campus community was essential. Since the establishment of this programme the link between increasing recycling behaviour and improving infrastructure accessibility and quality, raising awareness and increasing education has been shown as studies have taken place, changes have been made and recycling has increased. Details of these studies can be found in the previous section on Zero Waste Massey (page 29-32). Fundamentally, a successful recycling program depends not only on technology but also on the response of the community towards environmental sustainability (Begum, Siwar et al. 2009) and the development of methods of carrying out monitoring, such as waste auditing.

2.6 Waste Auditing

There are two approaches that can be used to audit waste management practices, waste auditing and recycling auditing. A waste audit is a formal, structured process used to quantify the amount and type of waste being generated by an organisation (Dowie, McCartney et al., 1998; McCartney, 2003). In general, a waste audit is a more quantitative process providing data regarding specific types of waste (Nilsson, Bjuggren et al., 1998). The auditing information can help investigate current waste practices and how they can be improved. As an outcome of the waste audit, recommendations on how to introduce or increase recycling can be developed (Mahwar, Verma et al., 1997; McCartney, 2003). A recycling audit also uses sorting to determine the level of contamination in recycle bins, and identifies what is being placed into the bins that doesn't belong there (Concordia University, 2011). Both of these types of auditing can contribute to developing and improving waste management systems.

The objectives of an audit will largely be determined by the waste types and physical location to be audited. There are a number of objectives in conducting a waste or recycling audit including, to determine the composition and quantities of waste and recyclables being generated, to measure the effectiveness of existing waste management systems, to identify opportunities for improving waste management systems and strategies, and to collect baseline data for measuring the effectiveness of waste minimisation strategies (McCartney, 2003).

In relation to this study, both waste and recycling audits were conducted from January 2010 to March 2011 at the Massey University Turitea Campus. The aim of conducting the waste and recycling audits in this study was to identify the amount and type of waste produced, as well as investigating the effectiveness of the recycling and waste collection systems by measuring contamination levels. Therefore the findings of this study will provide information of how to enhance and improve campus recycling programme in Massey University.

In New Zealand, a number of existing waste management programmes have applied waste auditing in order to identify the waste production and to enhance the improvement of waste management system. For example, waste auditing projects of particular interest for this study were undertaken in Christchurch, the North Shore of Auckland and Timaru. The Timaru District Council, (2007), used waste auditing to determine the level of waste contamination in recycle bins (inappropriately disposed of rubbish i.e. was the rubbish potentially recyclable waste disposed of as landfill). How this was achieved was by way of a stepped process. The first step was to identify all the rubbish bins. Next, the waste found in the contaminated bins was removed and sorted by category (type). Thereafter, the results of the audit were recorded according to the quantity of each specific type of waste i.e. organic waste, cans, paper or cardboard. Waste auditing, as described above, is a practical method or tool that is used to help identify the type of waste (Waste Not Limited, 2001). In addition, waste audits also enable a connection to be made to the source of waste.

In order to develop the methodology for this research it was necessary to consider a range of previous studies and create an adapted audit to suit the Massey University context. The following is a detailed description of how a general waste and recycling audit would be conducted.

2.6.1 The Method of Conducting a Waste Audit

There are a number of key principles that need to be considered when conducting a waste or recycling audit. These have been identified using a number of examples and existing guidelines and include steps such as:

- Scoping (Waste Not Limited, 2001; Pearson, 2002a; New South Wales Government, 2011),
- Setting up (Waste Not Limited, 2001; New South Wales Government, 2011; New South Wales Government, 2011),

- Sorting it out (Waste Not Limited, 2001; Pearson, 2002a; Department of Environmental Protection Pennsylvania, 2010; New South Wales Government, 2011),
- Health and safety (Waste Not Limited, 2001; Pearson, 2002a; New South Wales Government, 2011),
- Managing data and analysing data (Waste Not Limited, 2001; Pearson, 2002b; New South Wales Government, 2011).

Following is detailed information concerning the steps of how a waste audit is conducted.

2.6.1.1 Scoping

Initially, it is important to conduct a scoping of the audit site which will include locating the bins onsite, finding out when emptying is scheduled, determining if different bins are used for different activities, locating a space to be used for sorting, and getting an early feeling for any health and safety issues that may arise as this will affect the equipment you may need (Waste Not Limited, 2001). It will also be necessary to let people affected by the waste audit know how long it will take, and ensure that any other relevant people are contacted. Once this has been undertaken a detailed methodology and plan can be created.

2.6.1.2 Health and Safety

Health and safety is an overriding consideration for all organisations. Workplace occupational health and safety (OSH) is covered by NZ legislation. There are hazards associated with waste auditing, these include the following examples. Accordingly, a waste audit has to consider OSH both during the development and application of the methodology. Prior to doing the physical waste audit, consideration needs to be given to keeping auditors safe from any kind of health risk or physical injury. According to Waste Not Limited (2001), there are a number of important requirements related to health and safety; (i) identifying any kind of risk which has the potential to cause injury, and (ii) creating a plan to minimise or isolate the health and safety risks associated with the audit. In terms of risk identification, there are several common things which can put auditors at risk and that can cause physical injury. These considerations are as follows.

1. Waste may contain needles, broken glass or other sharp objects, chemicals and even infectious material. Inadequately stored food waste may have infestations of insects or rodents.
2. Injuries may result from lifting and carrying heavy waste bins/bags or containers, and dropping objects on hands, legs or feet.
3. There are many on site hazards to consider such as: vehicles, machinery, tripping hazards, slippery surfaces, dust, odours, and even non-audit personnel who may use the space on a daily basis as they go about their normal routine.

Prior to the audit being conducted a health and safety plan needs to identify each risk or hazard, the steps taken to avoid or minimise the risk and the procedure should a hazard be encountered. It is also necessary to identify safety equipment that is required, of which a first aid kit is a priority, and most importantly a trained first aider should be included in the makeup of the audit team. Safety equipment should be provided for all team members, which will include protective gloves, breathing masks, safety goggles and sanitising products. Safety equipment should also include provision for wash down should a contamination event occur and obviously a place for team members to prepare, dress appropriately prior to conducting the audit and change after work, shower and remove potential risky and hazardous material from their person. In addition vaccinations, such as tetanus and Hepatitis B should be considered (Waste Not Ltd, 2001).

A health and safety briefing should be held prior to the audit process and should encompass all that is mentioned above to a sufficiently high degree that all team members are fully aware of the difficulties, potential risks/hazards and how to effectively deal with them.

2.6.1.3 Setting up a Waste Audit

There are several important physical elements which are required by any team if they are to conduct a physical waste audit namely, equipment and recognition of site requirements (Waste not limit, 2001; Timaru District Council, 2007). These elements play a crucial role in undertaking a waste audit. Locating a place in which to work is considered a high priority. The selected site is important because rubbish cannot simply be sorted anywhere as, not surprisingly, many find rubbish to be an unpleasant reality – even aside from the high risk it presents for public and individual health and safety. Public attitudes aside, there are several site requirements to consider; such as, the place should be dry and out of the wind; close to the disposal point; and, at least 4m x 5m square with ample head space. Once this has been identified effective tools and equipment can be sourced.

An example of the sort and type of equipment required would be a heavy duty (industrial) scale (weighing device) of some sort. This tool is used to measure the weight of waste based on each category. Additionally, when sorting waste by type consideration needs to be given to whether it is organic matter or something else. Regardless of waste type protective gear is required (e.g. mask, gloves, and steel toed boots). Sorting may require extras bins or containers of an appropriate size.

Aside from all of the above, team members should also have an adequate supply of pens, clipboards and audit sheets. Additionally electronic devices such as a camera and a laptop computer may be useful. The use of technological aids such as computers and calculators will greatly assist in the process of data collection and speed up the process of analysis post audit. However if a laptop is unable to be acquired or not considered suited to the environment, data sheets can be used.

After addressing all that is mentioned above the actual physical task of auditing (waste sorting and quantification) can be planned.

2.6.1.4 Sorting out – Quantification of Waste Materials

After the site for physical waste audit is selected and set up, and all equipment is ready to go, there are the multiple steps in sorting process that need to be considered. The process of sorting the waste out is comprised of following six steps. Each step in the plan is considered to be sequential and each needs to occur, and in the correct order, before going on to the next. These steps are as follows.

1. Weigh the multiple sorting bins, while empty, and record the weight on the outside of each sorting bin. This means that the bin weight is recorded and can be excluded from the final weight.
2. Weigh the selected sample of waste and record that weight on sheet provided.
3. Empty the waste sample onto the sorting table.
4. Sort waste into the designated bins by category – record in audit sheet.
5. Weigh each designated sorting bin and record the weight on the audit sheet before appropriately disposing of the waste material.
6. Transfer the data from the waste audit sheet into a spreadsheet for further analysis back at the laboratory – a data management issue.

2.6.1.5 Managing Data

All the collected data, as mentioned above, will be, during the audit process, transferred to a spreadsheet. This can involve onsite entry into an excel spreadsheet using a laptop or entering data by hand onto datasheets. This is done in order to create a record of all of the data based on each category. The collection of data will influence the way in which it may be used so this needs to be considered. The data or spreadsheet needs to include all of the relevant categories, the date, time and location, and source of waste. Thereafter, all the recorded data is then available for further analysis.

Accuracy needs to be considered in terms of the unit of measurement selected (kilograms, grams, etc), and the number of decimal places the weight is measured and recorded to. When more than one person is conducting the audit training needs to be used to ensure that not only is all data collected in the same way but that the sorting process is carried out consistently.

2.6.1.6 Analysing the Data

Data analysis will depend on both the amount of data gathered and the questions that are being asked. Data needs to be summarised into tables and graphs while making sure that important details are not lost. This will allow the data to be reviewed. Further analysis of the data can require the resorting, ranking, or standardisation of the information gleaned from the audit. When analysing the data it is important to consider the information about the context of where the waste or recycling came from, for example what type of bins were available in the location and how many of each type (Pearson, 2002b). This can help to determine where the real issues lie, such as recycling awareness or a lack of facilities. Following this, graphs or tables are constructed which facilitate the communication of the audits findings. If the material warrants it then comparative analysis can also be undertaken. The final step is a written report.

CHAPTER 3
METHODOLOGY

3.1 Introduction

This research has been undertaken as a case study, to evaluate zero waste management process at Turitea campus, Massey University. Underpinning this project is the idea that implementing routine waste and recycling auditing should be part of evaluating existing and designing new development in zero waste management at Massey. This project provided an opportunity to trial a waste and recycling auditing procedure which had been specifically developed for the Massey University context and to then use the findings to make recommendations about how the recycling collection infrastructure and programme as a whole might be improved. Trial I of this research operated as a pilot trial after which a number of improvements were made which are described in the results chapter. In addition to this a number of other minor changes were made during Trial II and III in order ensure that the best possible data would be collected. Trial IV focused on the location of the student hostels in order to provide a clear picture to RFM about how effectively the recycling facilities were functioning.

As a result of the collaboration with RFM a brief report of the research findings was created in order to provide them with information in relation to the Turitea campus and the student hostels (see Appendix I). The briefing report was based upon two parts. Part I describes the basic waste and recycling infrastructure across the campus, alongside the key findings from auditing the waste and recycling programme. This baseline report was presented in a meeting with Massey's Facilities Management staff. As a result of the discussion and feedback, further research questions were identified and additional work was undertaken. This second body of work forms Part II and presents the key findings from the audit of the recycling and waste in the student hostels, as well as addressing the required volumetric component for this project. It was also requested that this report be presented to the Massey Sustainable Development steering committee, as it is an input into the redevelopment of the current waste and recycling infrastruture at Turitea campus.

Waste and recycling auditing involves physically sorting and classifying heterogeneous mixture of recyclable, unrecyclable, and organic materials. This provides quantification of: a- the recyclables in the solid waste stream, and b- the waste and other contamination in the recycling stream. For the first, this would involve materials that should be in recycling bins being disposed of in waste bins that go to landfill. Alternatively contamination of recyclables can involve the wrong category of recyclable or non-recyclable materials being placed in the bin. These findings shed light of the awareness levels and nature of participation of the university community in on-campus recycling (Timlett & Williams, 2008).

3.2 Location of Study

The study was undertaken at Turitea campus, Massey University. This study focused on certain places within the university campus namely the concourse area, in between library, the student-dining hall, staff common room for trials I, II and III; and student accommodation or hostels for trial IV (see Figure 3 below).

In the sample area, the waste audit could then be undertaken. The audit consisted of the selection of the many waste bins located on the campus. The location chosen for the study (the concourse and dining hall) was identified because it is recognised as a high use area (an area of high waste and recycling production generated by the university community), and is also high profile in terms of demonstrating the recycling bin cluster system. Following is Figure 6, an aerial photograph map that provides an overview of the area from where the sample bins were selected.

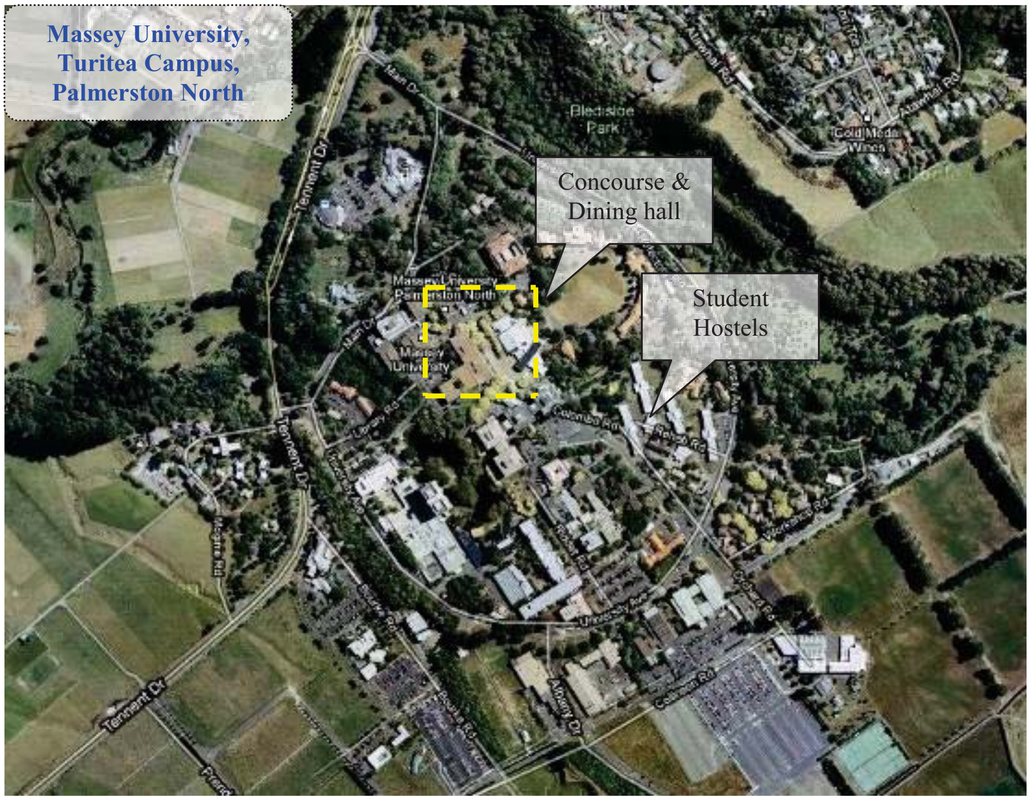

Figure 6, Site location of study.

3.3 Survey Period

The process of conducting waste auditing in this study consists of four trials. Each trial consisted of a one week period of time. Furthermore, each trial represents a comparable point during semester one and two where all students are around on campus and during summer school where there are few students. The survey periods for this study were selected in order to deal with the pattern of waste disposal which is directly related to the number of students and staff present on campus throughout the year. It was necessary to consider this pattern to be 'seasonal' as it varies throughout the year but stays the same when considered on a year to year basis. The survey periods selected aim to give a representation of a typical year with this seasonal pattern in mind. This also allows for the data collected to show an accurate representation of what can be expected at high-generation periods, which is an important consideration when redesigning existing waste and recycling disposal systems.

The waste audit took place:

- Trial I – 25th – 29th January, 2010; summer semester = decreased student density.
- Trial II – 13th -17th September, 2010; second semester = high student density.
- Trial III – 29th November – 3rd December 2010; summer semester = decreased student density.
- Trial IV – 7th – 11th March 2011; first semester = high student density.

3.4 Research Method

Conducting a waste and recycling audit is a useful way to investigate the effectiveness of the waste management systems in an institution (McCartney 2003; Smyth, Fredeen et al. 2010). The process of undertaking a waste audit in this study consisted of several steps. The following is a detailed description of the steps and process of conducting waste audit in this study.

3.4.1 Waste Auditing

The method of conducting waste audit in this study is comprised of several steps. The steps are as follow;

1. Scoping or choosing the site location.
2. Selecting the sample bins based on the high production of waste and systematic random sampling.
3. Consultation with key staff at Massey.
4. Identifying the equipment required to undertake the waste audit.
5. The quantification of waste material.
6. Analysing data.

Following is a detailed elaboration of each of the above steps.

3.4.1.1 The Locations, Types and Sizes of the Bin Codes

Prior to undertaking the recycling and waste audit process at Massey's Turitea campus, there were several factors which needed to be taken into consideration with regards to planning. The key planning considerations were determining the site location; the size of the bin used for the audit process; talking to everyone involved to find out the necessary information; finding a place to sort the materials; finding out how often rubbish bins were emptied and making sure that the bins were not emptied prior to doing the audit.

At present Massey uses a variety of different types of bins around the campus. Each bin is designed for a different purpose and this is reflected in the characteristics and size of each bin. This diverse variety of bins also reflects that the overall system has been expanded in a number of phases, as need required it. These bins range from rather small to extremely large (see Figure 7). These bin types and their locations are described in the following section.

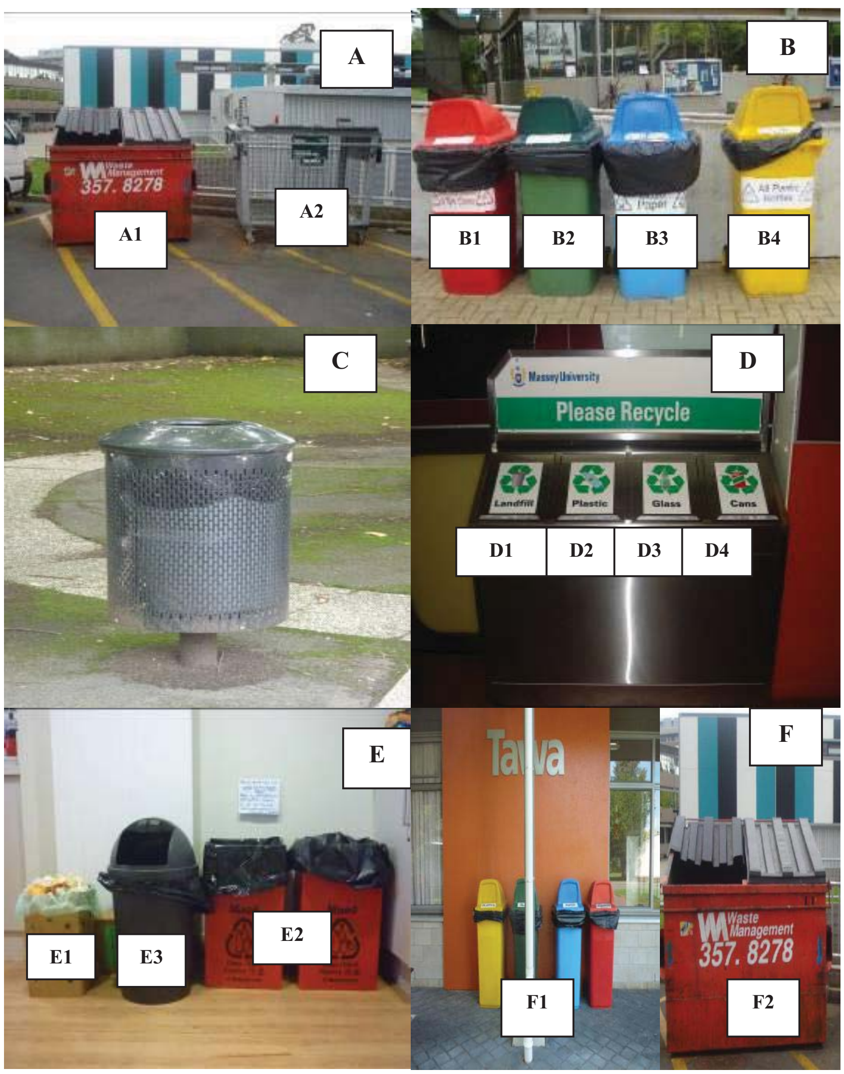

Figure 7, Samples of bins audited in this study.

As shown in Figure 7 above, Code A contains the largest of the waste bins used at Massey (A1) and also includes the paper/cardboard recycling cages. Codes C and E are the smallest, and Codes B, D, and F, are the intermediate size bins. Each bin serves a specific purpose in a specific environment. Generally these bins are placed at various locations around the campus where they are needed which results in there being more bins in high pedestrian/use areas such as the concourse area, the student accommodation areas, and the student dining hall, as well as the staff common rooms (see Figure 8).

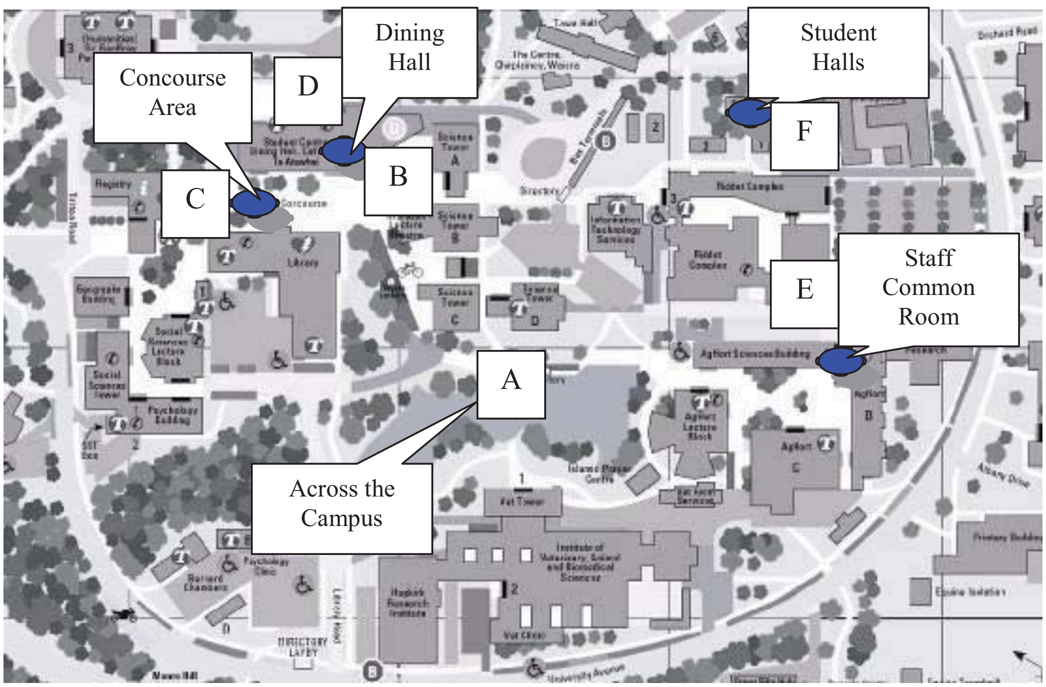

Figure 8, the locations of bins

These six bin types were given a code, from A to E, in order to be easily identified during the process of the waste and recycling audits (see Table 1 and Figure 7). These codes and sub-codes where necessary are shown in Table 1.

Table 1, Bin code and location

No	Type of Bin	Code	Sub-Code	Category	Location
1	Large Waste and Recycling Cage Bins	A	A1	Large Waste Bin	Across the Turitea campus
			A2	Recycling Cage Bin	
2	Recycling Wheelie Bin	B	B1	Plastic and Bottles	Concourse area & Dining Hall
			B2	Aluminium and Tin Cans	
			B3	Mixed paper	
			B4	Mixed Glass Bottles	
3	Small Waste Bin	C	-	Waste	Concourse Area
4	Massey Recycling Bin	D	D1	Landfill	Dining Hall
			D2	Plastic	
			D3	Glass	
			D4	Cans	
5	Waste, Organic & Recycling Bins	E	E1	Organic Waste	Staff Common Rooms
			E2	Recyclables	
			E3	Waste	
6	Wheelie Bin	F	F1	Recyclables	Student Hostels
			F2	Waste	

1. Code A was the large/bulk waste bin and paper/cardboard recycling cage bin. There were 40 large waste bins and 19 paper/cardboard recycling cage bins located across Turitea campus.
2. Code B was the recycling wheelie bin clusters, which each consist of four bin types (sub-code B1 is Aluminium & Tin Cans; B2 is Plastic & Bottles; B3 is Mixed Paper; and B4 is Mixed Glass and Bottles). There were a total of 26 of these clusters located around the campus, including those at the student hostels.

3. Code C was the small waste bins of which there were 12 that were located in the concourse and other nearby areas.
4. Code D was the Massey recycling bins which were made up of four categories namely, D1 (landfill), D2 (plastic), D3 (glass), and D4 (cans). The total amount of code D bins was two and these were located inside the dining hall.
5. Code E was the organic (E1), recycling (E2) and waste (E3). There were a total of 31 bins which were located in the staff common rooms.
6. Code F was used for the audit conducted during Trial IV of the student hostels which consisted of recycling wheelie bins (F1) and large waste bins (F2). These bins were also a part of the wider campus waste and recycling management program, so were a part of the 26 recycling wheelie bin clusters and 40 large waste bins.

Two different approaches were used to select the bins from each code to be audited. For Code B, D and E the selection was based for the largely on there being adequate quantities of material to audit, particularly for Code B and D during Trial I which was conducted during the summer semester when less students are on campus. For Code C the small number of bins (2) meant that it was possible to audit all of this bin type. Code E? For Code A and F a process of systematic random sampling was used to select which bins would be audited. What was sample size based on?

3.4.1.2 Description of Bin Types

The large waste and paper/cardboard recycling cage bins (Code A)

Firstly, the large waste bins (Code A1) used at the Turitea campus range in size from 1.5m^3, 2m^3, 3m^3 to 4.5m^3 (Massey Regional Facility Management (RFM), 2010). In total, there are 40 bins used at Turitea campus, which consist of twenty one bins of 1.5m^3, one bin of 2m^3, 5 of 3m^3, and thirteen of 4.5m^3. These bins are located in various places around Turitea campus and the Massey student halls. These bins are managed and emptied by a contractor (Waste Management Ltd) through RFM, and are emptied on demand. These bins contain waste that has come from a variety of locations including that collected by cleaners from inside buildings and the contents of the small waste bins (Code C). This waste is contained within large black plastic bags. Table 2 below shows the detailed information provided by RFM with regard to the location and size of the large waste bins.

Table 2, the location and size of the large waste bins, Turitea campus

No	Waste bin Location	Size (m^3)
1	Bernard Chambers Carpark, off Library Rd	1.5
2	Vet Tower, outside gate to yard, off University Ave into Ag Eng car park	4.5
3	Vet Clinic Garage, by Vet Clinic Garage	1.5
4	Library, beside loading Bay back of library, Library Rd	4.5
5	Science Tower D, loading Bay Science Tower D, end of Riddet Road	3
6	Social Science Tower, car park to right of SST Building, University Ave	4.5
7	Wharerata, Wharerata car park, University Avenue	1.5
8	Mognie Hall	4.5
9	Craig Lockhart & Walter Dyer Halls	1.5
10	Tararua & Ruahine Halls	4.5
11	AgHort B	1.5
12	AgHort C	1.5
13	Green Bike Trust (GBT)	4.5
14	Boiler House	3
15	Maori Studies, Bourke Road, Maori Studies building loading bay	1.5
16	Creche car park	1.5
17	Maori Studies, Bourke Road, Childcare	1.5
18	Printery, car park behind Printery, off Collinson Rd	4.5
19	Prac Teach Agrom, compound behind building, off Collinson Rd	1.5
20	Riddet Compound, Riddet Rd, (between Riddet bldgs)	1.5
21	Kairanga Court, second bin in Workshop Rd	4.5
22	City Court Hostel, first bin in Workshop Rd	4.5
23	Rotary Court, University Ave	3
24	Matai & Kiwitea Halls	4.5
25	MacHardy Hall	1.5
26	Refectory, Refectory Rd, behind Refectory building	1.5
27	Business Studies, University Ave, car park behind Bus. Studies Central	1.5
28	International Office	1.5
29	University House, Japanese Theatre	1.5
30	Main Building, adjacent Old Registry	4.5
31	Dining Hall	4.5
32	Science Tower A, Colombo Rd, back of Science Tower A	3
33	Tawa Hall	1.5
34	Residential service office (RSO), Colombo Rd	1.5
35	RFM, inside W&S courtyard, Colombo Rd	1.5
36	Colombo Hall, outside Colombo Hall	3
37	Food Technology	4.5
38	Riddet 2, off University Ave, between Colombo & Riddet Roads	1.5
39	Riddet labs, between Riddet and Computing Services bldgs	1.5
40	Sport Complex, Orchard Rd behind Sports centre	2

The paper/cardboard recycling cage bin (sub-code A2) was also located across Turitea campus with there being a total of 19 bins. The volume of the recycling cage bin is 3 m^3 and these bins are managed by RFM and emptied under contract by Fullcircle on demand. Table 3 below describes the total number and location of recycling cage bins across campus.

Table 3, Recycling cage bins

No	**Recycling cage bin**	**Total**
1	Printery	2
2	Green Bike Trust	2
3	RFM	2
4	Creche	1
5	Old Main Building	1
6	Cafeteria	1
7	Computing Services	1
8	Registry	1
9	Sports Institute	1
10	Business Studies	1
11	Riddet 2, off University Avenue ,between Colombo & Riddet Roads	1
12	Science Tower C	1
13	Vet Clinic	1
14	Library	1
15	Science Tower A	1
16	Wharerata	1
Total		**19**

Recycling Wheelie bins (Code B and F1)

The wheelie bins (Code B and F1) are located adjacent to the concourse area, in the student dining hall, and distributed around the student accommodation halls. The size or volume of each recycling wheelie bin is 240 litres and there are a total of 26 clusters. Each cluster is colour coded, for instance red colour is for aluminium and tin cans; and the green colour is for plastics and bottles (see Figure 7). Using wheelie bins for these recycling facilities means that they are easily moved into high use areas, and are also easily emptied. However, an issue for these bins is that the signage needs to be clear in order for them to be used properly and it is already recognised that in some cases this signage is not adequate and in other cases is non-existent. This has been potentially creating confusion for the campus community resulting in incorrect choices being made about recycling and waste disposal. This prior knowledge was factored in during the auditing process.

The process of removing the recyclable materials from the wheelie bins is coordinated by Green Bike Trust (GBT). This is undertaken twice a week on Tuesday and Thursday using the small truck to transport the materials. It is known that in general there are quite significant waste and food contamination issues, therefore the recycling is hand sorted on campus prior to be transported to the ASDC-PNCC. One of the aims of redesigning the current recycling facilties is to improve the quality of campus recycling (reduce contamination) to the point where hand sorting is no longer required.

Small Waste bins (Code C)

There are two types of small waste bins around campus. These are either round or square shaped, which represent a new model versus an old model. In total there are 12 round bins and 8 square bins. There is a significant price difference between the two and a replacement process is being undertaken. These waste bins are placed in a variety of sites around and adjacent to the concourse and the student dining hall in areas with medium to high amounts of foot traffic. These waste bins are supposed to be dedicated for waste materials only but do not have clear signage and tend to be used for waste, recyclables and compostables. The fact that they also tend to not be located near recycling facilities such as the wheelie bin clusters also affects their usage. These bins are managed and emptied by RFM staff and they are emptied daily.

Massey Recycling Bin (Code D)

The Massey recycling bins are located inside inside the dining hall and consists of two groups with four categories in each. These categories are landfill (D1), plastic (D2), glass (D3) and cans (D4). The student dining hall staff was responsible for coordinating and managing these bins and the process of removing the materials from these bins was carried out daily. This bin was removed from service by RFM at the end of 2010. The primary reasons for removing the two Massey recycling bins from the student dining hall was due to the fact that "the recyclables found in these bins was simply thrown away to the large waste bin which is located in between the dining hall and Science Tower A" (A. Shannon, personal communication, April 15, 2011).

This meant that the choosing of categories in which to dispose waste and recycling by people was basically useless as the contents were disposed of as general waste and ended up going to landfill. After these bins were removed they were replaced with two clusters of recycling wheelie bins, which were now co-ordinated by GBT. In addition to these new recycling clusters three organic waste bins were added to the facilities provided in the dining hall. These are shown in Figure 9 below and as can be seen they did not have signs to indicate their function. As a result of the change, these bins were only audited during Trial I and II.

Figure 9, the picture of the organic waste bisn in the Dining Hall area

Organics, Recycling, and Waste bins (Code E)

These bins are located in the staff common rooms and are made up of facilities for compostable/organic waste (E1), mixed recyclables (E2) (plastic, glass and cans) and waste (E3). This style of all in recycling facility can only be found in the staff common rooms across Turitea campus. Figure 7 on page 51 illustrates the arrangement of these bins. This current configuration of bins was adopted in March 2010 with the addition of the compostable waste bins which began as a pilot project managed by a contractor. This then expanded to the current system. There were a total of 30 groupings of Code E bins across the various staff common rooms. The process of emptying the recycling and waste bins was carried out daily by RFM, whereas compostable waste was collected out twice a week (Wednesday and Friday). The detailed information with regard to the locations of compostable, recycling and waste bins is shown below in Table 4.

Table 4, the locations of waste, organic and recycling bins in the staff common rooms, Turitea campus. Note: y = yes

No	Location	Organic	Recycling	Waste
1	International Office	y	y	y
2	Research Management Service	y	y	y
3	University House	y	y	y
4	Japan Lecture Theatre	y	y	y
5	Humanities Building	y	y	y
6	HR Reception	y	y	y
7	Business Studies	y	y	y
8	Refectory building	y	y	y
9	Communication building	y	y	y
10	Registry Building Level 1	y	y	y
11	Registry Building Level 2	y	y	y
12	Social Science Tower Level 1	y	y	y
13	Social Science Tower Level 6	y	y	y
14	Geographic Building Level 3	y	y	y
15	Library Level 2	y	y	y
16	Library Level 3	y	y	y
17	Radio Fm	y	y	y
18	Maori Studies	y	y	y
19	Vet-Equine Blood	y	y	y
20	Vet-Common Room	y	y	y
21	Aghort Common Room	y	y	y
22	Riddet-School of Engineering	y	y	y
23	School of Engineering	y	y	y
24	I.T Common Room	y	y	y
25	RFM	y	y	y
26	Riddet	y	y	y
27	Wool Building	y	y	y
28	Recreation Centre	y	y	y
29	Printery	y	y	y
30	NSAT	y	y	y

Systematic Random Sampling

In order to conduct a waste audit in a large scale organisation it is necessary to use sampling methods to ensure a representative sample is selected and to give the data validity. By using sampling, issues to do with time and physical resources can be minimised as the audit does not need to include all waste and recycling bins across the campus. Systematic random sampling is a statistical method involving the selection of elements from an ordered sampling frame (Bellhouse, 1988; Christman, 2009). The most common form of systematic sampling is an equal probability method. The systematic random sampling applied in this study was used specifically to investigate the large waste and recycling cage bins (Code A), and the recycling wheelie bins and large waste bins located at the student hostels (Code F). The systematic random sampling was applied in this study for these codes because the number of bins was widely spread around the campus and by using this approach each sample had an equal probability of being chosen at any stage during the sample process. The following is the formula used for systematic random sampling and detailed information where the samples were taken in the selected areas.

$$K = N/n$$

Where ***K***, the sample interval; ***N*** the population size; and ***n*** the sample size (Bellhouse, 1988; Christman, 2009).

Code A

There were two sub-codes in Code A, these being A1 the large waste bins and A2 the paper/cardboard recycling cage bins. This means there were two sample sizes, one for each of the sub-codes, which were chosen based on Table 1 page 53. This was applied in both Trial II and III. The process that was undertaken is described below.

Firstly, there was a total of 40 samples in the sub-code A1. Accordingly, by applying the formula of systematic random sampling, the total population of 40 was divided by the sample size of 2 which equalled 20 (40/2= 20). This meant that every 20th sample of sub-code A1 was chosen to get the sample of 2, beginning at a random starting point between 1 and 20. In the case of the first trial, the random starting point was 5, thus the sample of bins selected for sub-code A1 were 5 and 25, which were located in the loading bays of Science Tower D and Social Science Tower. In the second trial, the starting point for selecting the random sample of 2 was 18, as a result the sample bins chosen were 18 and 38, which were situated at Main Building, adjacent to the Old Registry, and Riddet 2, off University Avenue, between Colombo & Riddet Roads.

Secondly for sub-code A2, there were a total of 19 cage bins located across the campus. The method used to select the sample in the code A2 was similar to that used above for sub-code A1, with the two samples being chosen using systematic random sampling. The total population size of 19 was divided by 2 (the sample size) which equalled 9.5 (19/2=9.5). This was rounded down to 9. As a result in the first trial the random starting point selected was 2, resulting in bins 2 and 11 being selected. However it was found that one of the bins selected (as well as the majority of those on campus) was empty so only the bin located at the Green Bike Trust (GBT) could be audited in Trial II. For Trial III it was decided to audit the recycling cages next to the large waste bins already selected, these being at Main Building and Riddet.

Code F

The bin sample of Code F was included in this project as a result of a specific request that was made by RFM to audit the campus hostels. This resulted in Trial IV focusing on a waste and recycling audit of the large waste bins and recycling wheelie bins of the student halls. In order to identify the current level of performance the audit was focused on identifying the contamination levels of non-recyclable waste in the recycling bins, the contamination level of recyclable materials in the wrong recycling bins, and the contamination level of recyclable and compostable materials in the large waste bins. In addition to this the volumes of recyclables was calculated in order to provide information that RFM could use to redevelop the current recycling facilities. This meant that a conversion factor needed to be created to convert the weighed results (kg) into volumes (m3). This is found in Table 6.

Therefore, the method of systematic random sampling was also applied for bin Code F. There were a total of 17 student hostels across the Massey University, Turitea campus. These hostels consist of four main groupings, some of which are then made up of individual halls. These four groupings were Atawhai, Moginie, the Courts, and Turitea (see Figure 10). The names of the individual halls are shown in Table 5, page 62. Another factor to consider for the student halls is the tendency for certain ones to be home to either mostly international or mostly domestic students. Depending on the findings of the data analysis this may result in interesting disucssions around recycling behaviour. The international student halls consisted of Atawhai, Rotary

Court, Kairanga Court, Egmont Court, Tararua, Ruahine and Kiwitea, whereas domestic student halls included Moginie Hall, Bindaloe Hall, Craig Lockhart, Walter Dyer, Colombo Hall, Tawa Hall, Matai Hall, Miro Hall, Totara Hall, McHardy, and City Court.

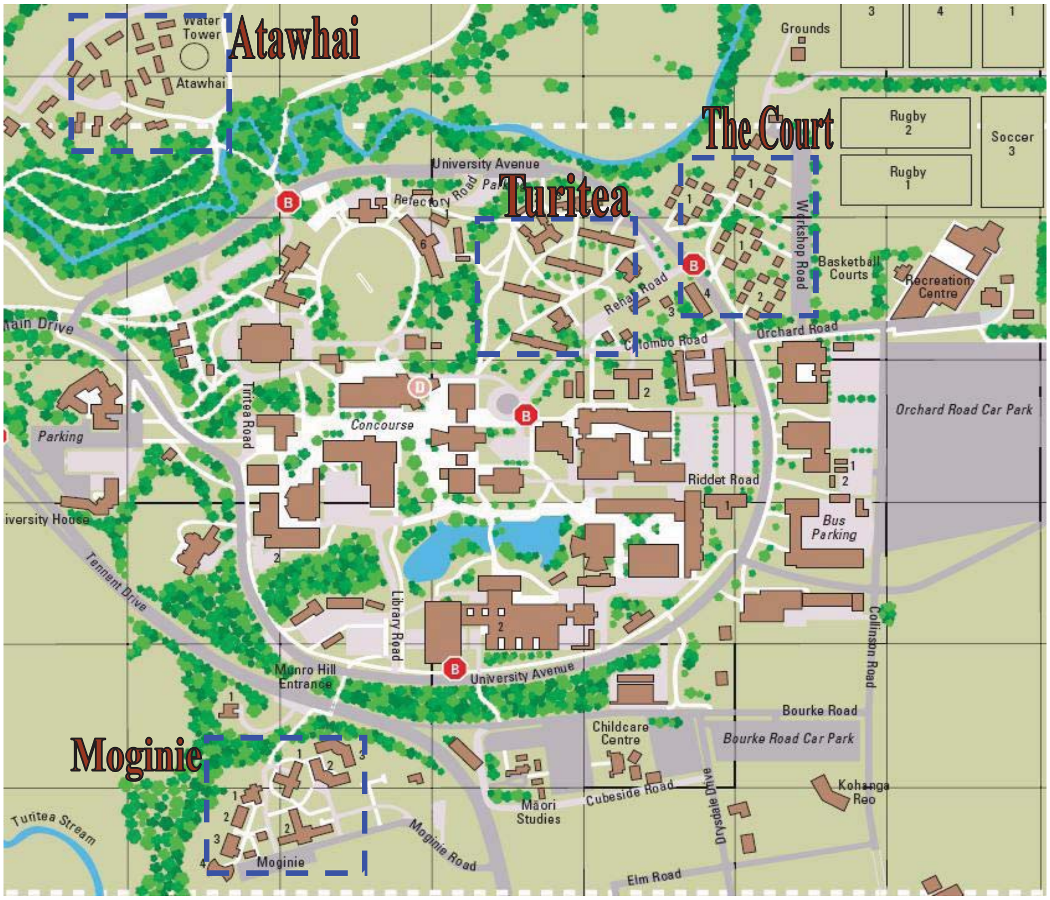

Figure 10, the four groups of student hostels.

The same process for selecting the samples was used with the addition of a cyclical aspect. Samples were selected from within each of the four groupings as follows:

1. Three samples of recycling wheelie bin clusters were chosen for both Moginie and Turitea.
2. Two samples were selected from the Courts.
3. Due to there only being a single cluster at Atawhai village there could only be one sample selected.

As a result there were nine samples chosen from the student hostels to be audited. In Table 5 below these nine hostels are highlighted.

Table 5, Student hostels at Massey University, Turitea campus

No	Location	Hostel	
1	Moginie	1	Moginie
		2	Craig Lockhart
		3	Bindaloe
		4	Walter Dyer
		5	Tararua & Ruahine
2	Turitea	1	McHardy
		2	Colombo
		3	Matai
		4	Totara
		5	Miro
		6	Tawa
		7	Kiwitea
3	The Court	1	City Court
		2	Egmont Court
		3	Kairanga Court
		4	Rotary Court
4	Atawhai	1	Atawhai

Additionally for Code F four large waste bins were selected for auditing based on observations of there being contents available for sorting. As a result the bins at Moginie, Tawa, Colombo and City and Egmont Courts were selected.

Massey's Conversion factor

As briefly mentioned previously the primary idea behind Massey's conversion factor was to fulfil a request by RFM so that the rate of recyclables could be quantified by volume, in order to be able to use this measurement for redevelopment of the current recycling facilities. The conversion factor is a measurement that is used specifically to determine the volume of recyclable materials and compostable/organics, from a weighed sample. This measurement means that a recyclables sample that has been weighed in kilograms can easily be converted to volume in cubic meters. The aim of establishing Massey's conversion factor is to convert the weight of recyclables and compostable organic waste generated during the audits into volumes for use by RFM in future planning. The types of recyclables measured include plastic and bottles; aluminium & tin cans; mixed paper and glass.

In order to determine the conversion factor for Massey two different methods were used in order to compare the accuracy. These two methods are described below.

Method I

- The volume used for the conversion factor is 100 litres ($0.1m^3$). This number was used so that it can be easily converted to both higher and lower volumes, for example 50 litres or 200 litres. The next step was to use the 240 litres ($0.24m^3$) bin as a sample (see Figure below) to define 100 litres. The volume of $0.1m^3$ was measured using a measurement tape. The measurement process took the length, width, and height, which were then used to calculate the 100 litres by multiplying the length, width and height. The following photographs show the measurement process.

Figure 11, method one of the Massey conversion factor

- Based on the calculation process as seen from the figure above, the result of $0.1m^3$ is as follows – length = 50cm; width = 55cm; and height = 36cm. accordingly, the tape line shown in the above figures shows the volume of 100 litres.
- After defining $0.1m^3$ for the sample wheelie bin, the amount of the various types of recyclable materials and compostable organic food were then

measured. The bin was filled up to the tape mark with each material, and then the bin was weighed using scales and recordings made of each result.

Method II

This method was developed in order to improve the accuracy of the previous method. Accordingly, a 150 litres wheelie bin was used as a sample to be filled with 100 litres of water. The measurement process is as follow;

- Using a 5 litre jar to fill up the wheelie bin with the water to define 100 litres. The following is an illustration of defining 100 litres using a 5 litre jar (5 x 20 = 100 litres).

- After defining the 100 litres with water and marking the bin, the recyclables (plastic, paper, glass and aluminium) and compostable organic food were then measured by filling the bin up to the mark with each one, and then weighing the bin each time to determine the weight in kilograms. In order to obtain an accurate result, the measuring process for each type of recyclables was completed twice. The following is an illustration of this process.

Figure 12, method two of the Massey conversion factor

In addition, the process of measuring plastic materials was done at both Massey and the Ferguson St recycling centre. The reason for doing this was to make a comparison between the plastic and bottles, and aluminium and tin cans generated by the household communities in Palmerston North and the campus community at Massey University.

As a result, a table of Massey's conversion factor was created.

Table 6, Massey's conversion factor

Category	**Volume ($0.1m^3$)**
Plastic & Bottles	2.1 kg
Aluminium & Tin Cans	4.10 kg
Mixed Paper	10.9 kg
Glass	25.76 kg
Organic Food	18.40kg

3.4.1.3 Consultation with Key Staff Regarding the Waste and Recycling Audit at Massey

Prior to conducting Massey's waste audit, collaborating and communicating with key people on campus was very important because they were a source of essential information in relation to the current recycling programme at Massey. In addition to this data was provided about the location and number of waste and recycling bins, and information about the current recycling programme (such as frequency of waste collection), as well as providing the location in which the audit was carried out. The key individuals identified in this study included the coordinator of Zero Waste Academy (Mr. J, Hannon), who is also a supervisor for this research, the Campus environmental and emergency operations manager based at RFM (Mr. Ken McEwen and Kerry Lee), RFM - Grounds personnel (Gary Mack, Manager, and Andrew) who provided support in conducting the physical waste audit, the GBT Programme manager (Yvonne Marsh) as well as other GBT personnel (Sandra and Ricky), and Helen Mays an independent contractor working in synergy with the GBT to develop efficient organic waste bins at Massey University.

3.4.1.4 Equipment

Equipment plays an essential role in conducting waste audits (Waste not limit, 2001; Timaru District Council, 2007), and these tools were identified as being necessary prior to the audit being conducted:

a. Electronic platform scale (50 kg capacity)
b. Sorting tables
c. Protective gear e.g. gloves and masks.
d. Bins to sort into
e. Rubbish bag to sort into
f. Pen and clipboard
g. Audit sheets
h. Calculator
i. Camera
j. First aid kit
k. Transportation to pick up the waste

3.4.1.5 Site Requirements for Sorting

The waste audit was conducted outside the premises of the Green Bike Trust (GBT), which is otherwise known as the Massey 'boiler house' The GBT building met the requirements of the audit plan because it was:

- Dry
- Out of the wind
- Away from hazards and traffic areas
- At least 5m x5m with sufficient head room.

It was also important to set up a sorting table at the correct height (waist high) in order to minimise the risk of back injuries during this process. The following Figure (13) shows the waste sorting facilities.

Figure 13, Waste auditing facility

3.4.1.6 The Process of Auditing

The process of auditing the waste out is as following:

a. Empty the bag onto the sorting table based on each bin code
b. Sort into the different category bin code
c. Weigh each bin of different category material separately and record the weight before disposing of the material.
d. Keep doing this until all the waste has been sorted and the data entered on the sheet
e. Clean up all the residue waste and make sure the place is left as clean as you found it before.
f. Take photos and make a note of any relevant observation during the sorting process.

The following images in Figure 14, illustrate how the auditing process was undertaken.

Figure 14, the process of sorting out the waste

3.4.1.7 Data Analysis

Once data had been collected it was to be analysed in order to fulfil the research objectives. This involved the following:

- For the recycling audit the amount of contamination for each recyclable category was first quantified in kilograms. This was then converted into a percentage for both incorrect and correct recyclable disposal.
- A general waste composition (recyclable, compostable and waste) was quantified in some cases, in relation to specific locations and/or bin categories.
- Recycling waste compositions were quantified for specific recycling bin codes.

The results of this data analysis were presented in appropriate tables, graphs and pie charts for each trial and bin code.

In order to audit the large waste bins it was necessary to use a method of sorting that could handle the complex range of waste that would be present. For this reason a SWAP analysis categorisation method was used. This is shown in Figure 1 (page 29-30). It was also necessary to use a well known method which could be understood and potentially used for future waste and recycling audits. Once the SWAP analysis had been used to categorise the waste it was then possible to quantify the relative amounts of recyclables, compostable and waste.

CHAPTER 4
RESULTS

The results section of this study is based around the four trials outlined in section 3.3. The section is highly detailed and contains the research results using two forms of presentation; tables and figures with accompanying text. For each trial the main considerations were to find indicators in the data that show the key areas of the current waste and recycling system that need to be redesigned to enhance the recycling behaviours on campus. The analysis methods that were used for this included the calculating and comparing of contamination levels within both the waste and recycling categories. While any contamination can indicate a recycling system that is not functioning properly, the contamination of waste (that will go to landfill) with recyclable material is particularly concerning because these materials are a potential resource that is being lost by not being placed into the recycling stream. In addition to this any relevant qualitative data that was noted during the audits was included. First the results of each trial are presented followed by an analysis of what these trials mean in relation to each other, and to create a broader picture of the current recycling and waste management system at Massey University's Turitea campus. The following section is the detailed description of the result of Trial I which represents one week data collection (25^{th} – 29^{th} January 2010 during summer school).

Trial I was conducted as a pilot audit and following its completion a number of changes were made in order to improve the range of the findings for Trial II and III.

The key changes were:

- The addition of Code A (large waste bin and recycling cage), and Code E (organic and recyclable staff room bins) to get a broader picture of the current waste and recycling management systems across the Turitea campus.
- Adding a compostable category to the sorting process for Code C (small waste bins).

In addition to this a change was made for Code E between Trial II and Trial III by adding the auditing of the staff common room waste bins (were present) in addition to the mixed recycling and organic bins.

Furthermore, Trial IV was conducted in this study due to the request of information with regard to the performance of the current recycling programme in the Massey Turitea hostels by RFM. The information provided in Trial IV included the volumes of recyclables found in the recycling wheelie bins, as well as the contamination levels found in both recycling clusters and large waste bins.

4.1 Trial I

4.1.1 Auditing the Recycling Wheelie Bins (Code B)

The first task undertaken was the auditing of the recycling wheelie bins that were located in the concourse and the dining hall area. This audit consisted of seven clusters, each consisting of four bins, out of a total 26 clusters across campus. Of the seven clusters audited two were located inside the dining hall while the others were on the concourse. The collection of these bins was coordinated with the regular waste removal which is undertaken by GBT twice a week on a regular cycle. According to the material categories the contents of each bin was combined and weighed. The contents were then sorted to ascertain the amount of each type of recyclable that was correctly placed in each labelled recycling bin, and conversely the amount of waste that was incorrectly disposed of in that recycling bin (NB: A waste bin is included in each cluster of recycling bins. So in this case the opposite measures were sought).

The Massey conversion factor (as shown in Table 6) was used to calculate the volume of recyclables for each sub-code, and in total. The calculation of these volumes is an important part of future redesign and redevelopment of the current facilities. The results of that process are displayed below in Table 7, and Figure 15 shows the comparative percentages of the sub-categories.

Table 7, the Auditing result, Code B Trial I

Code B	Category (Recycling-Wheelie Bin)	Correct (kg)	Incorrect (kg)	Total (kg)	Total Volume (m3)
B1	Plastic Bottles	8.51	2.64	11.15	0.58
B2	Aluminium & Tin Cans	44.93	3.03	47.96	1.19
B3	Mixed Paper	2.61	0.58	3.19	0.03
B4	Mixed Glass Bottles	63.96	0.1	64.06	0.25
Resource Totals		**120.01**	**6.35**	**126.36**	
B5	Waste	19.18	3.59	22.77	
Totals		**139.19**	**9.94**	**149.13**	**2.05**

According to Table 7 above, the total volume of recyclable material generated was 2.05m^3. These totals show that aluminium & tin cans, and mixed glass bottles were significantly higher in total than the other categories by weight. These totals were affected by the fact that there was a conference held which included a social function, and the recyclables produced were of typical categories for this situation. This is also reflected in the following pie chart, Figure 15, that shows the categories according to their percentage of the total.

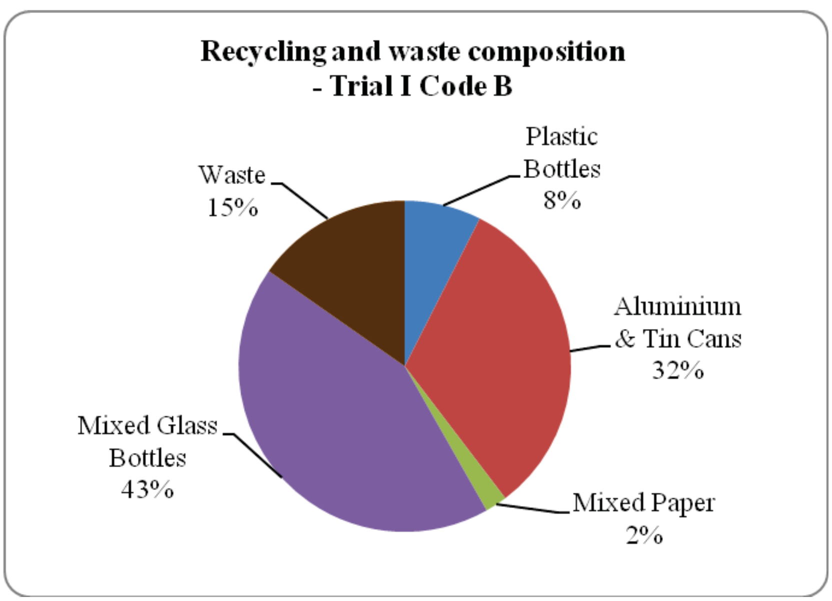

Figure 15, the percentage of recycling and waste generated by Code B in Trial I by weight (kg)

The totals displayed in Table 7 suggest that the vast majority of the recycling or waste was correctly identified and disposed of appropriately in the correctly labelled bin. In order to create an easy comparison the weights for each sub-code above were used to calculate the percentages of correct vs. incorrect for each. The formula used is shown below.

Correct or incorrect weight (kg) ÷ Total weight (kg) = n x 100/1

The following graph, Figure 16, displays the percentage of correctly vs. incorrectly disposed of for each sub-code. This shows that the incorrect choice percentage ranges from 0.1 to 24 %, with contamination being the highest for plastic bottles followed by mixed paper, and waste.

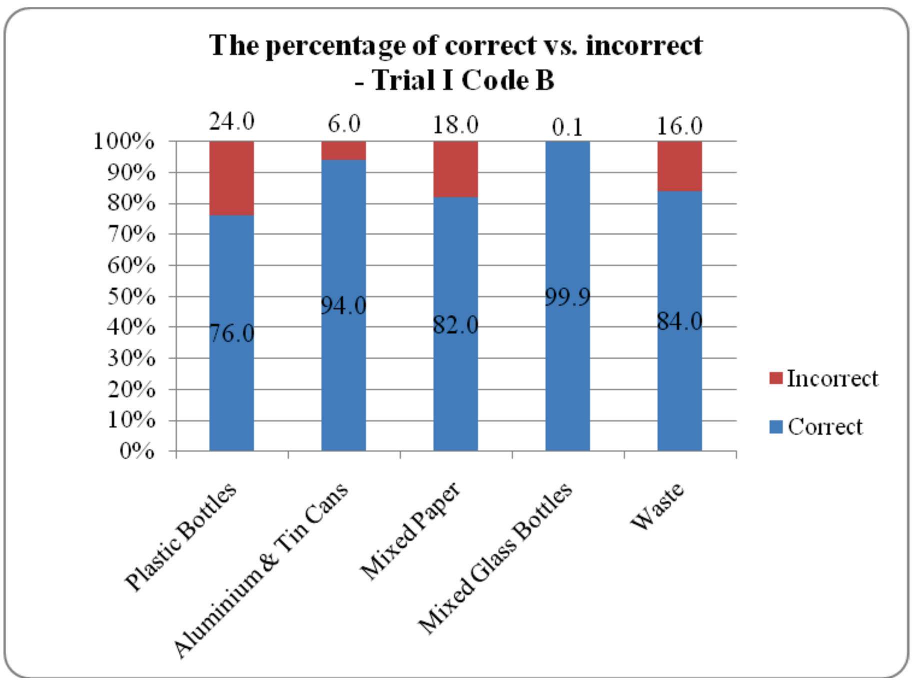

Figure 16, the percentage of correct vs. incorrect for Code B Trial I

It is important to consider the different types of contamination when looking at this graph. The percentage of incorrectly disposed of waste consists of anything that is in the wrong bin. For the recyclable categories this may be in the form of a different type of recyclable material, or it may be waste or compostable waste. For categories which contain commonly used food packaging items it is often the case that contamination is in the form of potentially compostable waste, for which there was not a dedicated bin in these clusters. However for the waste category the contamination consisted of recyclable materials and potentially compostable waste. This contamination is in fact made up of potential resources that would end up in landfill due to not being placed in the correct bin. In this instant that was 16 % of the contents of this category, which was above the average contamination level of 7 % which is described as follows.

Subsequently the overall average percentage of correctly vs. incorrectly disposed of waste and recycling was calculated and this is shown in the following pie chart, Figure 17. This shows that on average 93 % of the choices made about which bins to use were correct, with 7 % being incorrect. This is a direct reflection of the recycling behaviours of the people that use these waste and recycling bins.

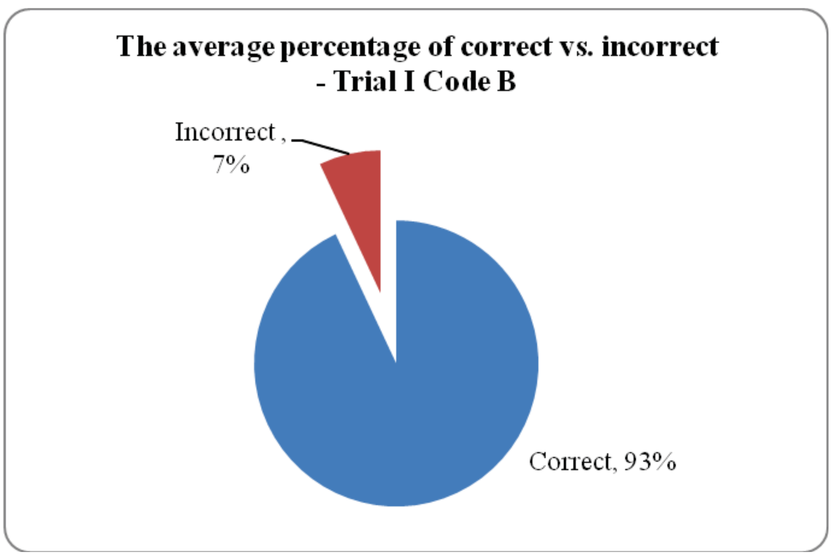

Figure 17, the average percentage of correct vs. incorrect for Code B Trial I

During the audit additional information was noted that may relate to the recycling behaviours shown by the quantified results. It was observed that the signage for the recycling wheelie bins was in most cases unclear, both in terms of instructing people what to dispose of and visually with regard to fading and damage. Factors such as this need to be taken into consideration when redesigning and improving the current waste and recycling system, as they may be contributing to the effectiveness of the wheelie bin clusters.

4.1.2 Auditing the Small Waste Bins (Code C)

The collection and auditing process of the small waste bins (Code C) is similar to above Code B in terms of sorting and quantifying the waste and recycling, and consisted of 12 bins from the concourse area, out of the total of 20. The audit was conducted from the 25th – 29th January, 2010, and was coordinated with the regular daily emptying which is undertaken by RFM. After collecting the waste, the audit process was then undertaken to separate the waste from any recycling that had been wrongly placed in the small waste bins. In this trial organic food waste was sorted as waste rather than as a potentially recyclable material. This categorisation was changed for Trial II and III in order to improve the audit design. These bins are supposed to be dedicated to waste but lack signage and as a result recyclables are often placed in them mistakenly. The weight of contamination was then measured and the quantified result is shown in the table below.

Table 8, the Auditing result, Code C Trial I

Code	Category	Waste-Landfill	Recyclable	Total (kg)
		(kg)	(kg)	
C	Waste	9.75	2.14	11.89

The Table 8 above indicates the total amount of waste for the small waste bins in the concourse area which is 11.89kg. Further analysis of the makeup of this 'waste' found that 18% actually consisted of recyclable materials, as is shown in the pie chart below, Figure 18. This can be considered as incorrect disposal and this means that nearly 1/5th of the contents of these bins could be recycled if it was disposed of correctly. It is unknown what ratio of this could have been composted for this trial. It is important to remember that these bins are a standalone waste bin and that there is no other option to hand for people to choose.

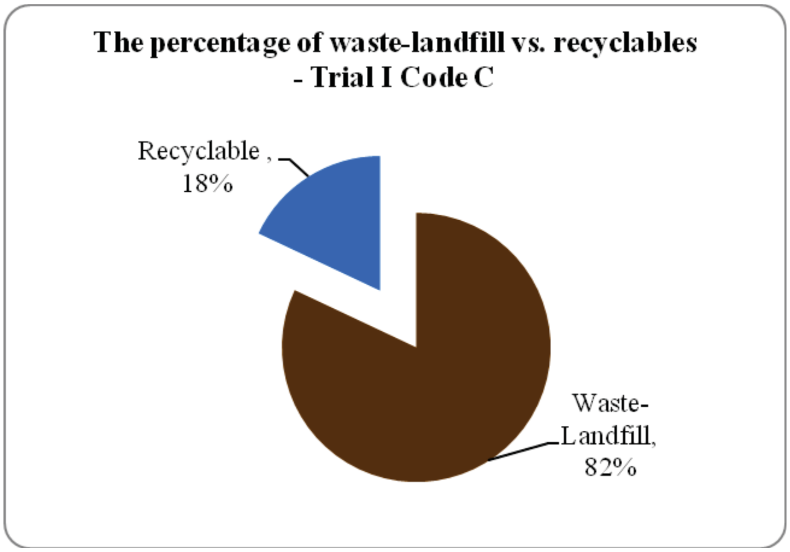

Figure 18, the percentage of waste-landfill to recyclables for Code C Trial I

4.1.3 Auditing the Massey Dining Hall Recycling Bins (Code D)

The process of collecting these recyclables was conducted over three days (26th – 28th January 2010). These bins were located in the dining hall area and consisted of two clusters with four categories in each with names being based on the existing signage. In this case landfill corresponds to the waste category in previous audits. The auditing process followed the same procedures as out lined in the previous section for bin Code B i.e. weight, sorting within each category and weighing, followed by determining the percentage of correct and incorrect recycling. The volume for each recyclable type was also calculated using the Massey conversion factor. The following are the detailed results.

Table 9, the Auditing result, Code D Trial I

Code D	Category	Correct (Kg)	Incorrect (Kg)	Total (kg)	Total Volume (m3)
D1	Landfill	5.89	0.25	6.14	
D2	Plastic	0.63	0.27	0.9	0.040
D3	Glass	0.38	0.02	0.4	0.001
D4	Cans	4.05	0	4.05	0.090
Total		**10.95**	**0.54**	**11.49**	**0.131**

As is shown in Table 9 the landfill category contained the largest amount of waste overall, followed by cans, then plastic and glass. The percentages of these categories are shown below in Figure 19.

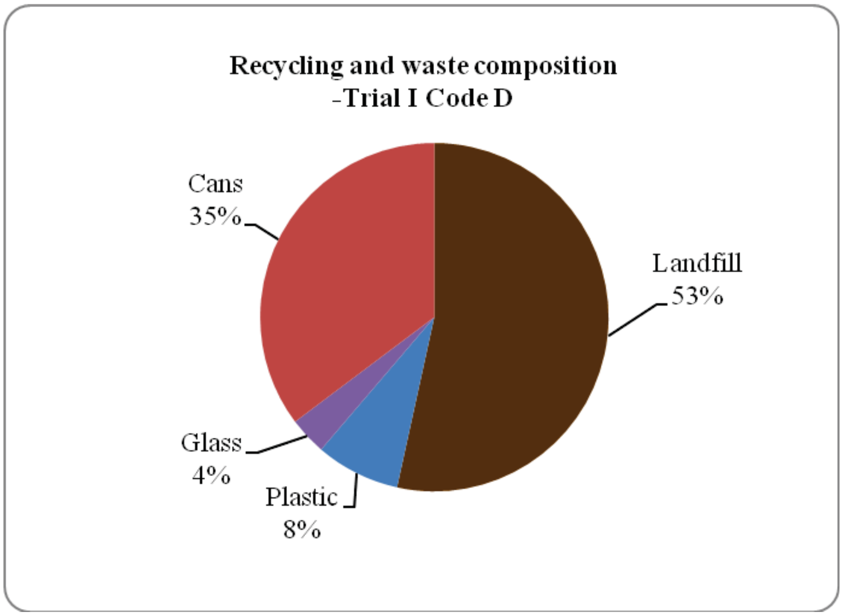

Figure 19, the percentage of recycling and waste for Code D in Trial I

As was done for the code B audit the percentage of correct vs. incorrectly disposed of was calculated using the following formula.

Correct or incorrect weight (kg) ÷ Total weight (kg) = n x 100/1

These results are shown in Figure 20 below.

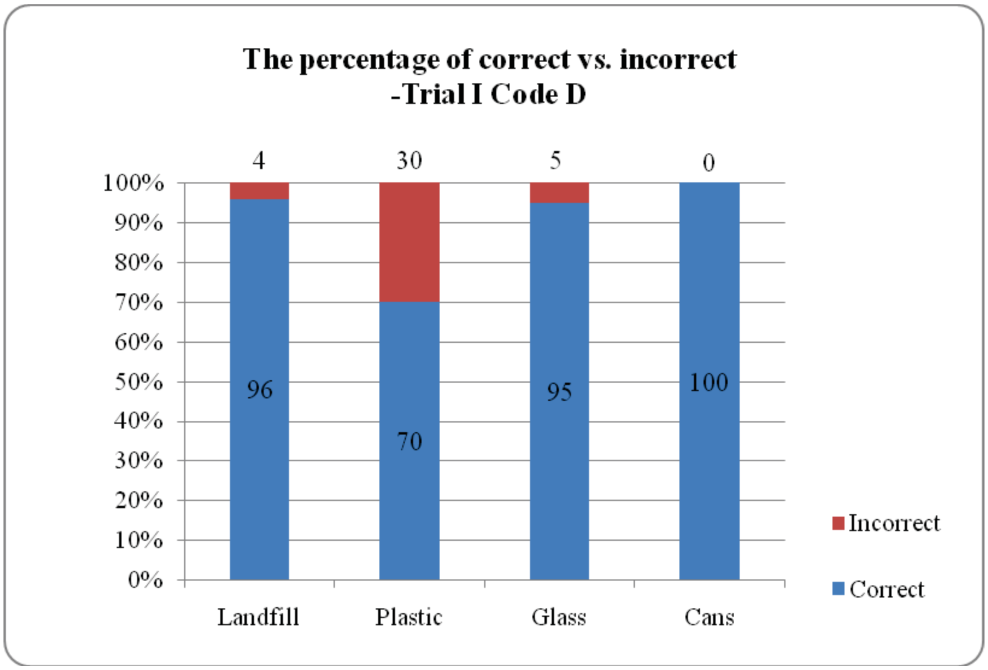

Figure 20, the percentage of correct vs. incorrect for Code D Trial I

While the range of contamination was from 0 to 30 % the most significant result of recyclable contamination found was for the plastic sub-code (D2). This had a much higher level than any of the others at 30% with only 70% of plastic being disposed of correctly. The same different types of contamination as described on page 54 should be considered for this graph as well although in this case the results show that contamination is less of a concern for the waste category. This means that there was less potential loss of resources through the incorrect disposal of recyclables in the non-recycling stream. It is possible to gain insight into the benefits or limitations of this style of waste and recycling disposal facilities. For the least successful category, plastic, the main contaminants were compostable or food waste which relates to the dining hall location. The choices made with regard to what category to use are also potentially affected by the fact that there was not a bin provided for compostable waste, and that the waste category was labelled as 'landfill' which was potentially confusing for people.

Following this it was possible to calculate the average contamination level which is shown below in Figure 21. This found that 90.3 % of the choices made in disposing of the waste and recyclables were correct, while 9.7 % were incorrect.

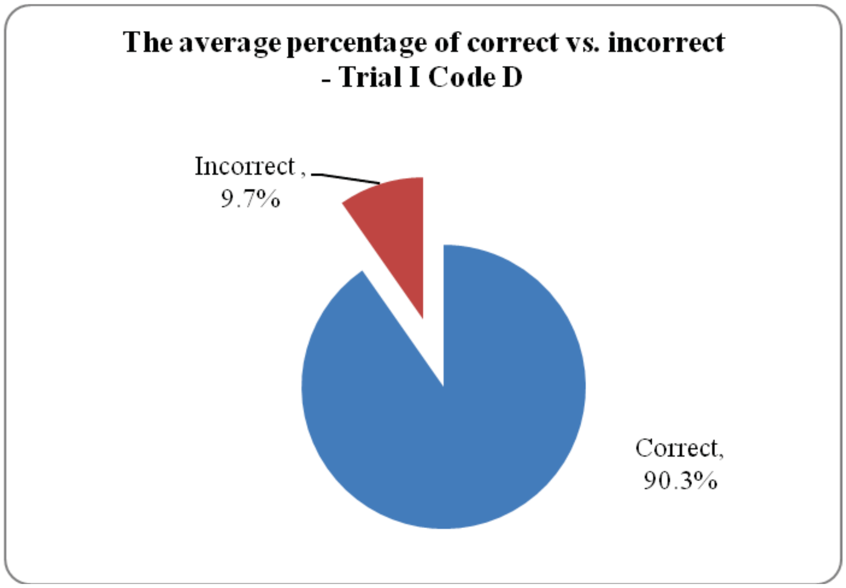

Figure 21, the average percentage of correct vs. incorrect for Code D Trial I

4.2 Trial II

This trial was conducted from 13th – 17th September 2010. It included the previous codes B, C and D from Trial I and also added in code A (the large waste bins and recycling cage bins) and code E (the organic waste and inorganic waste bins from the staff common rooms). As previously described the benefit of adding these two codes is that a more detailed picture could be gained of waste and recycling management, and recycling behaviours across the campus.

4.2.1 Auditing the Large Waste Bins and Recycling Cage Bins (Code A)

Auditing the large waste bin (A1) was undertaken in two different locations, namely Science Tower D, and Social Science Tower, while the recycling cage bin (A2) audited was located at the Green Bike Trust (GBT). There were a total of 40 large waste bins across campus and 19 recycling cage bins for paper and cardboard, and those that were audited were selected using systematic random sampling. Initially another recycling cage bin was selected using this method but was found to be empty at the time of the audit. While the large waste bins go to landfill the recycling cage bins are a part of the campus recycling system and the emptying of these is managed by RFM using a range of contractors.

In order to conduct a detailed audit of the general waste bins the New Zealand ‘solid waste analysis protocol’ (SWAP) landfill waste auditing methodology was selected for use – because this material is taken directly from Massey to landfill. The SWAP methodology utilises 12 waste classifications, and therefore provides considerable detail as to what potentially recyclable materials may be currently going to landfill, and hence may in future be targeted by upgrades in the Massey zero waste programme. The 12 SWAP classifications are: waste, glass, cans, mixed paper, mixed plastic, organic waste, metal, textiles, rubber~~s~~, trees, timber, and potentially hazardous waste. The results of the detailed sorting and weighing of the classifications of the resources currently in the waste Massey generates in each of the selected bin locations are shown in Table 10 and Figure 22, 23, and 24 below. Similarly, detailed information regarding the total amount of waste generated based on three classifications namely recyclables, compostable, and waste was produced during the audit and can be found below in Table 11, and Figure 25.

Table 10, the Auditing result, Code A Trial II

Bin/Cage Code A	Category	Location	Waste/Resource Classification												Total kg
			Waste	Glass	Cans	Mixed Paper	Mixed Plastic	Organic Waste	Metal	Textiles	Rubber	Trees	Timber	Potentially Hazardous	
A1	**Waste**	**Science Tower D**	32.62	0.63	0.1	7.85	1.5	1.5			0.25	3.36	0.32	24.6	**72.73**
		Social Science	60.34	6.32	1.95	15.32	4.32	4.56	0.96			0.84	0.62	9.23	**104.46**
Total			**92.96**	**6.95**	**2.05**	**23.17**	**5.82**	**6.06**	**0.96**		**0.25**	**4.2**	**0.94**	**33.83**	**177.19**
A2	**Recycling-Cardboard**	**GBT**		3		224									**227**

The above Table 10 illustrates the total amount of waste generated in both categories of Code A1, the large waste bin and Code A2 the recycling cage bin. The total amount of waste produced in both categories is the accumulation of the total amount of waste produced in the 12 different types of waste classification.

For sub-code A2 the highest category produced was mixed paper at 224 kg. This indicates that the total amount of mixed paper generated is almost 100% of the total amount of waste in the recycling cage bin. It is important to acknowledge that the contents of A2 are a part of the recycling stream and so the key consideration is the amount of contamination that occurs whether by waste or other recyclables. The small amount of non mixed paper material found in the bin is most likely an irregularity, and future trials will show if this is an occurrence to be concerned about.

The total amount of waste produced for Code A1 was 177.19 kg, which is accumulated from the two locations. Science Tower D and Social Science Building are two of the main buildings on campus and incorporate lecture theatres, class rooms, computer labs, science labs, and staff and student offices. This means that they produce a diverse range of waste and recyclables which is demonstrated in Table 10. The following graph, Figure 22, shows the percentages of each category produced relative to the two locations.

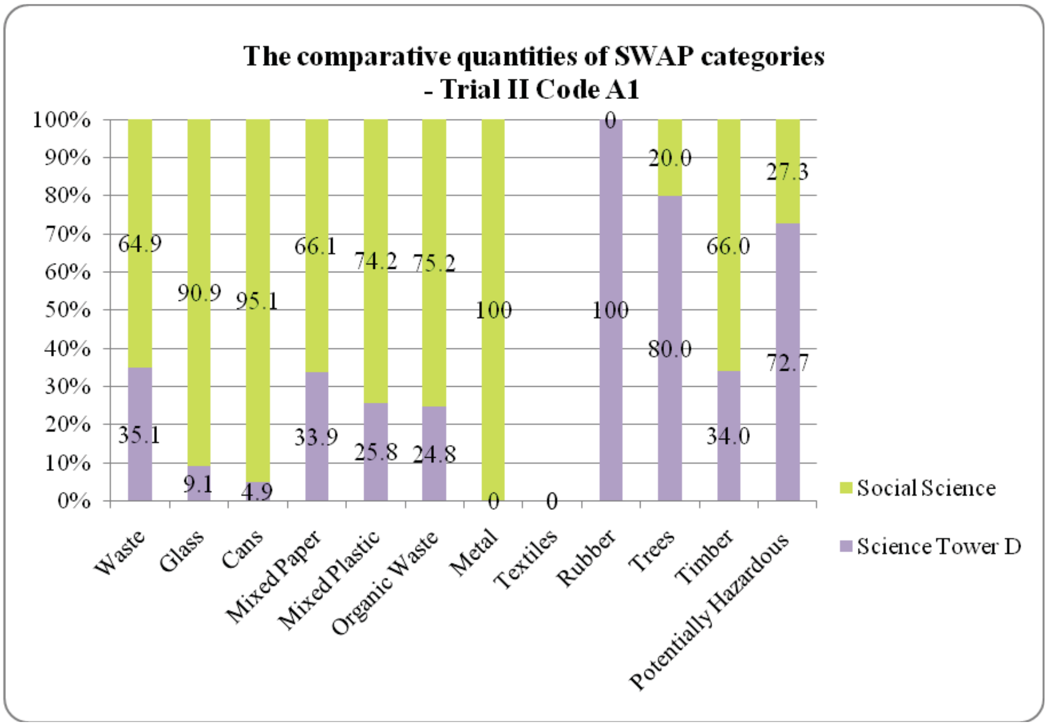

Figure 22, the percentage of SWAP categories for Code A1 Trial II

The highest amount of materials generated in these locations was the waste category with 65% coming from the Social Science Building. The second highest category was potentially hazardous waste with 73% coming from Science Tower D, which directly reflects the link between the category of waste produced and the types of activities carried out in the building. In this case the potentially hazardous waste is for the most part made up of chemicals and aerosols and is a result of the high number of science labs at the location. Following this was the mixed paper category with 66% coming from the Social Science building which is directly related to the academic and office based context of the bins.

The following charts, Figure 23 and 24, display the makeup of waste produced by each building audited in percentages. These were calculated using the formula shown on page 61.

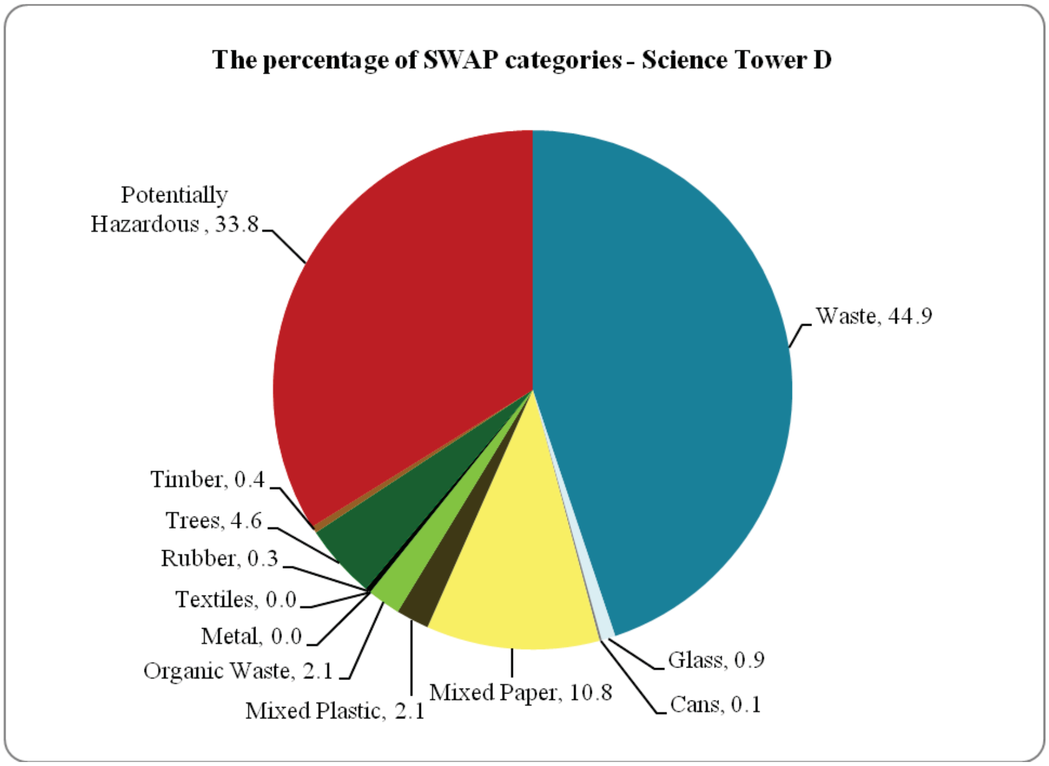

Figure 23, the percentage composition of SWAP categories for Code A1 – Science Tower D Trial II

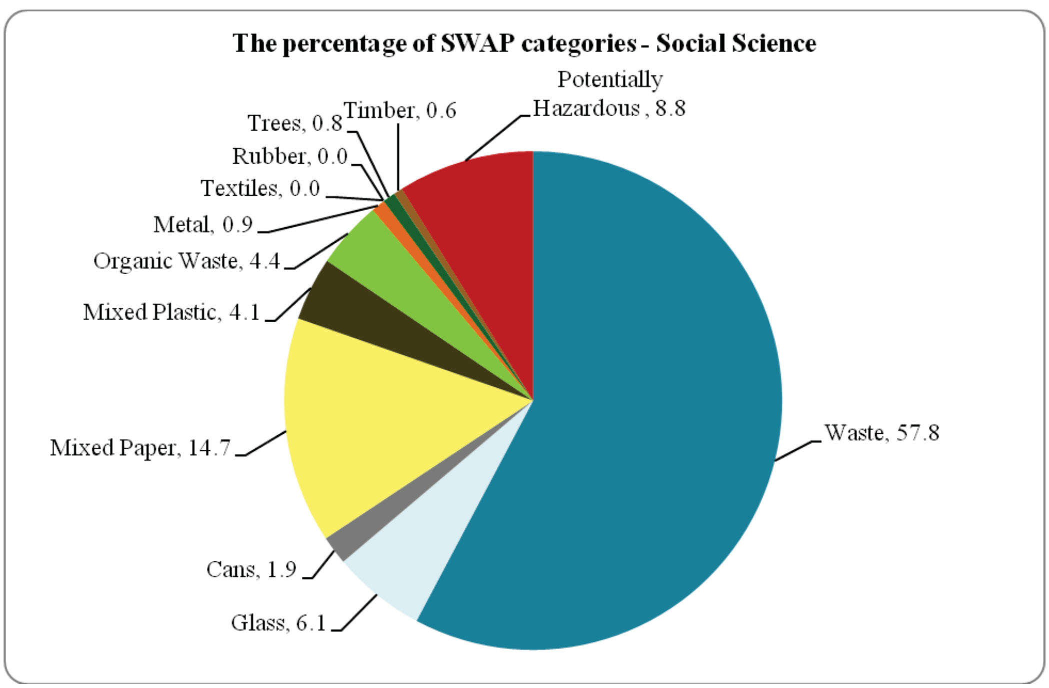

Figure 24, the percentage composition of SWAP categories for Code A1 – Social Science Trial II

For both locations waste was the highest category, and for the Social Science Building the difference between the waste category at 58% was significantly higher than the next highest category of mixed paper at 15%. For Science Tower D the second highest category was potentially hazardous materials at 34%, although unless an appropriate recycling scheme is in place for these, they would actually be considered as waste. This would mean that the waste category would in fact be 79% of the total materials disposed of. Following this in terms of percentage was mixed paper at 11% which aligns with the pattern found for Social Science Building.

The following diagrams (Table 11, Figure 25) illustrate the total amount of waste generated at each location according to three different compositions namely recyclables, compostable and waste. In order to re-categorise the 12 types of waste into these three key waste streams the following groupings were made based on local recycling guidelines provided by PNCC (n.db). Recyclables consisted of glass, cans, mixed paper, mixed plastic, timber, textiles and metal. Compostable consisted of organic waste and trees, and waste consisted of waste, rubber and potentially hazardous materials. This provides a consistent method that will be followed in future trials for large waste bins.

Table 11, the Auditing result of the large waste bins based on three key waste streams, Sub-code A1 Trial II

Sub-code A1 - Categorisation into 3 key waste streams				
Location	**Recyclables (kg)**	**Compostable (kg)**	**Waste (kg)**	**Totals**
Science Tower D	10.4	4.86	57.47	**72.73**
Social Science	29.49	5.4	69.57	**104.46**
Totals	**39.89**	**10.26**	**127.04**	**177.19**

Based on the results shown above a number of key findings were noted. Firstly that the composition of waste, recyclables and compostable varies between the two locations. This is shown more clearly in Figure 25 which shows the percentage of each category for each location. One of the main factors in these categories was the previously mentioned need to add the potentially hazardous materials into the waste category as no recycling scheme was in place for these. For Science Tower D this increased the waste category significantly which signals the importance of implementing an appropriate program to address this.

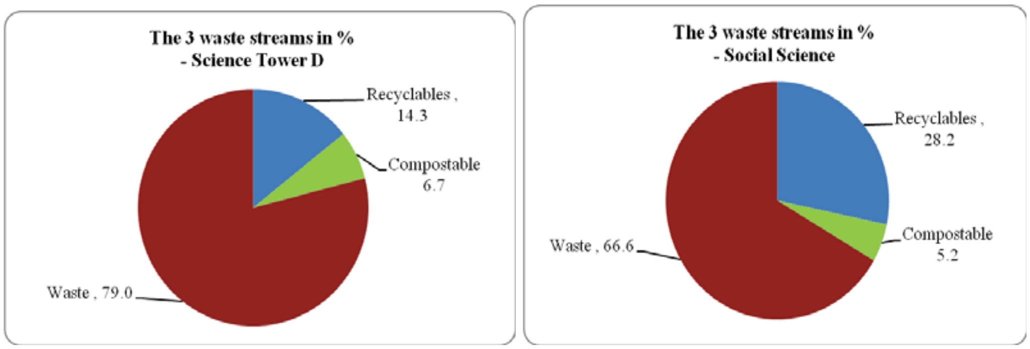

Figure 25, the composition of waste, recyclables, and compostable by percentage for Science Tower D and the Social Science Building, Sub-code A1 Trial II

4.2.2 Auditing the Recycling Wheelie Bins (Code B)

The second recycling wheelie bin audit (Code B) was conducted on two days (Tuesday 14th and Thursday 16th September 2010) during the Trial II survey period. Once again the collection involved 7 clusters, out of the total 26 clusters across campus and the location was based in the concourse and dining hall area. The same audit process was conducted as in Trial I (section 4.1.1) and the data collected from this process consists of weight by each category and the amount of waste and recycling categories that were correctly or incorrectly disposed of for both the recycling clusters and the associated waste bins. The total weights were converted into volume using the Massey conversion factor as before. This information is shown in Table 12 below.

Table 12, the Auditng result, Code B Trial I

Code B	Category (Recycling-Wheelie Bin)	Correct (kg)	Incorrect (kg)	Total (kg)	Total Volume (m3)
B1	Plastic Bottles	20.75	1.14	21.89	1.04
B2	Aluminium & Tin Cans	11.55	0.43	11.98	0.29
B3	Mixed Paper	65.55	15.13	80.68	1.19
B4	Mixed Glass Bottles	66.85	0.33	67.18	0.29
Resource Totals		**164.7**	**17.03**	**181.73**	
B5	Waste	17.32	20.7	38.02	
Totals		**182.02**	**37.73**	**219.75**	**1.77**

The total amount of waste generated was 219.75kg with 182.02kg being disposed of correctly and 37.73kg disposed of incorrectly. This suggests that the vast majority of the waste and recyclables are correctly identified and disposed of appropriately. A more detailed picture is provided by the breakdown into sub-codes and the percentage of correct vs. incorrect for each is shown in Figure 27 below. The overall composition of the waste and recycling is shown in Figure 26 as percentages of the total. This shows that mixed paper and mixed glass bottles were the most significant categories in terms of amount followed by general waste. This analysis helps to create a picture of a more typical waste and recycling composition for this location as it was conducted during semester two of the university year when students and staff on campus were present in normal patterns. The percentages found in this trial also support the fact that higher percentages of mixed glass bottles and aluminium and tin cans were found due to a non regular event (conference and social function).

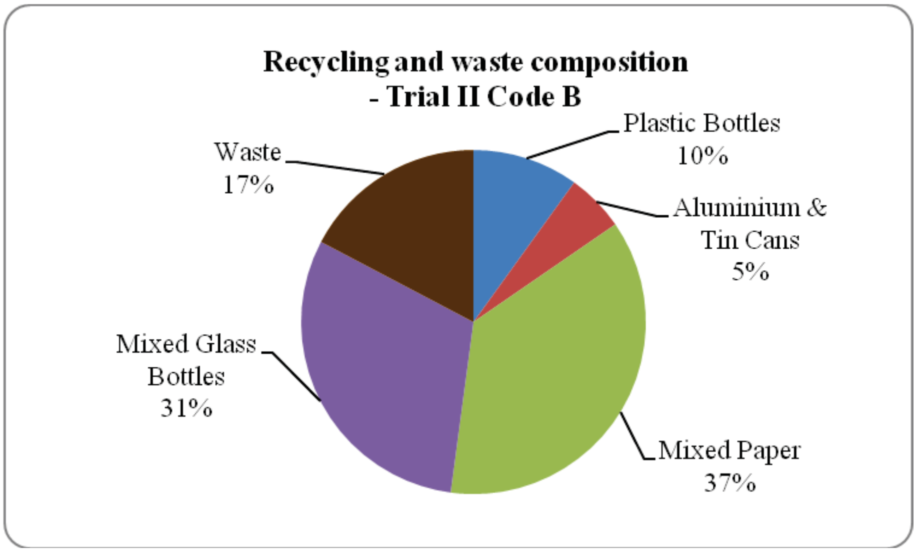

Figure 26, the percentage of recycling and waste generated by Code B in Trial II by weight (kg)

In order to get a clear picture of the contamination within each category a bar graph was once again created to show the correct vs. incorrect percentage for each sub-code, Figure 27.

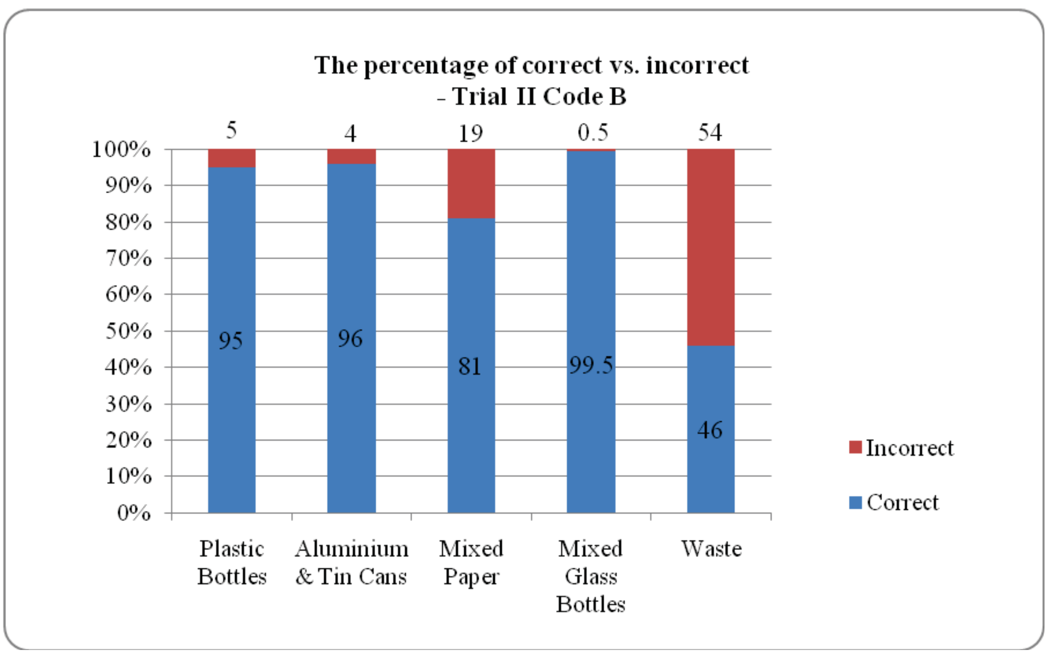

Figure 27, the percentage of correct vs. incorrect for Code B Trial II

The range of incorrectly disposed of was from 0.49 to 54 %, with the two most significant results being for the mixed paper and waste categories at 19 % and 54 %

respectively. For the most part the contamination in the mixed paper category was of organic food waste, which relates to the proximity to the dining hall location and the fact that a dedicated compostable/organic waste disposal bin is not provided. The other significant result, which was the fact that 54 % of the waste category could have been disposed of in the recyclable categories, shows a sizeable loss of potential resources to landfill. This contamination was made up of organic food waste, and recyclable food containers such as plastic. This amount was also a lot higher than in Trial I which may be the result of an increase in people (students and staff) on campus because of the time of the year (during semester 2).

Following this the average percentage of contamination was calculated as it was in Trial I, with this result shown in Figure 28 below.

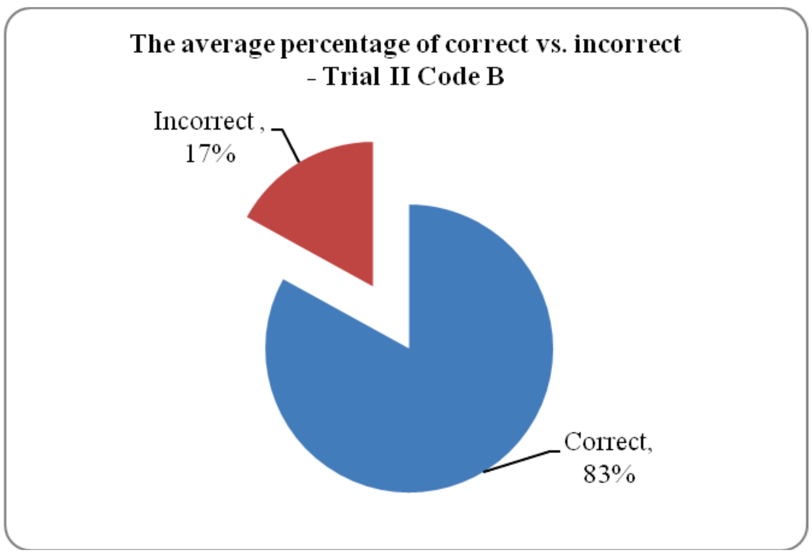

Figure 28, the average percentage of correct vs. incorrect for Code B Trial II

This shows that overall the incorrect recycling behaviour taking place was slightly higher than in Trial I with an increase from 13 to 17 %. This may or may not be a result of the fact that there were a lot more people using the facilities during the survey period of this second trial. It should be noted that the facilities provided during this trial had not been changed or improved in any way since the first trial so the issues of poor and unclear signage still existed.

4.2.3 Auditing the Small Waste Bins (Code C)

The Code C audit of the small waste bins located in the concourse area was the similar to that previously conducted in Trial I (section 4.1.2), with the exception that the sorting of the materials used three categories, namely waste, compostable and recyclables rather than just two as was previously done. The waste was collected three times during the week (13th, 15th, and 17th September 2010). After collecting the waste the audit process was conducted to separate the waste and recyclable materials into each category for weighing and quantifying the contamination levels using the correct vs. incorrect method previously established. The result of this audit is displayed in Table 13 below.

Table 13, the Auditing result, Code C Trial II

Code C	Categories			Total (kg)
	Waste-Landfill	Recyclables	Compostable	
	(kg)	(kg)	(kg)	
	17.85	27.27	16.42	**61.54**
Percentage of total	**29.0**	**44.3**	**26.7**	

The above Table 13 displays the total amount of waste generated in the small waste bins in the concourse area, which as previously noted are a standalone bin which is supposed to be used for general waste but this is not indicated with signage. The total amount of waste produced was 61.54kg which consisted of 17.85kg of waste-landfill and 43.69kg made up of recyclable and compostable materials.

By converting the weights for each category into percentages of the total a clearer picture can be seen of the waste and recycling composition for these bins, which is shown below, Figure 29. The highest percentage of waste produced is recyclables, 44 % followed by waste-landfill 29 % and compostable 27 %.

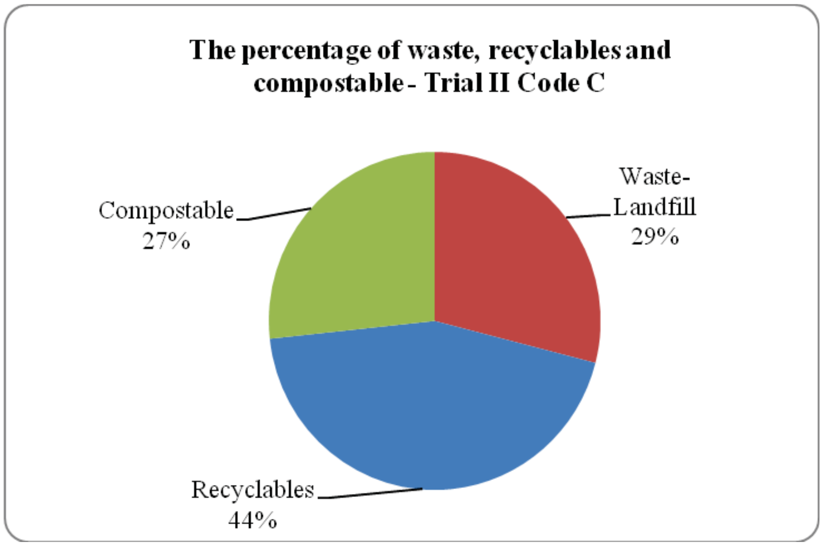

Figure 29, the percentage of waste-landfill, recyclables, and compostable for Code C Trial II

Another way to consider these figures is shown in Figure 30 which re-categorises the results into recyclable resources vs. non-recyclable materials. By using the two categories of waste-landfill and recyclable it is clear that there was a 71 % loss of potential resources (recyclable and compostable) to landfill due to them not being in the recycling stream.

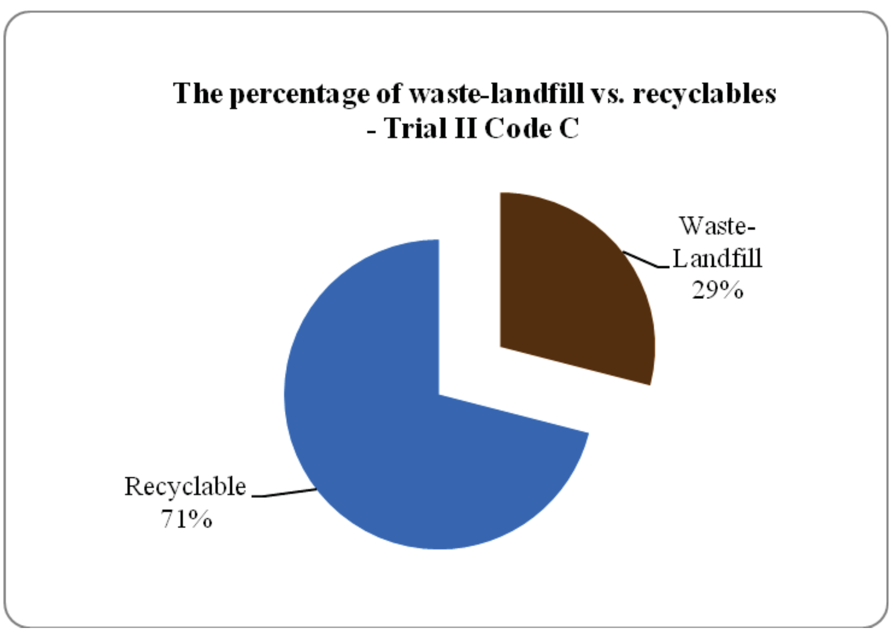

Figure 30, the percentage of waste-landfill to recyclables for Code C Trial II

4.2.4 Auditing the Massey Dining Hall Recycling Bins (Code D)

The process of collecting Massey Recycling Bin (Code D) was carried out on three days (13^{th}, 15^{th}, and 17^{th} September 2010). As stated in Trial I these bins were located in the dining hall area and consisted of two clusters, consisting of the four categories of recyclables. The auditing process followed the same procedure used in Trial I which involved collecting, sorting and weighing the material in each category/bin. The detailed information from this audit is shown in Table 14 below.

Table 14, the Auditing result, Code D Trial II

Code D	**Category**	**Correct**	**Incorrect**	**Total Weight (kg)**	**Total Volume (m3)**
		(kg)	**(kg)**		
D1	Landfill	8.16	6.76	14.92	0.20
D2	Plastic	1.42	2.01	3.43	0.16
D3	Glass	10.78	0	10.78	0.05
D4	Cans	0.66	0	0.66	0.02
Total		**21.02**	**8.77**	**29.79**	**0.42**

The total amount of waste produced was 29.79 kg, which was nearly three times the amount produced during Trial I which was conducted during summer semester when fewer students were on campus. As was done previously the percentages of each category of the total was calculated and is shown in Figure 31 below. While the percentage of waste is similar to that in Trial I at 53 %, there is a much lower proportion of glass, which may support the previous findings that the glass total had been affected by an irregular event taking place for Code B, the Recycling Wheelie Bins which are located in the same area. The other increases in cans and plastic can be said to reflect the typical quantities that would be found during semester two of the university year.

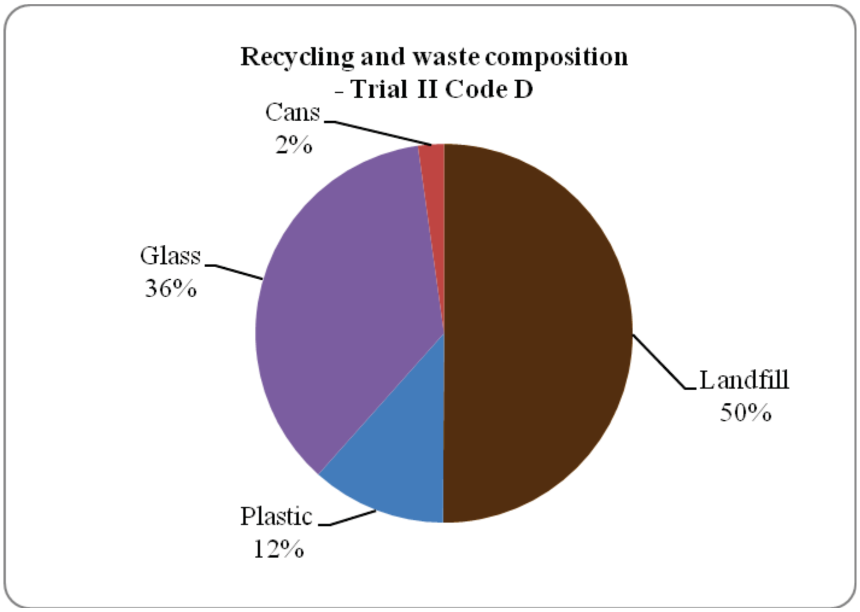

Figure 31, the percentage of recycling and waste for Code D Trial II

Following this the percentages of correct vs. incorrect disposal were calculated for each category following the same method as in Trial I. These results are shown in Figure 32 below.

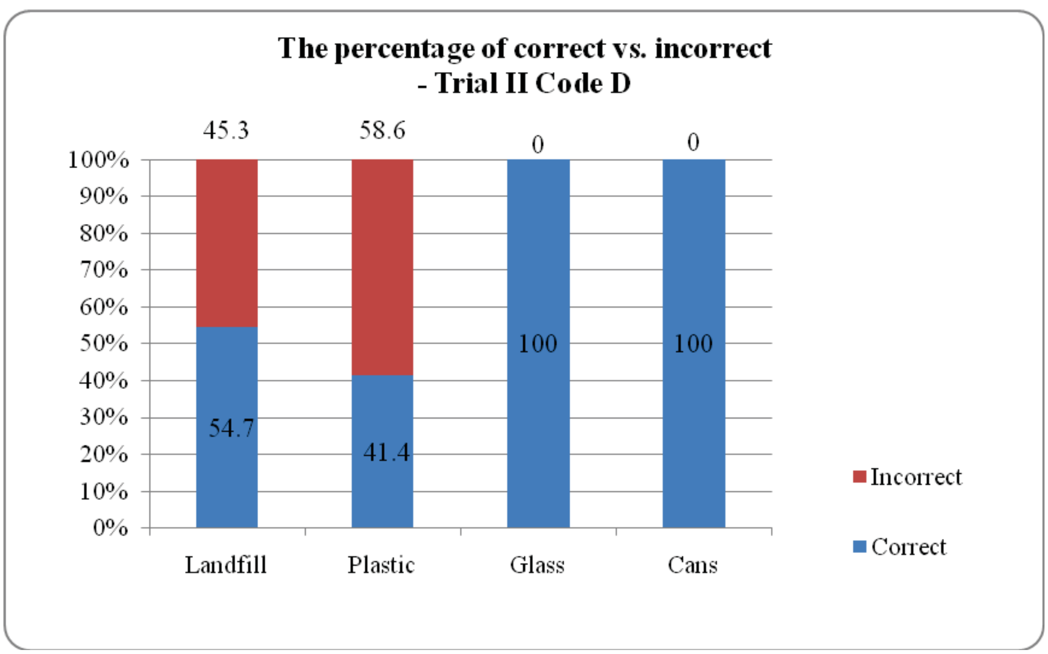

Figure 32, the percentage of correct vs. incorrect for Code D Trial II

The range of incorrect disposal was from 0 to 59 %. While glass and cans had zero contamination both plastic and landfill had high levels at 59 % and 45 % respectively. This indicates that when people were making a choice about using the glass and cans categories they were making the correct one; however this did not happen for plastic and landfill. For plastic the main contaminants were paper and organic/compostable waste. For landfill the main contaminants were plastic and organic/compostable waste. This indicates confusion around the disposal of plastic and paper and supports the fact that there was not an option for the easy disposal of organic food waste close by. The result for the glass and cans are similar to Trial I as contamination was 0 to 5 % in that case, whereas the contamination for plastic has nearly doubled, and the contamination for landfill has increased more than tenfold. This later result in particular indicates a significant issue with the understanding and use of the landfill category and 45 % of the materials in these bins were in fact potential resources for either recycling or composting.

These concerns are also reflected in the average contamination percentage calculations which are shown in Figure 33 below. The incorrect disposal of waste and recyclables had increased from just under 10 % to 26 %. A contributing factor for this is likely to be the increase of students using the dining hall because Trial II was conducted during semester two of the university year.

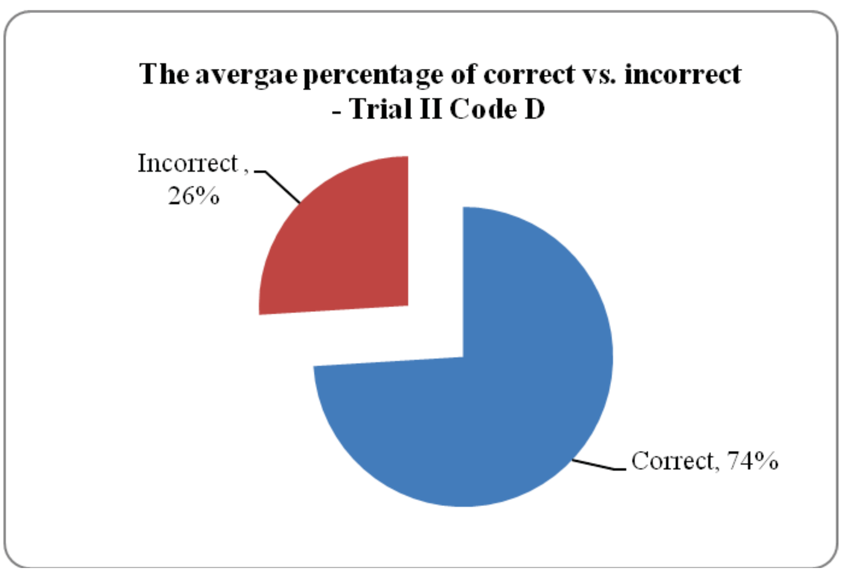

Figure 33, the average percentage of correct vs. incorrect for Code D Trial II

4.2.5 Auditing the Staff Common Room Organic and Recycling Bins (Code E)

Auditing the Organic and Recycling Bins (Code E) was undertaken twice during the survey week (Wednesday 15th and Friday 17th of September 2010), and was coordinated with the regular twice weekly collection of organic recycling by an independent contractor and on demand collection of recyclables by RFM. This consisted of the contents of 30 bins that are located in the Massey staff common rooms. Code E contains two sub-codes which represent compostable waste (E1) and recyclables (E2). The audit process that took place found that contamination levels were very low for both of these categories. Consequently, the audit focused on identifying both the combined weight and the weight for each category. Table 15 below shows the weight found for each category.

Table 15, the Auditing result, Code E Trial II

Code E	Category	Weight (kg)
E1	Compostable	78.5
E2	Recyclables	41.84
Total		**120.34**

Based on these quantities it was possible to calculate the percentage for each of the combined total and these are shown in Figure 34 below. This showed that compostable waste is a component of the materials disposed of in the staff common room bins and that the existing system which includes the facilities for their separate disposal is being effectively used. This was also supported by the low levels of contamination found. The recyclable disposal facilities provided were an 'all in' general recycling bin which allows for cans, glass and mixed plastic within the one bin. The fact that low levels of contamination were found in this indicates that the understanding of what can be disposed of is high. The 'all in' system decreases the potential choices that a person can make and in a sense simplifies the recycling facilities. The success of this supports this idea.

It was decided that in order to gain a more complete picture of the waste and recycling in the staff common rooms it was decided to add the category of general waste to Code E for Trial III. This means that it would be possible to get an idea of whether and what quantity of compostable and recyclables may be being wrongly put in to the general waste bins.

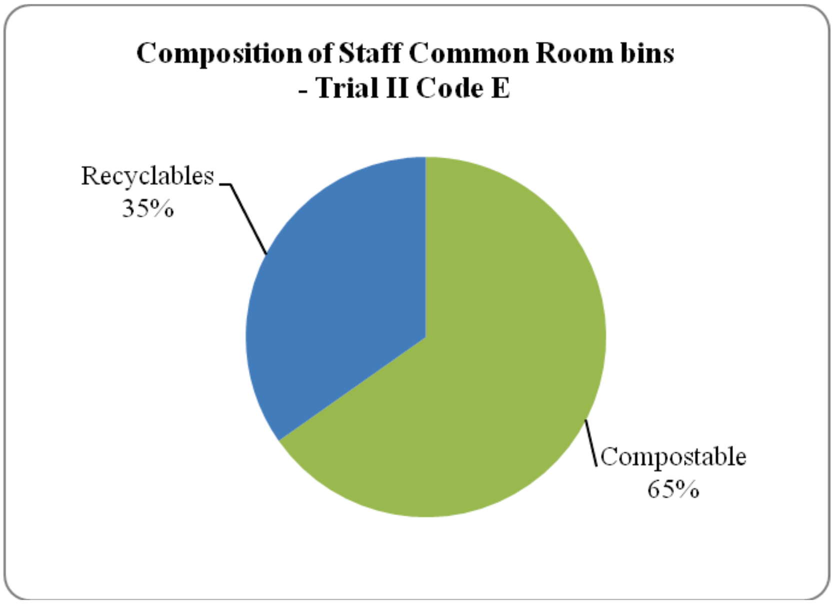

Figure 34, the percentage of compostable and recyclables for Code E Trial II

4.3 Trial III

This trial was conducted from 29th November – 3rd December 2010. It used the previous codes A, B, C, D and E from Trial II and used the same method except for Code E. In this case an additional sub-code (E3) for general waste was added to increase the potential findings about recycling behaviour from the audit.

4.3.1 Auditing the Large Waste Bins and Recycling Cage Bins (Code A)

For this trial the auditing process for the large waste bins (Code A) and the paper/cardboard recycling cage bins (A2) was undertaken in two different locations, namely the Main Building (now the Sir Geoffrey Peren building) adjacent to the old registry, and Riddet 2, off University Avenue ,between Colombo & Riddet Roads (see Figure 35 below). This meant that each sub-code had two locations feeding into its results. These bins were randomly selected from the total of 40 large waste bins across campus. As was done previously the contents were categorised according to the 12 categories based on a SWAP analysis method, namely waste, glass, cans, mixed paper, mixed plastic, organic waste, metal, textiles, rubber~~s~~, trees, timber and potentially hazardous waste.

Figure 35, The large waste bins and recycling cages at their locations; the Main building, adjacent to the old Registry building, and Riddet 2, off University Avenue, between Colombo & Riddet Roads

The result of the sorting and weighing process undertaken at each location are shown in Table 16 below.

Table 16, the Auditing result, Code A Trial III

Bin/Cage Code A	Category	Location	Waste/Resource Classification												Total kg
			Waste	Glass	Cans	Mixed Paper	Mixed Plastic	Organic Waste	Metal	Textiles	Rubber	Trees	Timber	Potentially Hazardous	
A1	**Waste**	**Main Building**	45	3.2	3	25	18	8.5			0.25	0.3			**103.25**
		Riddet	26	5.5	2.1	15	6.8	5.5					0.45	0.7	**62.05**
Total			**71**	**8.7**	**5.1**	**40**	**24.8**	**14**			**0.25**	**0.3**	**0.45**	**0.7**	**165.3**
A2	**Recycling-Cardboard**	**Main Building**				485									**485**
		Riddet				115									**115**

As can be seen from Table 16 the total amount of waste generated for each location from the two different types of bins and different places was comparatively different. Main Building had the most materials for sub-code A1 overall and for each category except glass, timber and potentially hazardous, as well as sub-code A2. The categories with the highest amount of material across both locations were waste, mixed paper and mixed plastic. The Main Building is used for teaching and offices and also has a number of other buildings in close proximity which have a similar function. Riddet has a combination of uses such as classrooms, laboratories, offices and workshops. These functions are reflected in the composition of the waste and recyclables found.

Following this the percentage of each category in sub-code A1 relative to the two locations were calculated once again. The results of this are shown in Figure 36 below.

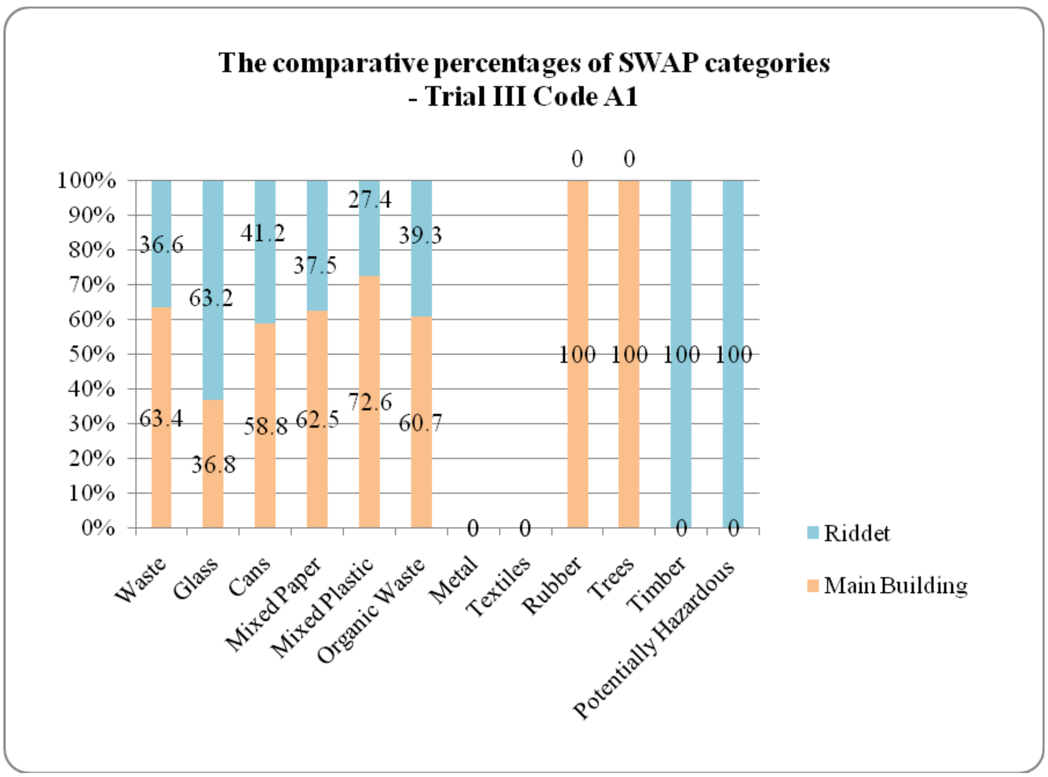

Figure 36, the percentages of SWAP categories for Code A1 Trial III

As can be seen the main differences were that Main Building had some rubber and tree material, whereas Riddet had some timber and potentially hazardous material.

Also the fact that Riddet had more glass material than Main Building was different to what is shown for the other categories where Main Building had a higher percentage. For sub-code A2, which had a total of 600kg of mixed paper and cardboard, the relative percentage for each location was calculated and this result is shown in Figure 37 below.

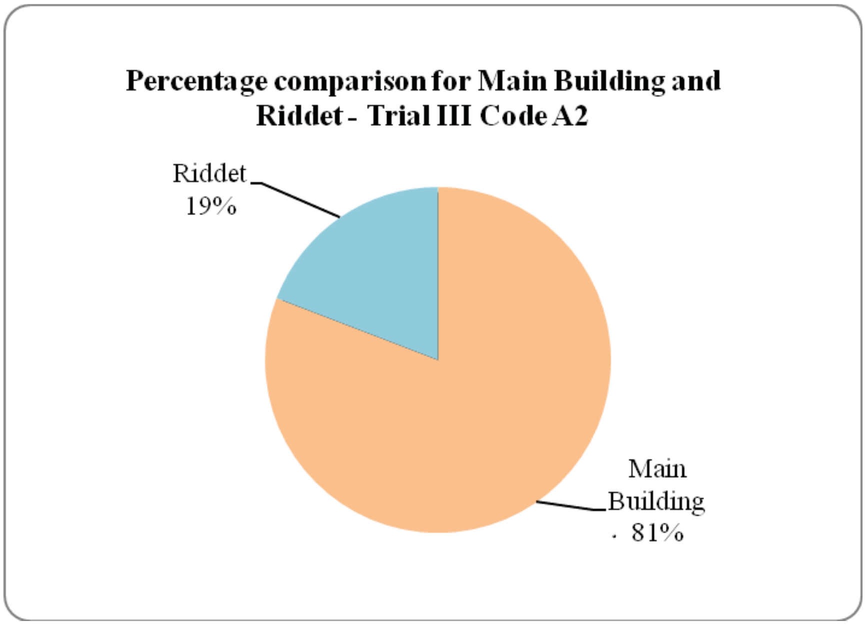

Figure 37, the percentage comparison of recycling paper and cardboard for Main Building and Riddet, Code A1 Trial III

This shows that Main Building produced more than four times the amount that Riddet did. For both locations no contamination or incorrectly disposed of materials were found in the recycling cage. This shows that when given the option to choose between the large waste bin and paper/cardboard recycling cage (which in this trial are located right next to each other) people are able to make the correct choice to put non-mixed paper materials in the waste bin. However there was a relatively large amount of mixed paper waste placed into the large waste bin which should have, and could easily have, been placed in the paper/cardboard recycling cage. This may have been made difficult by the cage bins being full.

This point also links to how the waste and recyclables are placed into these facilities to begin with. If the majority of the materials come through a process of being placed in smaller bins located in offices and classrooms, which are then combined when they are collected by cleaning staff before being placed in the large outside bins, this means the facilities inside the buildings needs to be considered. In relation to the previous point about the mixed paper being placed in the large waste bin this would raise the question of whether or not there are adequate mixed paper bins inside for people to make the correct choice to begin with.

Following this the comparative percentages of each category were calculated for each location and these are shown below in Figures 38 and 39.

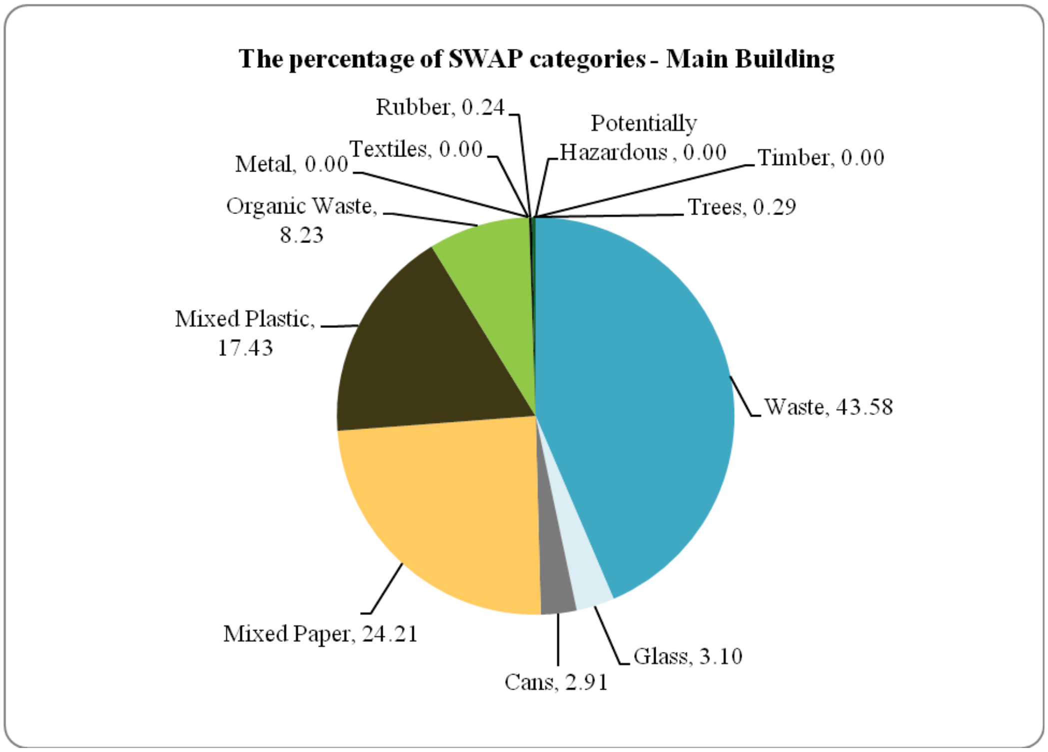

Figure 38, the percentage composition of SWAP categories for Code A1 – Main Building Trial II

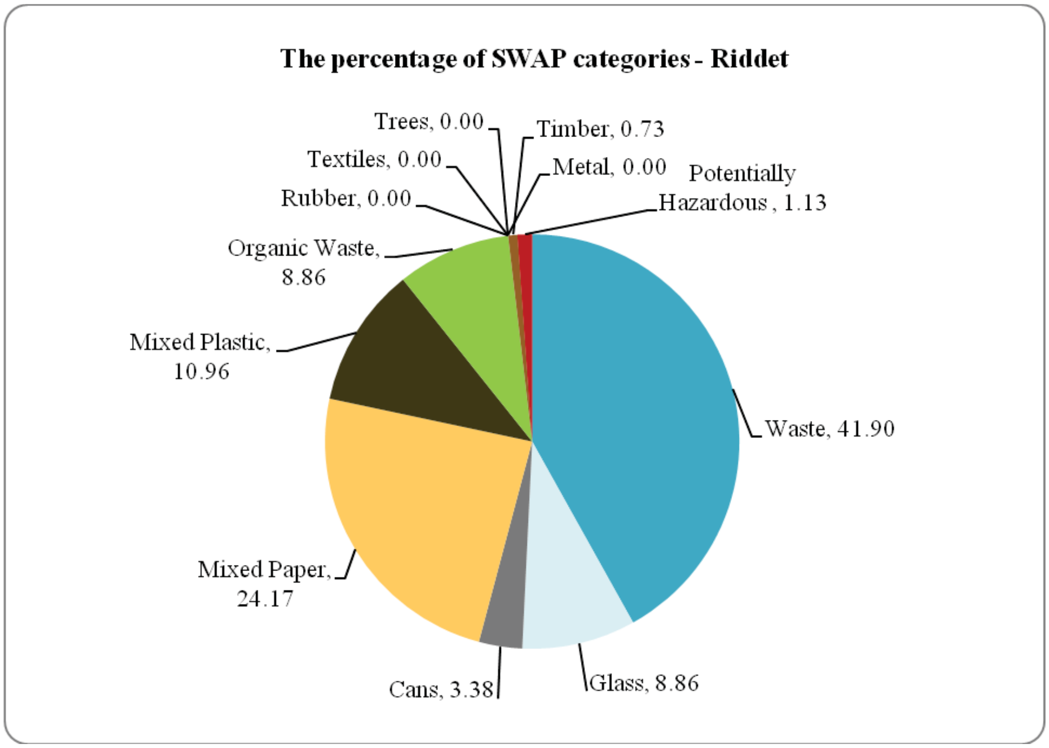

Figure 39, the percentage composition of SWAP categories for Code A1 – Riddet Trial II

The same process as was carried out in Trial II for re-categorisation was then followed. Recyclables consisted of glass, cans, mixed paper, mixed plastic, timber, textiles and metal. Compostable consisted of organic waste and trees, and waste consisted of waste, rubber and potentially hazardous materials. The result of this is shown in Table 17 below.

Table 17, the Auditing result of the large waste bins based on three key waste streams, Sub-code A1 Trial III

Code A - Categorisation into 3 key waste streams				
Location	**Recyclables (kg)**	**Compostable (kg)**	**Waste (kg)**	**Totals (kg)**
Main Building	49.2	8.8	45.25	**103.25**
Riddet	29.85	5.5	26.7	**62.05**
Totals	**79.05**	**14.3**	**71.95**	**165.3**

Based on the results shown above a number of key findings were noted. Firstly that the composition of waste, recyclables and compostable only varies a small amount between the two locations. This is shown more clearly in Figure 40 which shows the percentage of each category for each location. In both cases the recyclables category was the highest amount, followed by waste then compostable waste. This result was different to that found for Code A in Trial II where waste was the highest category by a considerable amount followed by recyclables then compostable waste. This was partly a result of the amount of potentially hazardous materials that were produced, and contributed to the waste category. This is linked to the type of waste produced and the activities undertaken in the specific buildings, as well as the current recycling programs that are or aren't in place.

It is also important to note that for both of these locations the amount of contamination of the large waste bins was considerable at more than 55 %. This means that resources are being lost due to being disposed of incorrectly, and that recycling behaviour needs to be improved somehow.

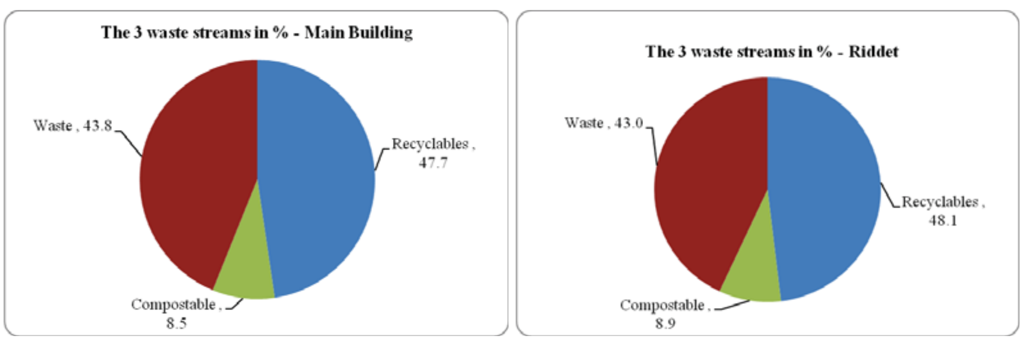

Figure 40, the composition of waste, recyclables, and compostable by percentage for Main Building and Riddet, Sub-code A1 Trial II

4.3.2 Auditing the Recycling Wheelie Bins (Code B)

The third recycling wheelie bin audit (Code B) was conducted on two days (Tuesday 30th November and Thursday 2nd December 2010) during the Trial III survey period. Once again the collection involved 7 clusters, out of the total 26 clusters across campus and the location was based in the concourse and dining hall area. The same audit process was conducted as in Trial I and II (section 4.1.1 and 4.2.2) and the data collected from this process consists of weight by each category and the amount of waste and recycling categories that were correctly or incorrectly disposed of for both the recycling clusters and the associated waste bins. The total weights were converted into volume using the Massey conversion factor as before. This information is shown in Table 18 below.

Table 18, the Auditing result, Code B Trial III

`Code B	Category (Recycling-Wheelie Bin)	Correct (kg)	Incorrect (kg)	Total (kg)	Total Volume (m3)
B1	Plastic Bottles	13.6	1.31	14.91	0.71
B2	Aluminium & Tin Cans	14.4	0.05	14.45	0.35
B3	Mixed Paper	27.35	10.88	38.23	0.56
B4	Mixed Glass Bottles	89.9	0.95	90.85	0.39
Resource Totals		**145.25**	**13.19**	**158.44**	
B5	Waste	22.3	9.25	31.55	0.58
	Totals	167.55	22.44	189.99	2.59

The total amount of waste generated was 189.99kg with 167.55kg being disposed of correctly and 37.73kg disposed of incorrectly. As was found in previous trials the majority of the waste and recyclables were correctly identified and disposed of appropriately. Once again a more detailed picture is provided by the breakdown into sub-codes and the percentage of correct vs. incorrect for each is shown in Figure 42 below. The overall composition of the waste and recycling is shown in Figure 41 as percentages of the total. This shows that mixed glass bottles and mixed paper were the most significant categories in terms of amount, followed by general waste. This analysis helps to create a picture of the trends of the waste and recyclables composition as it was the third trial for this location. When compared to Trial I and II this audit has similarities to Trial I with regards to the high amount of mixed glass, however the high percentage of mixed paper is similar to that found in Trial II. These patterns may relate to the time of the year that the audits were conducted, as well as the introduction of paper compostable plates and bowls in the dining hall.

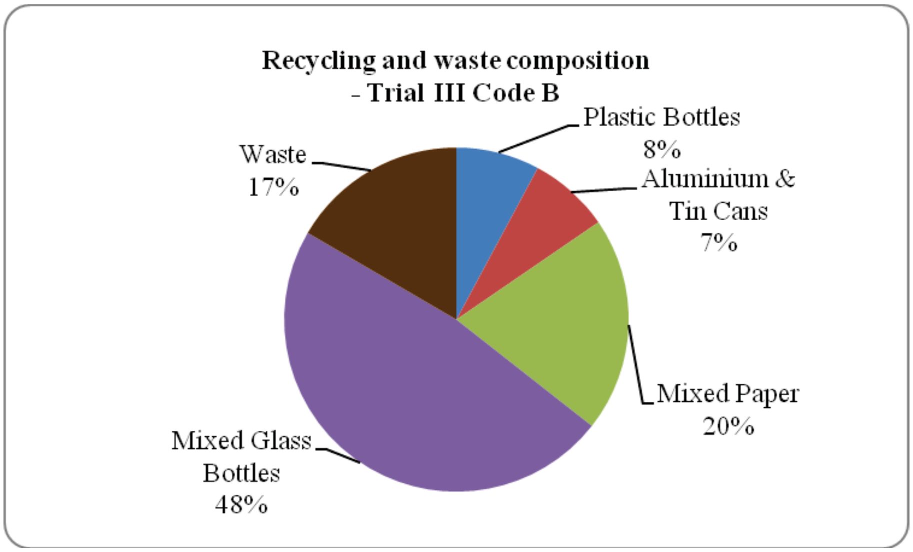

Figure 41, the percentage of recycling and waste generated by Code B in Trial III by weight (kg)

In order to get a clear picture of the contamination within each category a bar graph was once again created to show the correct vs. incorrect percentage for each sub-code, Figure 42.

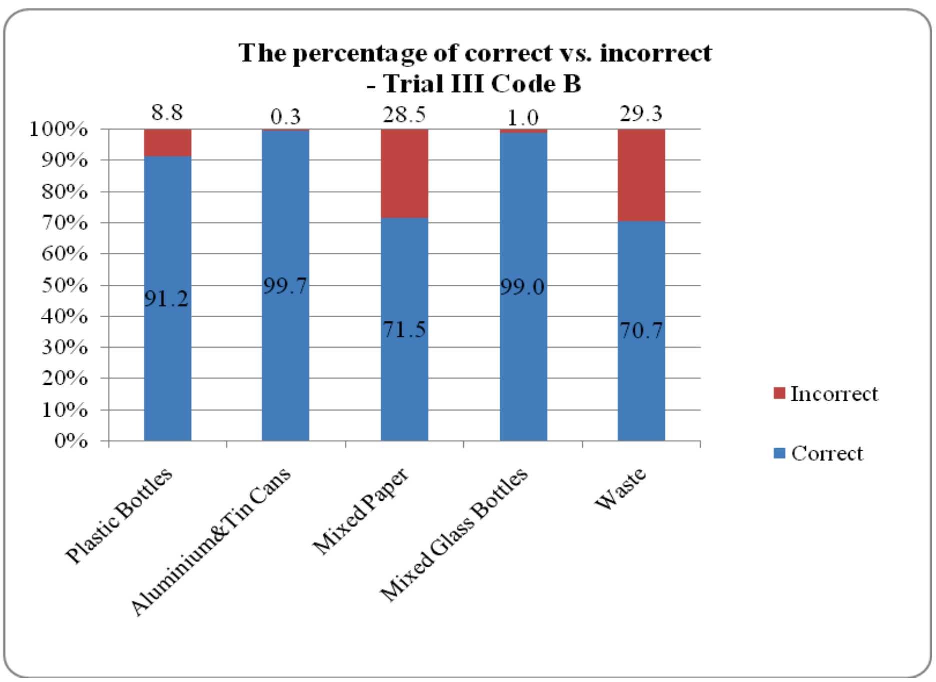

Figure 42, the percentage of correct vs. incorrect for Code B Trial III

The range of incorrectly disposed of was from 0.3 to 29.3 %, with the two most significant results being for the mixed paper and waste categories at 28.5 % and 29.3 % respectively. This trend is consistent with the results from Trial II and these were also two of the categories with significant results in Trial I. The types of contamination found were similar to Trial II and consisted of organic food waste in the mixed paper category. The other significant result, which was the fact that 29.3% of the waste category could have been disposed of in the recyclable categories, again shows a sizeable loss of potential resources to landfill although this amount was considerably less than in Trial II. This contamination was again made up of organic food waste, and recyclable food containers such as plastic.

Following this the overall percentage of contamination was calculated as it was in Trial I and II, with this result shown in Figure 43 below.

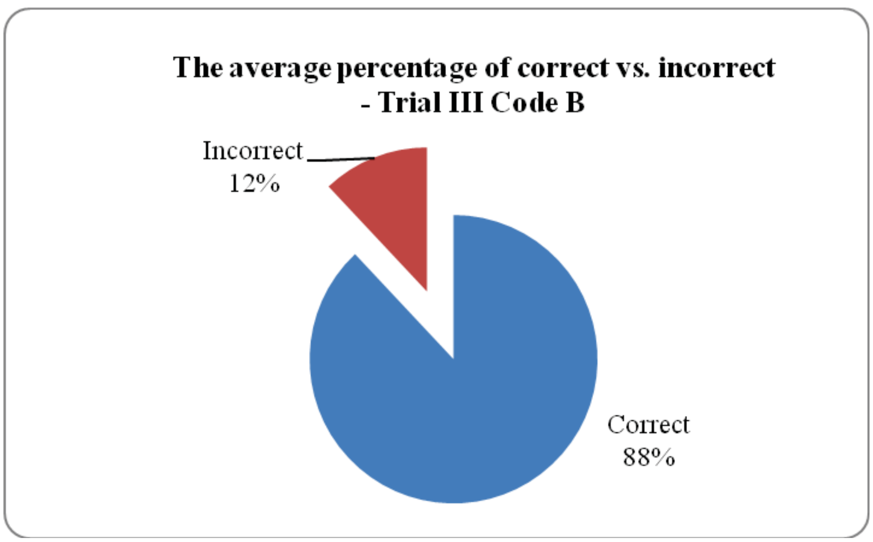

Figure 43, the average percentage of correct vs. incorrect for Code B Trial III

This shows that overall the incorrect recycling behaviour taking place was slightly lower than in Trial II with a decrease from 16 to 12 %. This result of 14 % is very close to the 13 % found in Trial I. This may be linked to the time of year during which the trials were conducted although the difference across the three trials is only 3 % at the most which is only a small difference. The most meaningful part of this result is the percentage of recyclable resources that are being lost due to being placed in the waste category which across the three trials is an average of 33.1%. This shows that recycling behaviour and choices needs to be improved.

4.3.3 Auditing the Small Waste Bins (Code C)

The Code C audit of the small waste bins located in the concourse area was the same as that previously conducted in Trial I and II (section 4.1.2 and 4.2.3). The waste was collected three times during the week (29th November, 1st and 3rd December 2010). After collecting the waste the audit process was conducted as for Trial II to separate the waste and recyclable materials into each category for weighing and quantifying the contamination levels using the correct vs. incorrect method previously established. The result of this audit is displayed in Table 19 below.

Table 19, the Auditing result, Code C Trial III

Code C	Categories			Total (kg)
	Waste-Landfill	Recyclables	Compostable	
	(kg)	(kg)	(kg)	
	6.15	7.56	5.7	**19.41**
Percentage of total	**31.7**	**38.9**	**29.4**	

The above Table 19 displays the total amount of waste generated in the small waste bins in the concourse area. The total amount of waste produced was 19.41kg which consisted of 6.15kg of waste-landfill and 13.26kg made up of recyclable and compostable materials. Once again the weights for each category were converted into percentages of the total, which is shown in Figure 44 below. These percentages are similar to those found in Trial II where exactly the same sorting process was used, with the highest being recyclables, followed by waste-landfill then compostable.

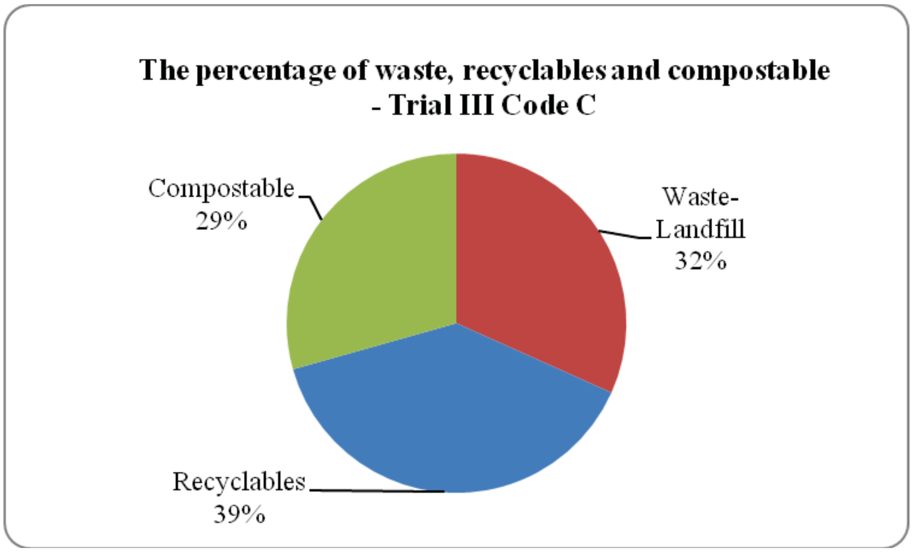

Figure 44, the percentage of waste-landfill, recyclables, and compostable for Code C Trial III

As noted in Trial II the alternative way of looking at this is to use the categories of waste-landfill and recyclable to focus on the potential resources lost through the incorrect disposal into a general waste bin. This also allows for the data collected during Trial I to be compared as this only used the two categories of recyclable and waste-landfill. This is shown in Figure 45 below and shows that 68 % of the materials in these bins were in fact recyclable which reinforces the lack of understanding of the purpose of these small waste bins that was also found in Trial I and II. The percentage of recyclable resources found in this bin code across the three trials has decreased somewhat from 82 % to 71 % then 68 %. In terms of the timing of the trials and the seasonality of the campus population the trials were conducted during summer semester, then semester two then the following summer semester so there may be an indication of student populations becoming more aware of the recycling facilities option and choosing to use it over the small waste bins. This seasonality of use is definitely reflected in the totals collected with Trial I being 11.89kg, Trial II 61.54kg and Trial III 19.41kg.

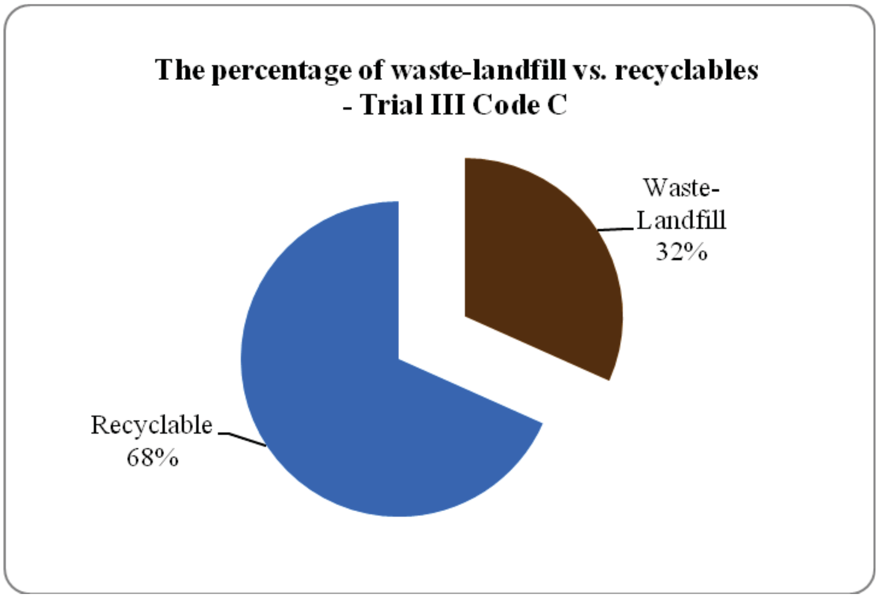

Figure 45, the percentage of waste-landfill to recyclables for Code C Trial III

4.3.4 Discontinued Audit of the Massey Dining Hall Recycling Bins (Code D)

In between the survey period of Trial II and III Massey removed the Massey Dining Hall Recycling Bins from the waste and recycling facilities provided in the dining hall due to impracticalities as described in section 3.4.1.2 (page 57). This meant that a third audit for code D was unable to be conducted for this trial. However because an audit was completed for the first two trials for this code there will still be some value to the results collected in terms of how well that layout of bin was used and understood. These will be discussed in section 4.5.2.

4.3.5 Auditing the Staff Common Room Waste, Organic and Recycling Bins (Code E)

As was undertaken previously bin Code E was audited twice during the survey period for Trial III (Wednesday 1st and Friday 3rd December 2010) in coordination with the regular collection process. In the previous trial the total number of bins was 30 however for this trial there were only 24 bins remaining. This was due to some of the locations being considered to be impractical and so being discontinued. In addition to this it was decided to add the waste category into the audit in order to quantify the total amount produced and determine the correct vs. incorrect disposal levels. As previously stated contamination of waste is an important indicator for recycling behaviour as it highlights when and where people are failing to recycle. In this particular instant, because there are also recyclable and compostable facilities provided, contamination is a direct indication of effective or non effective recycling choices being made. Table 20 below shows the results of the audit and sorting process for the three categories.

Table 20, the Auditing result, Code E Trial III

Code E	Category		Weight (kg)
E1	Compostable		119.75
E2	Recyclables		68.05
E3	Waste	Correct	15.5
		Incorrect	2.3
Total			**205.6**

As was done in previous cases the percentage of each category was calculated as this is shown in Figure 46.

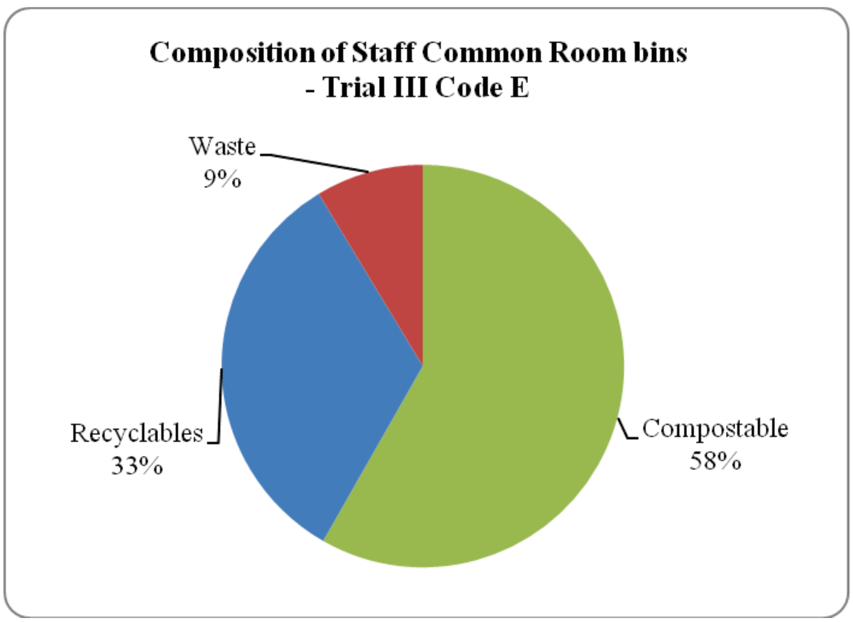

Figure 46, the percentage of compostable and recyclables for Code E Trial III

This shows that compostable waste was the highest category and was in fact more than six times the amount of waste found. This shows that the compostable waste disposal system which was implemented in March 2010 is functioning well and is understood by users. That recyclables were the second highest category shows that the all in recycling system is working effectively as well. The other important factor, as previously mentioned were the contamination levels for each category and these were calculated as previously and are shown in Figure 47 below.

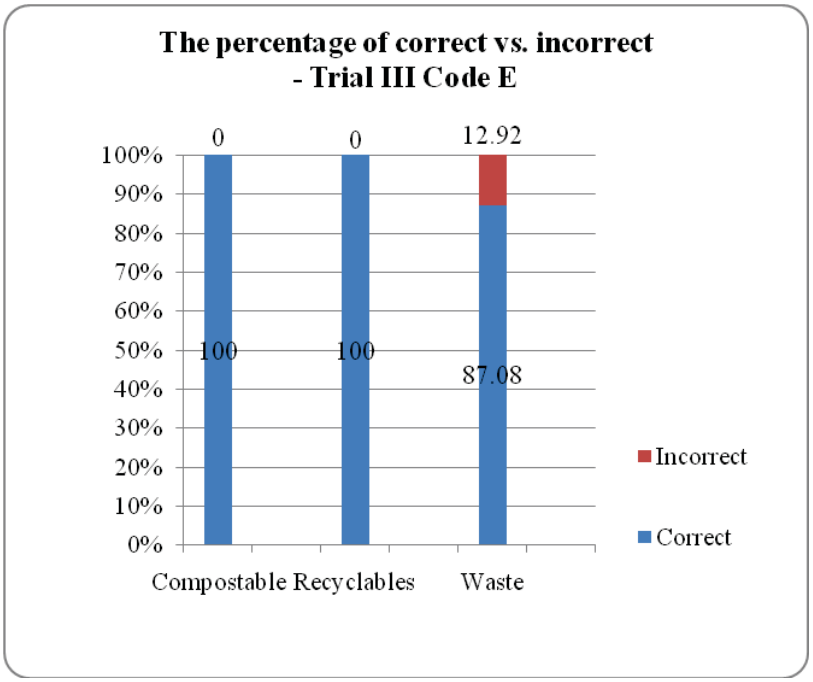

Figure 47, the percentage of correct vs incorrect for Code E Trial III

As was noted previously in Trial II there was no contamination found in the recyclables and compostable categories which confirms an understanding by the people choosing to use these categories. For the waste category there was an incorrect disposal level of nearly 13 %. This contamination was mainly made up of recyclables (mixed plastics and papers) and while the percentage is not high some people are failing to use the appropriate disposal facilities and therefore some resources are being lost to landfill.

4.4 Trial IV

The fourth trial of this study was slightly different from the previous trials I, II and III. In this particular case, this trial focused on the recycling wheelie bins and the large waste bins located in the student hostels at the Turitea campus at the specific request of RFM. They also requested that total weights (kg) of recyclables be converted into volume (m^3), which was why the Massey conversion factor was created in section 3.4.1.2, Table 6. In total, there were 17 clusters of wheelie bins in the student hostels. Of this total nine clusters were selected from the student hostels using systematic random sampling. In addition, there were nine large waste bins, and of these four waste bins were selected based on observations of where there were materials available to audit.

The data presented was collected over a one week data collection period (March 8th and 10th, 2011) during semester one of the year. The data obtained consists of weight by each audit category and the percentage of correct and incorrect recycling, based on each location. Following is the detailed information of the auditing result of the final trial.

4.4.1 Auditing the Recycling Wheelie Bins (Code F1)

4.4.1.1 Moginie Hall

The total amount of recyclables generated was 25.89kg with 25.1kg being disposed of correctly and 0.79kg disposed of incorrectly, as is shown in Table 21. This shows that the majority of the recyclables are correctly identified and disposed of appropriately. As was done for Code B through Trials I, II and III the next step was to calculate the percentage of the total for each category.

Table 21, the Auditing result for Moginie Hall, Code F1 Trial IV

Code F (Moginie)	Category	Correct (kg)	Incorrect (kg)	Total (kg)	Total Volume (m^3)
B1	Mixed Plastic	1.95	0.2	2.15	0.10
B2	Aluminium & Tin Cans	1.15	0	1.15	0.03
B3	Mixed Paper	10.05	0.22	10.27	0.09
B4	Mixed Glass Bottles	11.95	0.37	12.32	0.04
Total		**25.1**	**0.79**	**25.89**	**0.26**

The percentage of each category, plastic bottles, aluminium and tin cans, mixed glass bottles and mixed paper is shown in Figure 48 below. This gives an overall picture of the composition of the recyclables for Moginie Hall and by later doing this for each hostel audited patterns or trends may be discovered. For Moginie the highest categories were mixed glass bottles and mixed paper, which based on observations during the audit process, consisted of a large amount of glass alcohol bottles and cardboard packaging, as well as newspapers and other paper packaging.

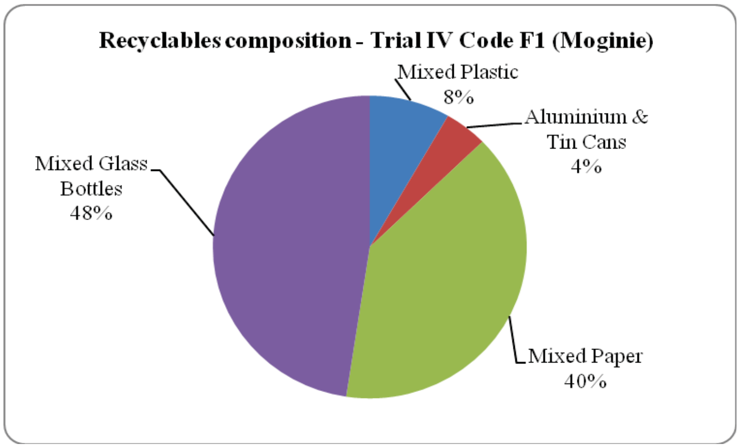

Figure 48, the percentage of recyclable categories for Code F1 Trial IV (Moginie)

While the amount of incorrectly disposed of recyclables was not a high number by creating a bar graph (Figure 49), as was done in previous trials, it created a clearer picture of what was happening. The category with the highest percentage of contamination was mixed plastic and this consisted of a mixture of other recyclables and compostable food waste. The average percentage of correct vs. incorrect was 96 to 4 %.

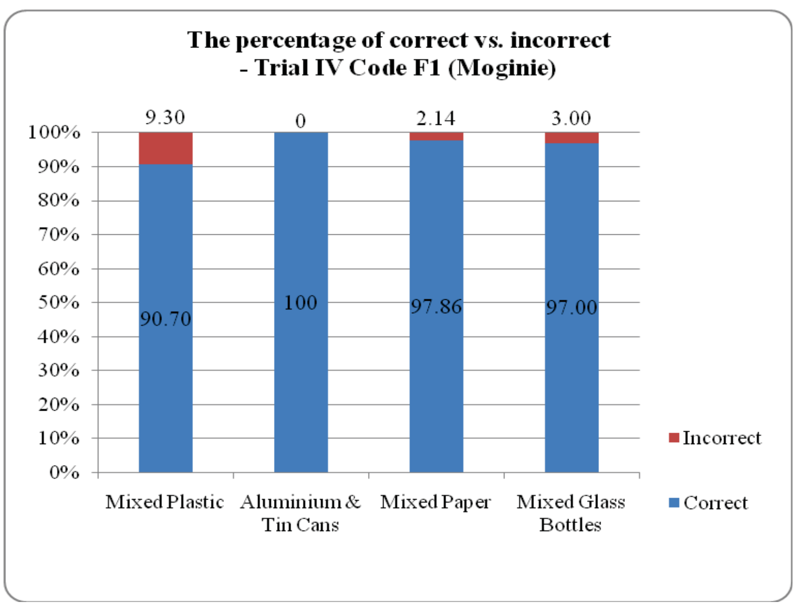

Figure 49, the percentage of correct vs. incorrect recyclables disposal for Code F1 Trial IV (Moginie Hall)

4.4.1.2 Tararua and Ruahine Halls

The total amount of waste generated was 22.99kg with 22.35kg being disposed of correctly and 0.64kg disposed of incorrectly, as is shown in Table 22. This shows that for these halls the majority of the recyclables are also correctly identified and disposed of appropriately. As was done for previous audits the next step was to calculate the percentage of the total for each category.

Table 22, the Auditing result for Tararua and Ruahine Halls, Code F1 Trial IV

Code F (Tararua)	Category	Correct (kg)	Incorrect (kg)	Total (kg)	Total Volume (m^3)
B1	Mixed Plastic	3.9	0.27	4.17	0.20
B2	Aluminium & Tin Cans	4.15	0.27	4.42	0.11
B3	Mixed Paper	5.1	0.1	5.2	0.04
B4	Mixed Glass Bottles	9.2	0	9.2	0.03
Total		**22.35**	**0.64**	**22.99**	**0.38**

As before the percentage of each category, plastic bottles, aluminium and tin cans, mixed glass bottles and mixed paper is shown in Figure 50 below. This gives an overall picture of the composition of the recyclables for Tararua and Ruahine Hall. As was found for Moginie Hall the highest categories were mixed glass bottles and mixed paper.

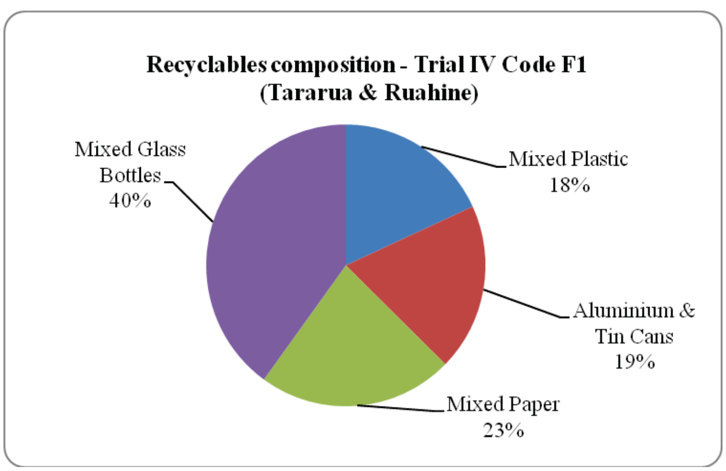

Figure 50, the percentage of recyclable categories for Code F1 Trial IV (Tararua & Ruahine Halls)

Following this the bar chart (Figure 51) was created to show the correct vs. incorrect for each category so that it would be possible to compare this result across the hostels. While the contamination level were still quite low Ruahine and Tararua did have some contamination in both mixed plastic and aluminium and tin cans. For the mixed plastic the contamination was mostly other recyclables and compostable food waste, while for the aluminium and tin cans the contamination was glass and cardboard packaging. The average percentage of correct vs. incorrect was 97.4 to 2.6 %.

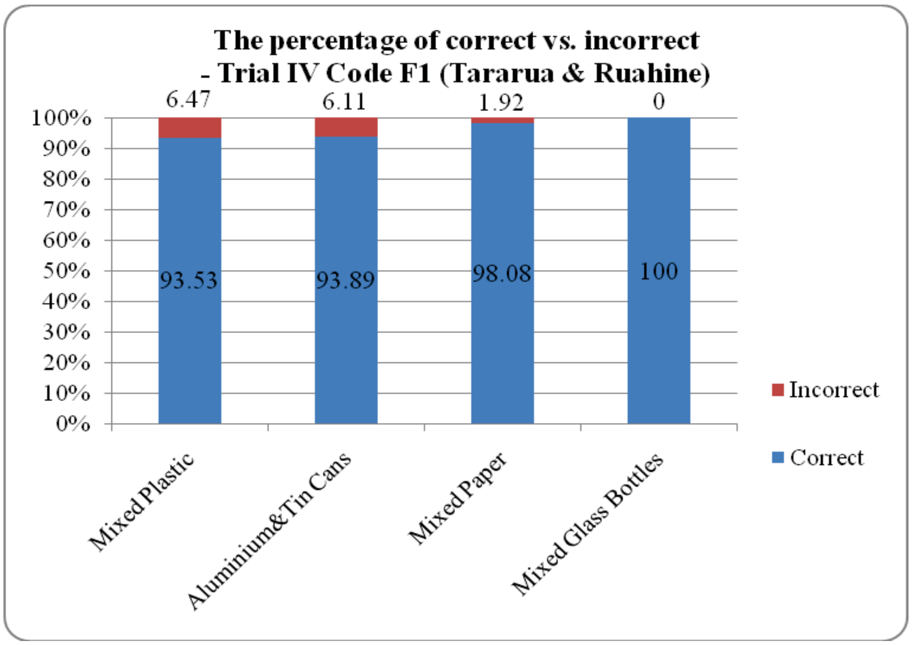

Figure 51, the percentage of correct vs. incorrect recyclables disposal for Code F1 Trial IV (Tararua & Ruahine Halls)

4.4.1.3 Bindaloe Hall

The total amount of recyclables generated was 44.38kg with 44.17kg being disposed of correctly and 0.21kg disposed of incorrectly, as is shown in Table 23 below. This low amount shows that for this hall the majority of the recyclables are also correctly identified and disposed of appropriately, so when people are recycling they are making the correct choices about which category to put things in. As was done for previous audits the next step was to calculate the percentage of the total for each category.

Table 23, the Auditing result for Bindaloe Hall, Code F1 Trial IV

Code F (Bindaloe)	Category	Correct (kg)	Incorrect (kg)	Total (kg)	Total Volume (m^3)
B1	Mixed Plastic	1.8	0.09	1.89	0.09
B2	Aluminium &Tin Cans	2.05	0	2.05	0.06
B3	Mixed Paper	3.27	0.12	3.39	0.03
B4	Mixed Glass Bottles	37.05	0	37.05	0.14
Total		**44.17**	**0.21**	**44.38**	**0.32**

The percentage of each category, plastic bottles, aluminium and tin cans, mixed glass bottles and mixed paper is shown in Figure 52 below. This gives an overall picture of the composition of the recyclables for Bindaloe Hall.

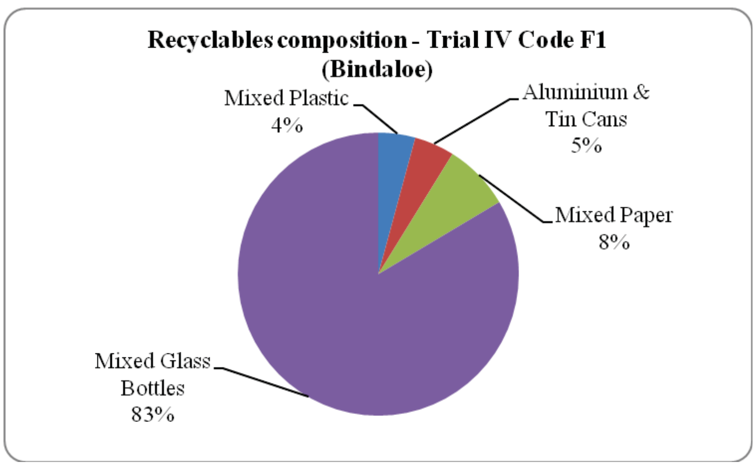

Figure 52, the percentage of recyclable categories for Code F1 Trial IV (Bindaloe Hall)

Following this the bar chart (Figure 53) was created to show the correct vs. incorrect for each category so that it would be possible to compare this result across the hostels. For Bindaloe Hall the contamination levesl were considerably low, which indicates that recycling choices are being made correctly. The average percentage of correct vs. incorrect was 97.9 to 2.1 %.

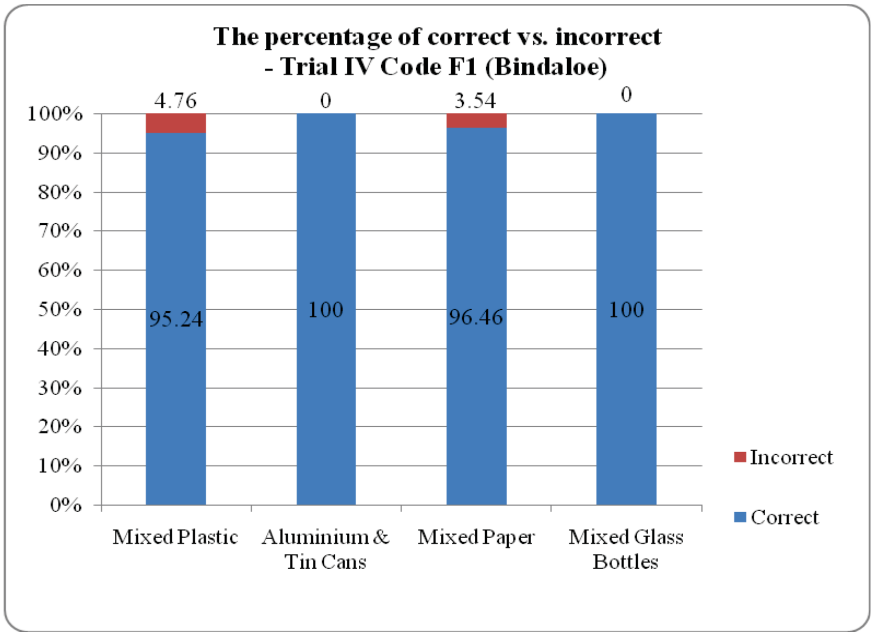

Figure 53, the percentage of correct vs. incorrect recyclables disposal for Code F1 Trial IV (Bindaloe Hall)

4.4.1.4 Colombo Hall

For Colombo Hall there was a total of 21.28kg recyclables generated with 21.1kg disposed of correctly and 0.18kg incorrectly. These results are shown below in Table 24.

Table 24, the Auditing result for Colombo Hall, Code F1 Trial IV

Code F (Colombo)	Category	Correct (kg)	Incorrect (kg)	Total (kg)	Total Volume (m3)
B1	Mixed Plastic	2.6	0.08	2.68	0.13
B2	Aluminium & Tin Cans	1.65	0	1.65	0.04
B3	Mixed Paper	6.85	0.1	6.95	0.06
B4	Mixed Glass Bottles	10	0	10	0.03
Total		**21.1**	**0.18**	**21.28**	**0.31**

Following this the percentage of the total for each category was calculated and this is displayed in the piechart below, Figure 54.

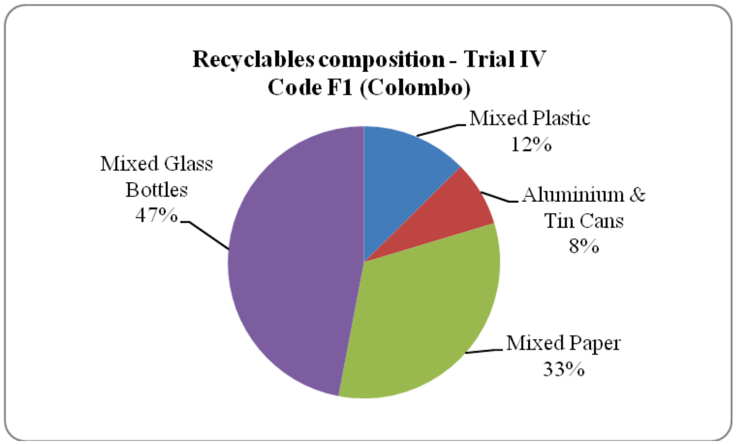

Figure 54, the percentage of recyclable categories for Code F1 Trial IV (Colombo Hall)

For Colombo the highest category was mixed glass bottles, followed by mixed paper, mixed plastic and aluminium and tin cans. This was fairly consistent, in terms of sequence, with the previous hostels, although the relative percentages for each have varied. As was undertaken previously a bar chart was created to give a clear picture of the recycling behaviour in terms of the correct vs. incorrect disposal choices being made, as this is shown below Figure 55. For Colombo Hall this confirmed that the contamination levels were very low, which shows that the majority of the choices being made were correct. The average percentage of correct vs. incorrect was 98.9 to 1.1 %.

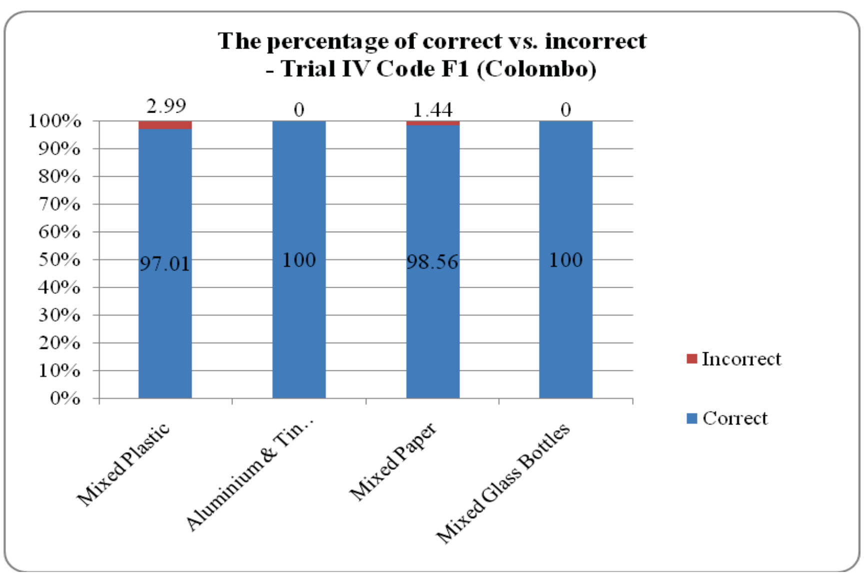

Figure 55, the percentage of correct vs. incorrect recyclables disposal for Code F1 Trial IV (Colombo Hall)

4.4.1.5 Tawa Hall

The audit of the recycling wheelie bins at Tawa Hall found that there was a total of 17.14kg recyclables generated, with 16.73kg being disposed of correctly and 0.41kg incorrectly. These totals are shown in Table 25 below. The next step was to calculate the percentage of the total for each category.

Table 25, the Auditing result for Tawa Hall, Code F1 Trial IV

Code F (Tawa)	Category	Correct (kg)	Incorrect (kg)	Total (kg)	Total Volume (m^3)
B1	Mixed Plastic	1.85	0.06	1.91	0.09
B2	Aluminium & Tin Cans	1.48	0.25	1.73	0.04
B3	Mixed Paper	2.95	0.1	3.05	0.02
B4	Mixed Glass Bottles	10.45	0	10.45	0.04
Total		**16.73**	**0.41**	**17.14**	**0.19**

Figure 56 below shows that once again mixed glass bottles was the highest category followed by mixed paper, mixed plastic and aluminium and tin cans at 61, 18, 11 and 10 % respectively.

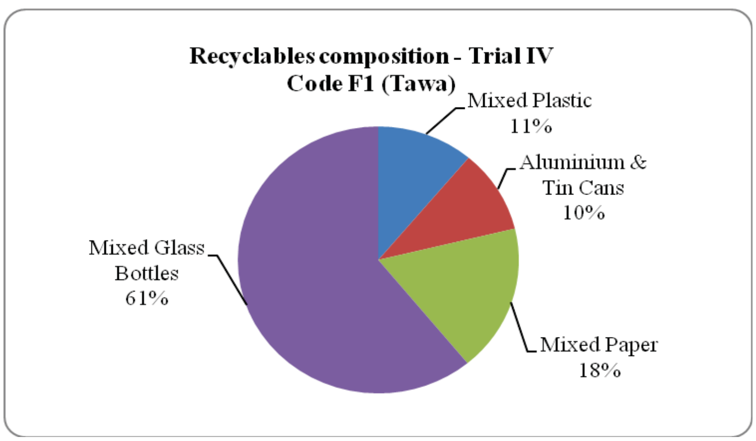

Figure 56, the percentage of recyclable categories for Code F1 Trial IV (Tawa Hall)

The bar chart (Figure 57) below illustrates more clearly the percentages of contamination found for each category. This shows that there was a considerable amount of contamination in the aluminium and tin cans category, while the three other categories for the most part had low or no contamination. This contamination in the aluminium and tin cans category was made up of mixed glass bottles and plastics. The average percentage of correct vs. incorrect was 94.8 to 5.2 %.

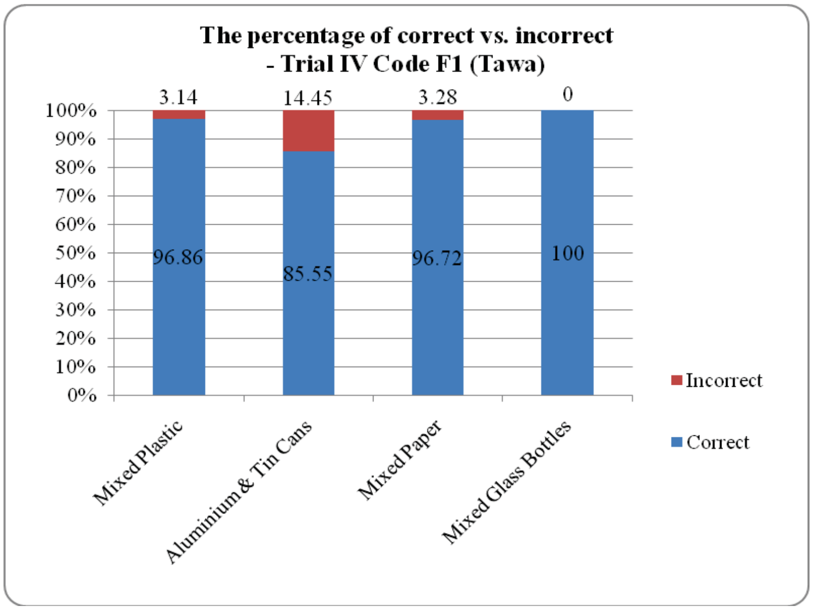

Figure 57, the percentage of correct vs. incorrect recyclables disposal for Code F1 Trial IV (Tawa Hall)

4.4.1.6 Matai Hall

The total amount of recyclables generated was 26.93kg with 26.4kg being disposed of correctly and 0.53kg disposed of incorrectly. This low amount shows that for Matai Hall the majority of the recyclables are correctly identified and disposed of appropriately, and that correct recycling behaviour is high. Table 26 below shows the results of thie audit. As was done for previous audits the next step was to calculate the percentage of the total for each category.

Table 26, the Auditing result for Matai Hall, Code F1 Trial IV

Code F (Matai)	Category	Correct (kg)	Incorrect (kg)	Total (kg)	Total Volume (m3)
B1	Mixed Plastic	2.25	0.15	2.4	0.11
B2	Aluminium & Tin Cans	1.95	0.08	2.03	0.05
B3	Mixed Paper	8.6	0.05	8.65	0.08
B4	Mixed Glass Bottles	13.6	0.25	13.85	0.05
Total		**26.4**	**0.53**	**26.93**	**0.29**

Figure 58 below shows the percentage of the total for each category and reproduces previous patterns for Code F Trial IV. The highest category was mixed glass bottles, followed by mixed paper, mixed plastic and aluminium and tin cans.

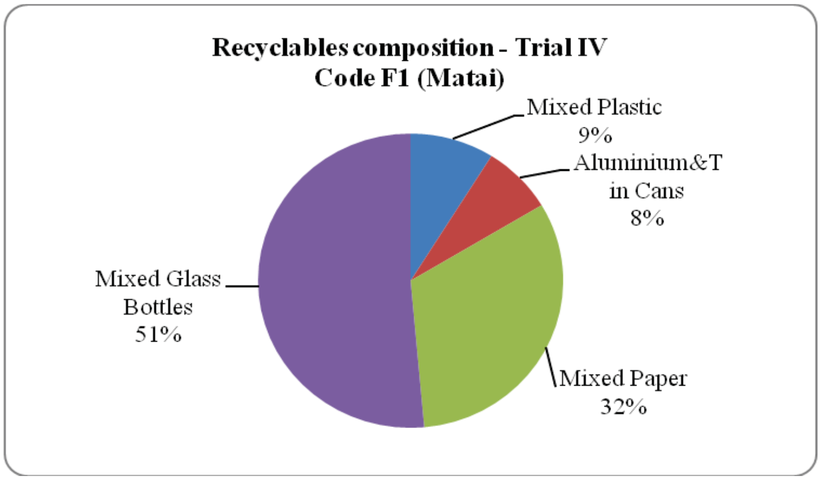

Figure 58, the percentage of recyclable categories for Code F1 Trial IV (Matai Hall)

Figure 59 below shows the contamination levels in terms of percentage of the total for each category. Once again these levels are quite low overall with the highest amount of contamination through incorrect disposal being for mixed plastic. This contamination was made up of paper and compostable waste. The average percentage of correct vs. incorrect was 96.9 to 3.1 %.

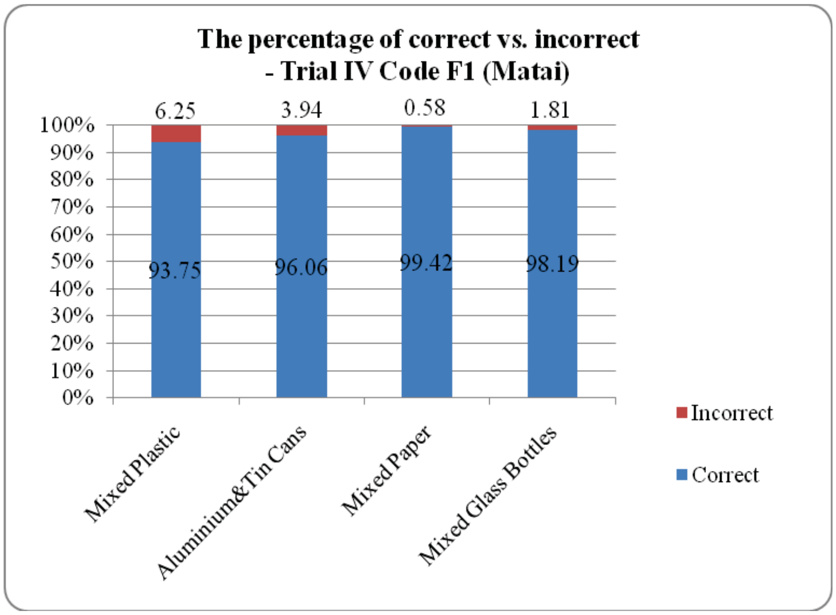

Figure 59, the percentage of correct vs. incorrect recyclables disposal for Code F1 Trial IV (Matai Hall)

4.4.1.7 City Court

For City Court there was a total of 37.79kg recyclables generated with 37kg disposed of correctly and 0.79kg incorrectly. These results are shown below in Table 27.

Table 27, the Auditing result for City Court, Code F1 Trial IV

Code F (City Court)	Category	Correct (kg)	Incorrect (kg)	Total (kg)	Total Volume (m3)
B1	Mixed Plastic	3.2	0.06	3.26	0.15
B2	Aluminium & Tin Cans	6.2	0.33	6.53	0.16
B3	Mixed Paper	4.95	0.2	5.15	0.04
B4	Mixed Glass Bottles	22.65	0.2	22.85	0.09
Total		**37**	**0.79**	**37.79**	**0.44**

Following this the percentage of the total for each category was calculated and this is displayed in Figure 60 below. This shows that for City Courts mixed glass bottles were the highest amount followed by mixed paper, aluminium and tin cans and mixed plastic.

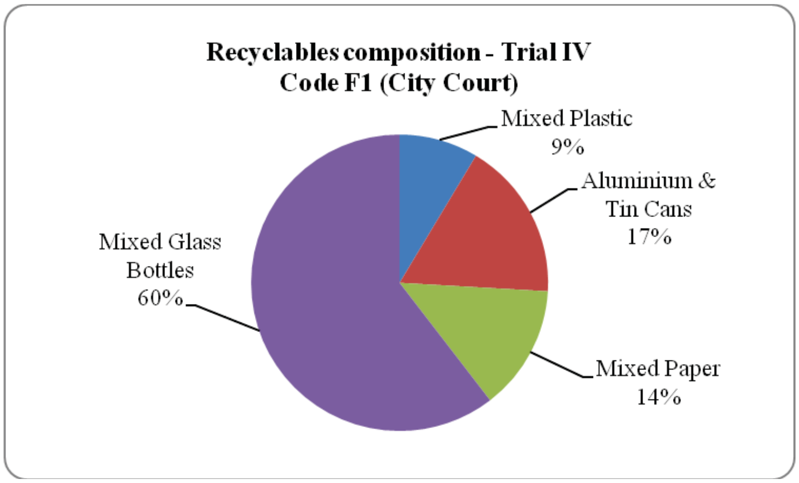

Figure 60, the percentage of recyclable categories for Code F1 Trial IV (City Court)

Following this, as was undertaken previously a bar chart was created to give a clear picture of the recycling behaviour in terms of the correct vs. incorrect disposal choices being made. As can be seen in Figure 61 below, for City Court contamination levels were low with the highest amount of incorrect disposal being just over 5 %. The average percentage of correct vs. incorrect was 97.1 to 2.9 %.

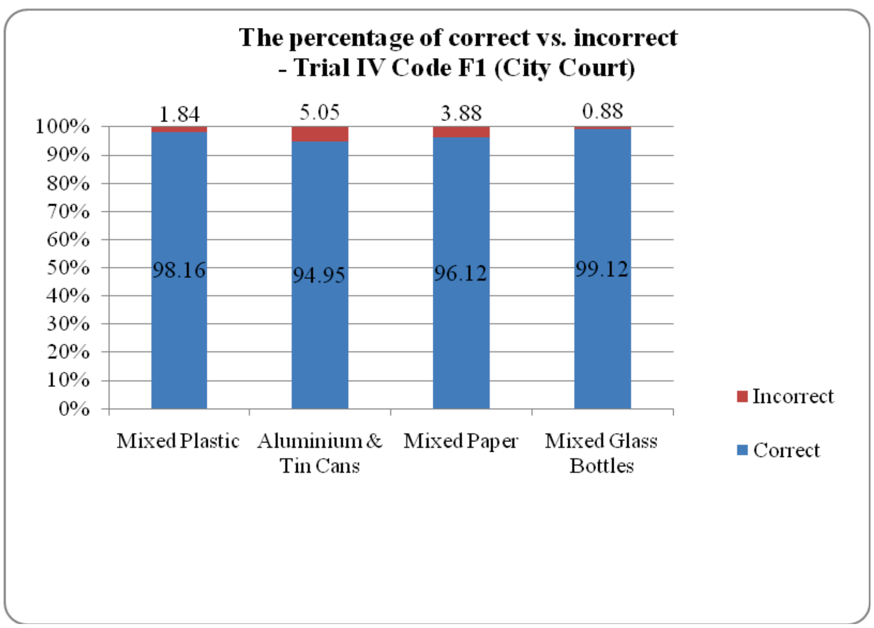

Figure 61, the percentage of correct vs. incorrect recyclables disposal for Code F1 Trial IV (City Court)

4.4.1.8 Kairanga Court

The audit of the recycling wheelie bins at Kairanga Court found that there was a total of 22.25kg recyclables generated, with 21.9kg being disposed of correctly and 0.35kg incorrectly. These totals are shown in Table 28 below. The next step was to calculate the percentage of the total for each category.

Table 28, the Auditing result for Kairanga Court, Code F1 Trial IV

Code F (Kairanga)	Category	Correct (kg)	Incorrect (kg)	Total (kg)	Total Volume (m^3)
B1	Mixed Plastic	3.3	0	3.3	0.16
B2	Aluminium & Tin Cans	2.85	0.16	3.01	0.07
B3	Mixed Paper	7.25	0.1	7.35	0.06
B4	Mixed Glass Bottles	8.5	0.09	8.59	0.03
Total		**21.9**	**0.35**	**22.25**	**0.32**

Figure 62 below shows that once again mixed glass bottles was the highest categoryat 39 %, although in this case the next highest category, mixed paper was much higher than found in previous hostel audits at 33 %. Following these came mixed plastic and aluminium and tin cans at 15 and 13 % respectively.

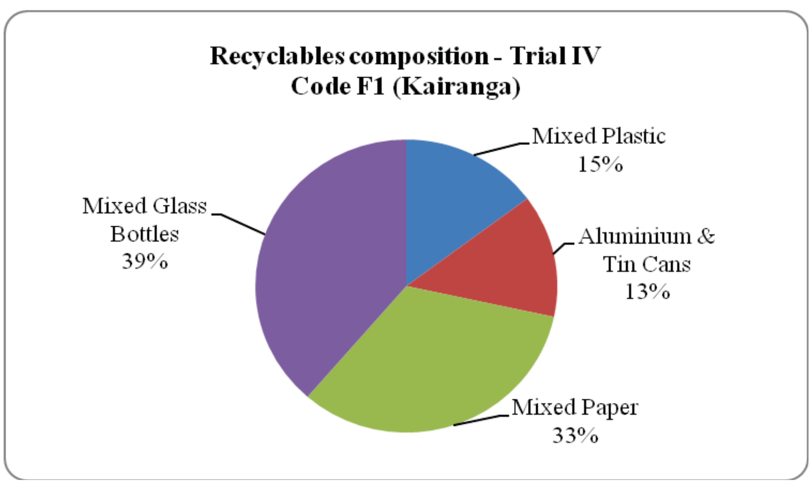

Figure 62, the percentage of recyclable categoriees for Code F1 Trial IV (Kairanga Court)

Figure 63 below shows the percentages of correct vs. incorrect disposal for each category and illustrates that level of incorrect disposal were low overall with the highest being 5.32 % for aluminium and tin cans. This contamination mainly consisted of glass bottles and plastics. The average percentage of correct vs. incorrect was 98.1 to 1.9 %.

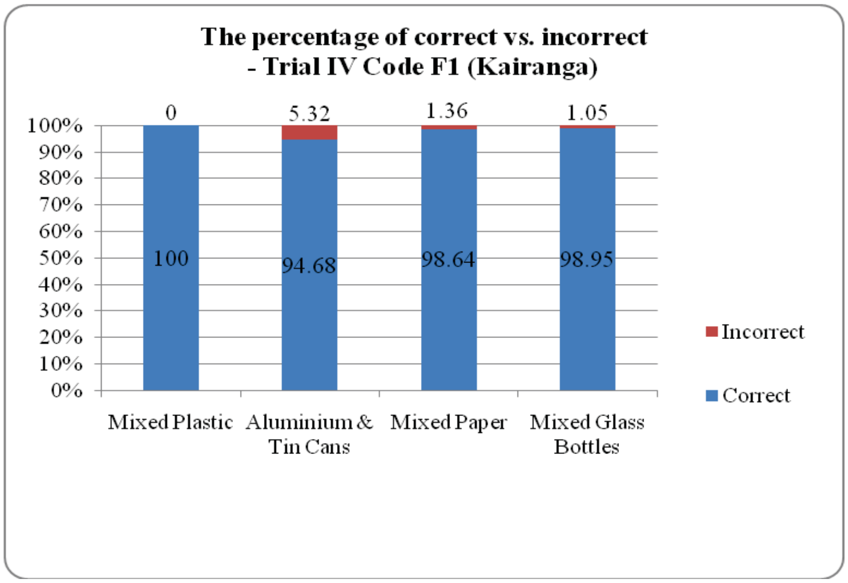

Figure 63, the percentage of correct vs. incorrect recyclables disposal for Code F1 Trial IV (Kairanga Court)

4.4.1.9 Atawhai

The audit of the recycling wheelie bins at Atawhai found that there was a total of 37.21kg recyclables generated, with 36.65kg being disposed of correctly and 0.56kg incorrectly. These totals are shown in Table 29 below. Once more, the next step was to calculate the percentage of the total for each category.

Table 29, the Auditing result for Atawhai, Code F1 Trial IV

Code F (Atawhai)	Category	Correct (kg)	Incorrect (kg)	Total (kg)	Total Volume (m3)
B1	Mixed Plastic	6.75	0.32	7.07	0.34
B2	Aluminium & Tin Cans	7.35	0.1	7.45	0.18
B3	Mixed Paper	10.2	0	10.2	0.09
B4	Mixed Glass Bottles	12.35	0.14	12.49	0.04
Total		**36.65**	**0.56**	**37.21**	**0.65**

Figure 64 below shows that once again mixed glass bottles was the highest category followed closely by mixed paper, aluminium and tin cans and mixed plastic at 34, 27, 20 and 19 % respectively.

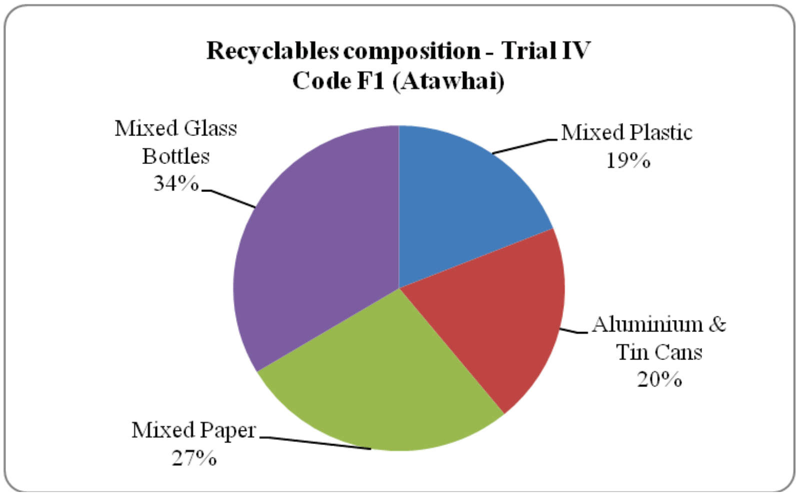

Figure 64, the percentage of recyclable categories for Code F1 Trial IV (Atawhai)

The barchart below, Figure 65, illustrates more clearly the percentages of contamination found for each category. This shows that there was minimal contamination for all categories although nearly 5 % for mixed plastic This contamination in the mixed plastic category consisted of paper and organic food. The average percentage of correct vs. incorrect was 98.3 to 1.7 %.

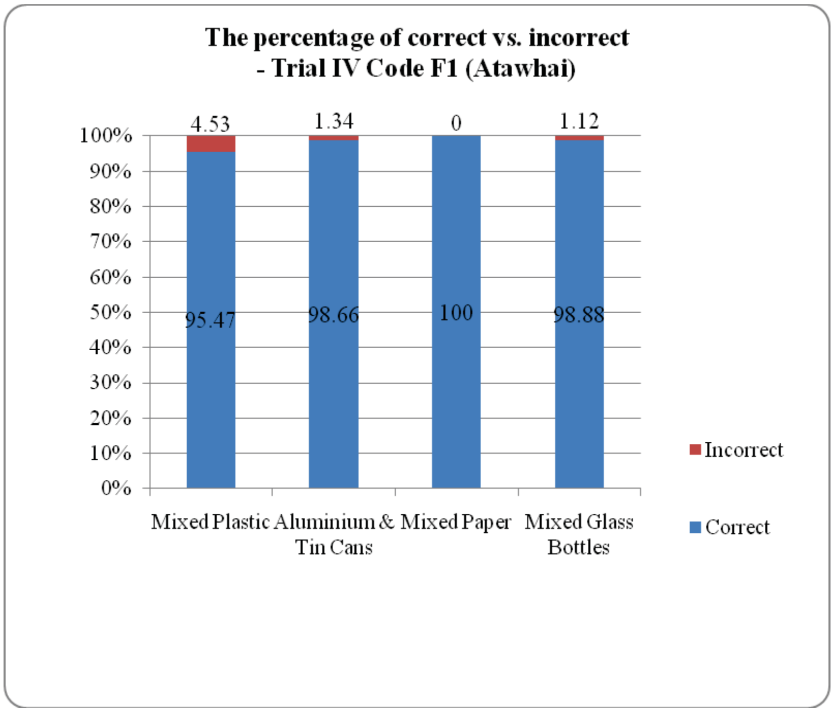

Figure 65, the percentage of correct vs. incorrect recyclables disposal for Code F1 Trial IV (Atawhai)

The following section will summarise the results for the audit carried out for Code F1 for all of the hostels in order to create a better picture of the results.

4.4.1.10 Summary of Recycling Audit for Student Hostels - Code F1 Trial IV

This section provides a brief overview of the results for the student hostel recycling wheelie bins that were audited during Trial IV. The barchart below, Figure 66, shows the total amounts in kg of each type of recyclable for each hostel.

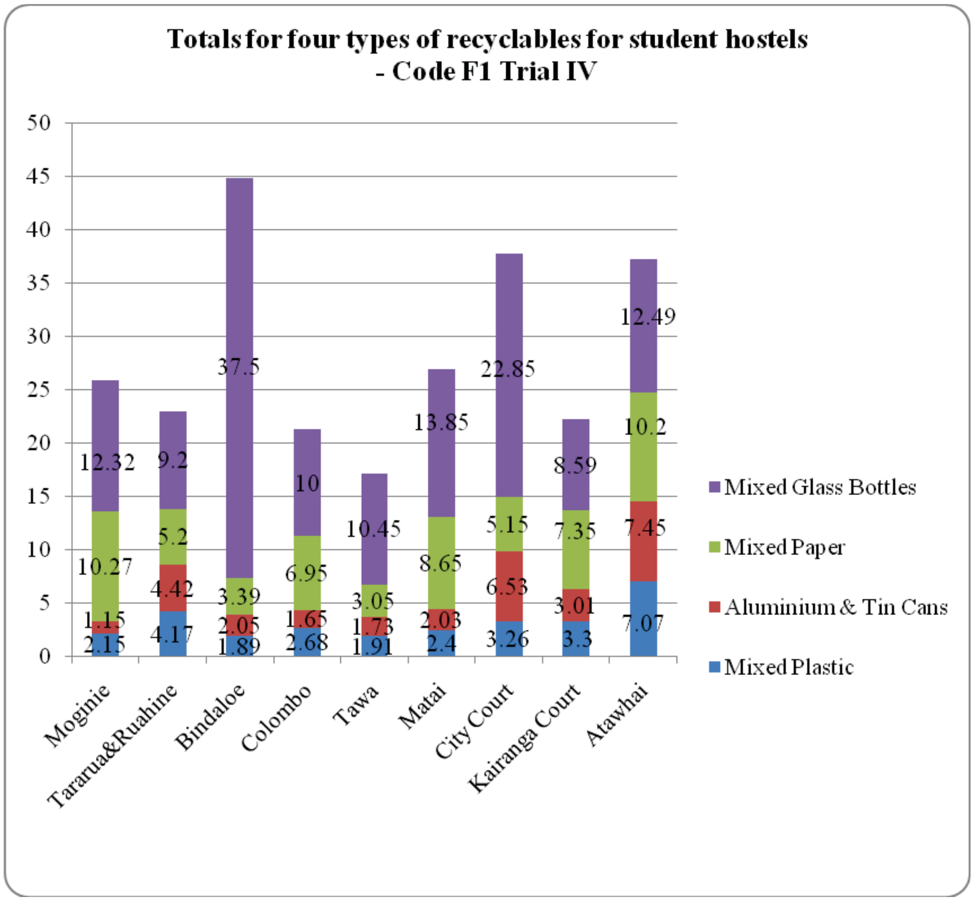

Figure 66, the total in kg for the four recyclable types at all nine hostels

This shows that the totals are quite variable across the hostels and in particular two of the mostly first year student hostels (Bindaloe and City Court) produced a high quantity of glass bottles. The range of totals for mixed glass bottles was from 8.59 to 37.5 kgs, mixed paper from 3.05 to 10.27 kgs, aluminium and tin cans from 1.15 to 7.45 kgs, and mixed plastic from 1.89 to 7.07 kgs. Bindaloe Hall, City Court and Atawhai Village produced the three highest totals overall and Tawa Hall produced the lowest total overall.

The volumes of recyclables produced by the hostels can be summarised as follows.

- Moginie Hall: 0.26 m^3
- Tararua and Ruahine Hall: 0.38 m^3
- Bindaloe Hall: 0.32 m^3
- Colombo Hall: 0.31 m^3
- Tawa Hall: 0.19 m^3

- Matai Hall: 0.29 m^3
- City Court: 0.44 m^3
- Kairanga Court: 0.32 m^3
- Atawhai: 0.65 m^3

The following Figure (67) illustrates the percentage of correct vs. incorrect disposal for all nine hostels. This visual representation helps to give a clear picture of where the key areas of concern over recycling behaviour are. If a single hostel was having major problems with recycling choices this would show clearly but this is not the case, and overall the majority of the choices being made are correct and indicate good recycling behaviour. The only incorrect percentage greater than 10 % was the 14 % contamination in the aluminium and tin cans category at Tawa Hall. This contamination consisted mostly of mixed glass bottles and cardboard packing boxes. Following this was the 9.3 % contamination in the mixed plastic category at Moginie Hall, which consisted mostly of organic food waste and aluminium cans. In all other cases the contamination level was below 6.5 % which indicates that the choices being made as to where to place recyclables are for the most part accurate.

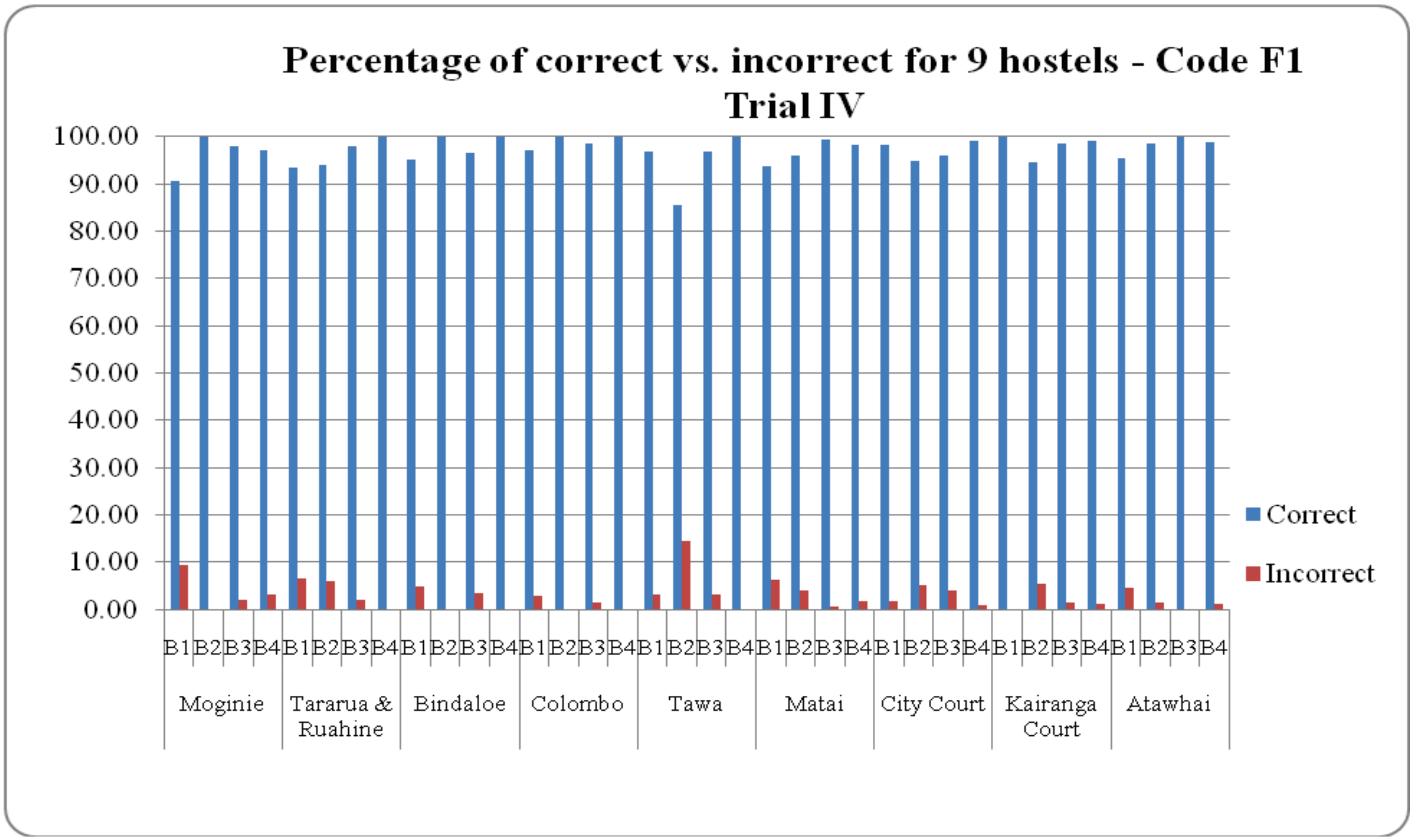

Figure 67, the percentage of correct vs. incorrect in the recycling wheelie bins for the 9 hostels, Trial IV

4.4.2 Auditing the Large Waste Bins (Code F2)

The auditing of the large waste bins at the hostels used the same process as for the large waste bins for code A1 in Trial II and III (section 4.2.1 and 4.3.1). This used the 12 category SWAP analysis to sort the waste, which was then weighed. This was carried out for four hostels Moginie, Colombo, Tawa and City and Egmont Courts. The results of this process are shown in Table 30 below.

Ta ble 30, the Auditing result for Code F2, Trial IV

Large Waste Bin	Category	Location	Waste/Resource Classification												Total kg
			Waste	Glass	Cans	Mixed Paper	Mixed Plastic	Organic Waste	Metal	Textiles	Rubber	Trees	Timber	Potentially Hazardous	
Code F2	Waste	Moginie	44.5	5.5	4.8	8.4	5.5	4.4	0.75					0.4	**74.25**
		Colombo	42.6	5.8	4.2	6.2	3.6	4.8						0.35	**67.55**
		Tawa	49.8	5.6	4.2	6.1	4.8	5.1							**75.6**
		City & Egmont Courts	57.2	9.3	6.3	11.3	6.8	6.6		0.55				0.8	**97.5**
Total			**194.1**	**26.2**	**19.5**	**32**	**20.7**	**20.9**	**0.75**	**0.55**				**1.55**	**313.4**

As can be seen from the above table the totals for the amount of material found in the large waste bins was reasonably consistent with a range from 67.55 to 97.5kgs. The bin with the highest total was actually used by two smaller hostels, and because the halls range in size of population it can be difficult to draw direct comparisons between the amount of materials produced. The majority of the materials could be categorised as waste, mixed paper, mixed plastic, glass, cans and organic waste, which reflects the function of the hostels as residences. During the audit process it was noted that the common materials found in the large waste bins as contaminants were food containers made of paper and plastic, glass and plastic bottles, food waste and cardboard packaging.

4.4.2.1 Moginie Hall

The following chart (Figure 68) displays the percentage per category of waste produced by Moginie Hall.

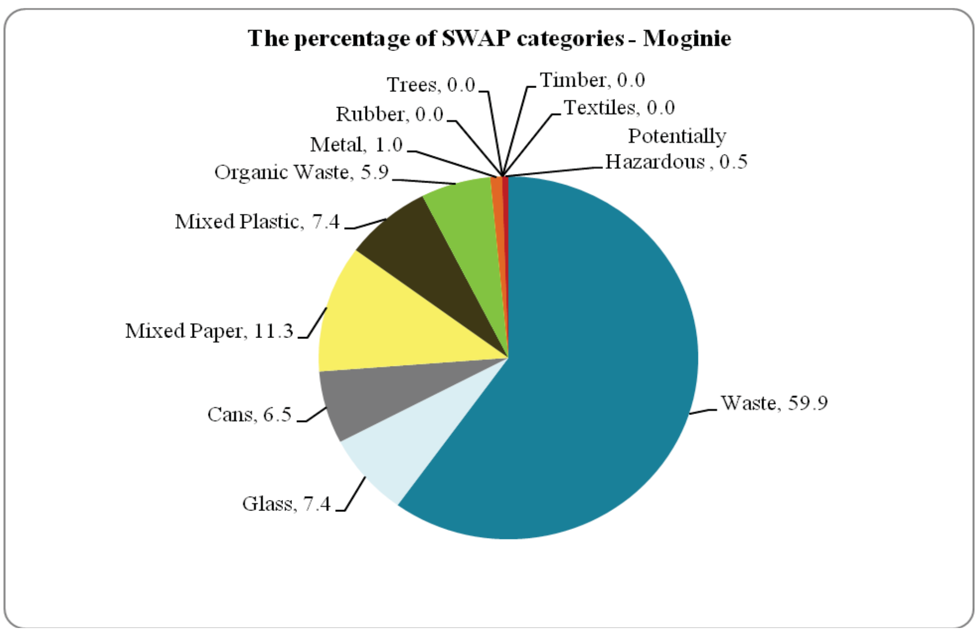

Figure 68, the percentage composition of Moginie Hall into twelve categories Code F2 Trial IV

The percentage found was 59.9 % for the waste category followed by mixed paper at 11.3 %, then mixed plastic and glass at 7.4 % each.

4.4.2.2 Colombo Hall

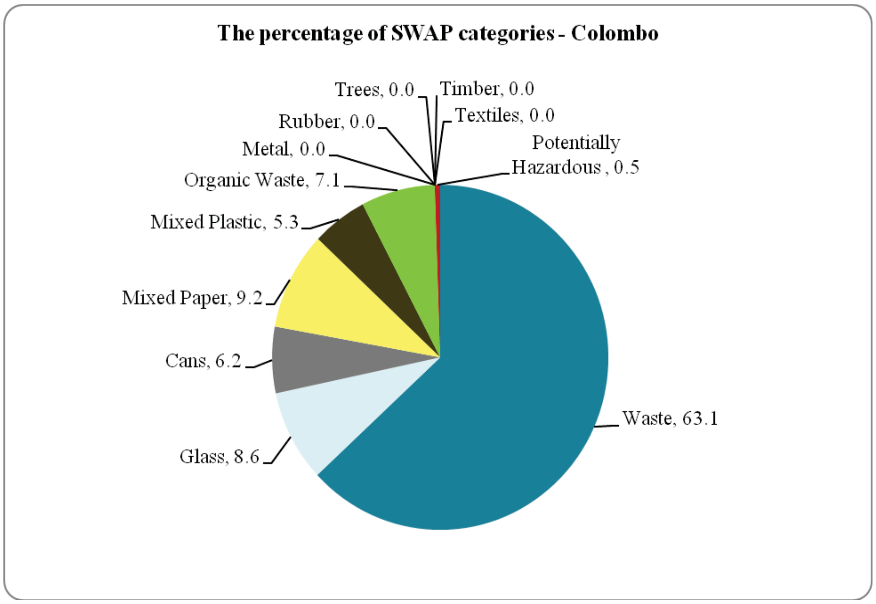

Figure 69, the percentage composition of Colombo Hall into twelve categories Code F2 Trial IV

As can be seen in the above chart (Figure 69) waste was the highest category at 63.1 % followed by mixed paper, glass and organic waste at 9.2, 8.6 and 7.1 % respectively.

4.4.2.3 Tawa Hall

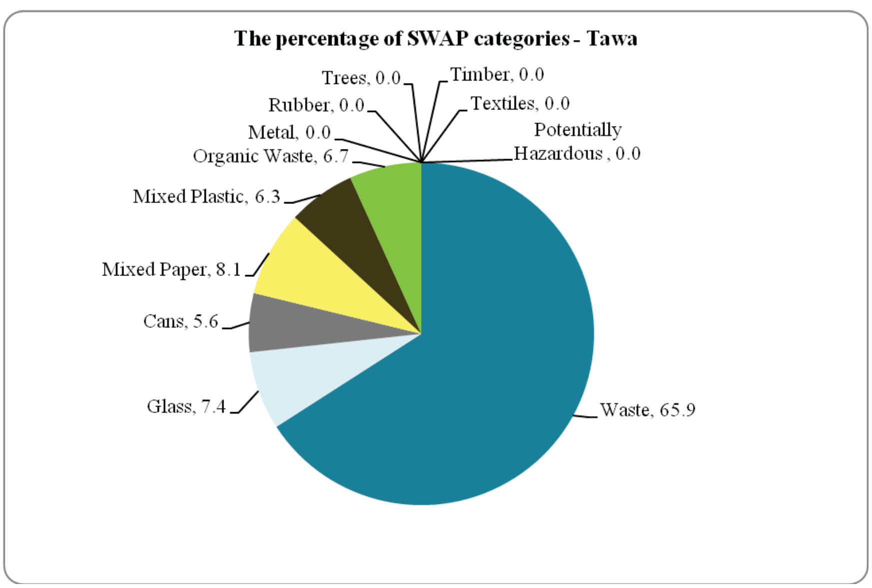

Figure 70, the percentage composition of Tawa Hall into twelve categories Code F2 Trial IV

For Tawa Hall waste was again the highest category at 65.9 % followed by mixed paper, glass, organic waste and mixed plastic at 8.1, 7.4, 6.7 and 6.3 % respectively (Figure 70).

4.4.2.4 City and Egmont Courts

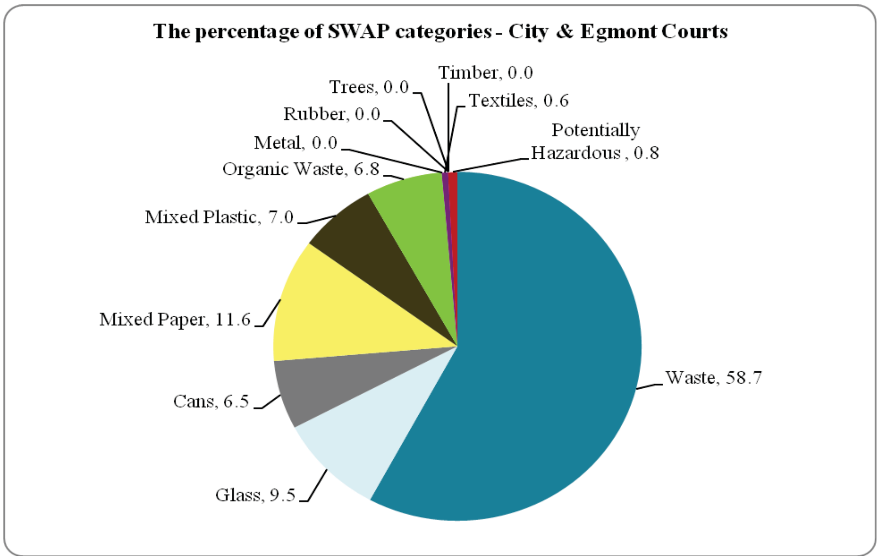

Figure 71, the percentage composition of City & Egmont Courts into twelve categories Code F2 Trial IV

And finally for City and Egmont Courts the highest category was waste at 58.7 % followed by mixed paper, glass, mixed plastic and organic waste at 11.6, 9.5, 7 and 6.8 % respectively (Figure 71).

4.4.2.5 Contamination of Large Waste Bins Code F2

As was done previously the 12 types of waste materials were recategorised into the 3 key waste streams of recyclables, compostable and waste. This process used the method from Trial II and III to maintain consistency. The results of this are shown in Table 31 below. This showed that the amounts for each category were similar across the four hostels and this is shown more clearly in the charts that were created below based on the percentage of each category of the total. This also meant that it was easier to determine the contamination levels of the large waste bins by combining the total of the recyclables and compostables.

Table 31, Categorisation into 3 waste streams for Code F2 Trial IV

Code F2 - Categorisation into 3 key waste streams				
Location	**Recyclables (kg)**	**Compostable (kg)**	**Waste (kg)**	**Totals (kg)**
Moginie	25.0	4.4	44.9	**74.3**
Colombo	19.8	4.8	43.0	**67.6**
Tawa	20.7	5.1	49.8	**75.6**
City & Egmont Courts	34.3	6.6	58.0	**98.9**
Totals	**99.7**	**20.9**	**195.7**	**316.3**

As is shown below in Figure 72, for Moginie Hall 40 % of the contents was contamination of recyclables and compostables.

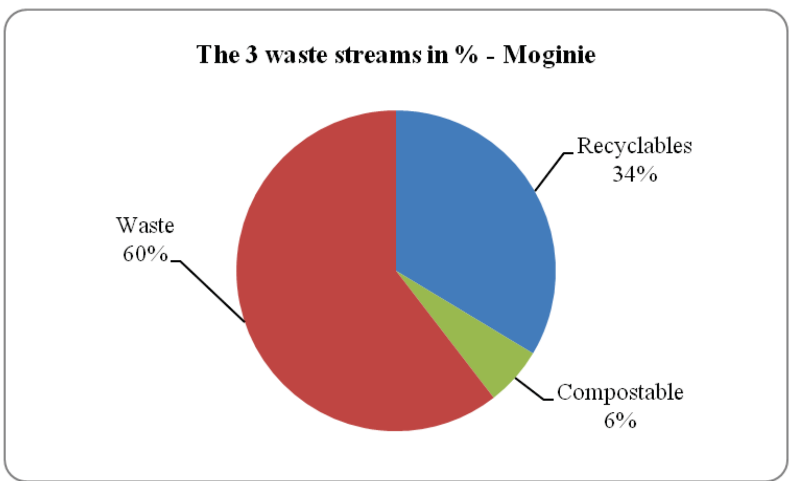

Figure 72, the composition by percentage of 3 key waste streams for Moginie Hall, Code F2 Trial IV

For Colombo Hall 36 % of the contents was contamination, as shown in Figure 73.

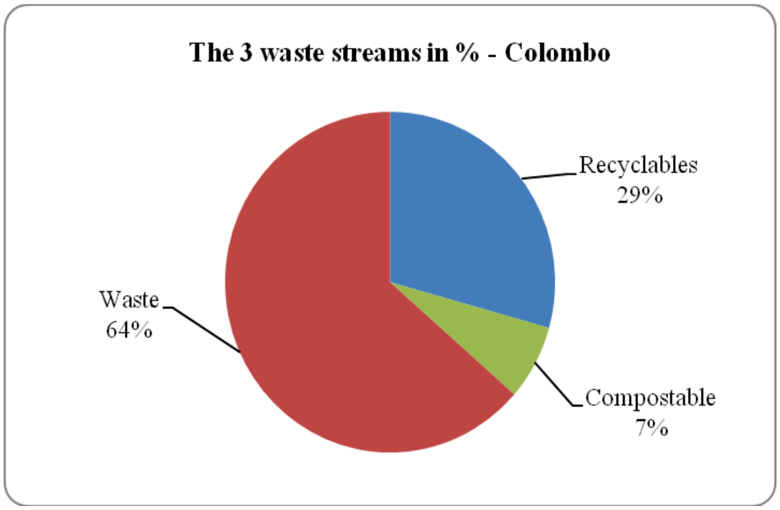

Figure 73, the composition by percentage of 3 key waste streams for Colombo Hall, Code F2 Trial IV

Figure 74 below shows that for Tawa Hall 34 % of the contents was contamination consisting of recyclables and compostables.

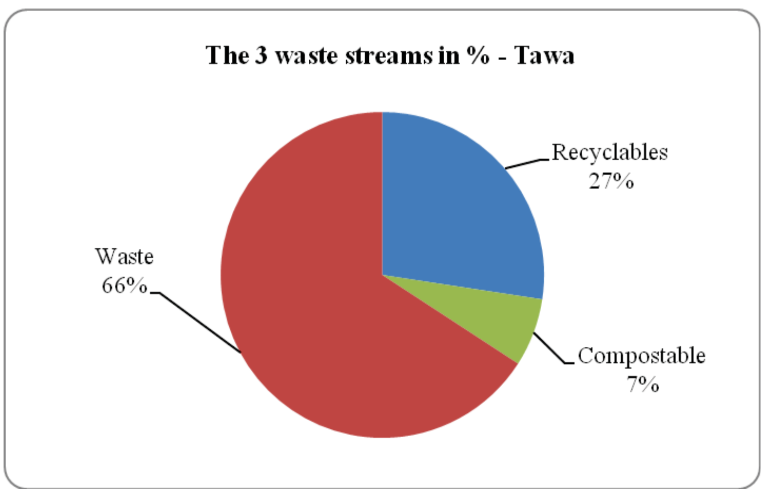

Figure 74, the composition by percentage of 3 key waste streams for Tawa Hall, Code F2 Trial IV

And finally for City and Egmont Courts (Figure 75) 41 % of the waste was actually recyclables and compostables.

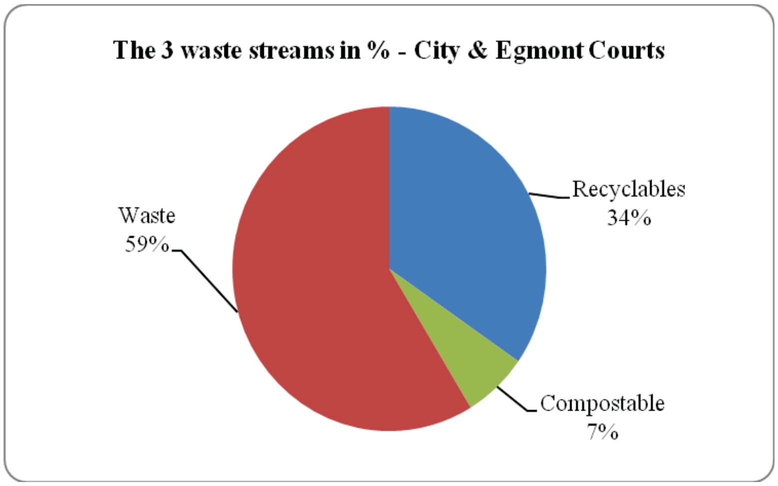

Figure 75, the composition by percentage of 3 key waste streams for City and Egmont Courts, Code F2 Trial IV

The range of contamination, or incorrectly disposed of materials was 34 % to 41 %. This is relatively high and shows that despite low contamination levels in the recycling clusters (Code F1) a considerable amount of resources are being disposed of incorrectly. This indicates that there needs to be an improvement in recycling behaviour to increase correct choices.

CHAPTER 5
DISCUSSION

The discussion section of this study, which consisted of four trials, is found below. The raw data presented above in the previous chapter (Chapter 4) has produced a number of results which now will be elaborated on in more detail. The discussion of this study are presented to address the research questions and accordingly, to achieve the objectives of this project. The research objectives are as follows;

1. Designing and trialling a suitable waste and recycling audit system for the campus.
2. Identifying the contamination levels in the waste and recycling bins selected for the study.
3. Reporting on the overall quantity of waste disposed of and the general recyclables and organic resources recycled on campus during each trial.
4. Having quantified, then advise Massey University Regional Facilities Management (RFM) on the effectiveness of the existing model for on campus collection and recycling.
5. Develop a set of recommendations for RFM (i.e. infrastructure design considerations, planning and implementation collections and processing) for a redeveloped campus recycling system.
6. Present these recommendations to RFM in way which mirrors a professional context and liaise and respond regarding queries and or follow-up actions.
7. Document this process as a model / pilot for the proposed Massey University 'sustainability internship' in which the campus is utilised as a living laboratory for addressing real world research problems through integrated learning.

By designing and undertaking the waste and recycling audit objective one was met. The results of this audit, which are in chapter four, identify and report on the contamination levels in the waste and recycling bins, and the quantities of waste and recyclables found to be generated during the four trials and fulfill objectives two and three. These are also discussed further in this chapter to follow along with the recommendations developed based on the audit findings. A briefing report was also created in order to communicate these findings and recommendations to RFM, which fulfilled objectives four, five and six. This report and the completed thesis will fulfil objective seven.

The following sections will discuss the audit findings for the four trials based on the bin codes.

5.1 Large Waste Bins and Recycling Cage Bins (Code A and Sub-code F2)

As mentioned in previously Code A is comprised of two categories, the large waste bin (Code A1) and the recycling cage bin (Code A2). Code A was audited during Trial II and III. In addition to this the large waste bins located at the student hostels (Code F2) were audited during Trial IV in order to provide information about the waste and recycling of the student hostels to RFM. So although these have a different code the can be compared to the other large waste bins as they are all a part of the same waste management system, that is collected by a private contractor, and were audited using the same method. The key findings from these audits will be discussed as follows.

5.1.1 Large Waste Bins (Sub-code A1 and F2)

Table 32 below shows the assembled results from the large waste bins audited in the various locations for all three trials based in the categorisation of the contents into recyclables, compostable and waste. Based on these totals the average total for each category was calculated for each trial as well as the average total for each category across the three trials.

Table 32, categorisation of Sub-code A1 and F2 into recyclables, compostable and waste, Trial II, III and IV

Categorisation into 3 key waste streams - Trial II, III, IV Code A1 & F2					
Location		**Recyclables (kg)**	**Compostable (kg)**	**Waste (kg)**	**Total (kg)**
Trial II	**Science Tower D**	10.4	4.9	57.5	**72.7**
	Social Science	29.5	5.4	69.6	**104.5**
Trial III	**Main Building**	49.2	8.8	45.3	**103.3**
	Riddet	29.9	5.5	26.7	**62.1**
Trial IV	**Moginie**	25.0	4.4	44.9	**74.3**
	Colombo	19.8	4.8	43.0	**67.6**
	Tawa	20.7	5.1	49.8	**75.6**
	City & Egmont Courts	34.3	6.6	58.0	**98.9**
Totals		**218.6**	**45.5**	**394.6**	**658.7**
Trial II Average		20.0	5.1	63.5	**88.6**
Trial III Average		39.5	7.2	36.0	**82.7**
Trial IV Average		24.9	5.2	48.9	**79.1**
Overall Average		**27.3**	**5.7**	**49.3**	**82.3**

The total amount of waste generated was 658.7kg for the 8 locations, the first four of which were education facilities while the latter four were student hostels. The recyclables found in the Science Tower D, Social Science, Main Building and Riddet bins were mostly mixed paper (e.g. news papers, magazines, paper hand towels, folders, and A4 paper). In this case, the main issue with these recyclable materials being placed into the waste bin may be explained by the many of the campus community that use these bins still being uncertain when it comes to what could be recycled and what could not be. Another factor may be that recycling facilities provided within the buildings are not widespread enough so recyclable materials end up going into general waste bins which are then emptied by cleaning staff into the large waste bins. One of the outcomes of the survey of students conducted by MUSA

(2008) was that more recycling bins were requested including inside buildings, which would help to address this issue, especially if combined with increased promotion of recycling across the campus. These facilities would need to be convenient, and this improvement to the current system would be likely to increase recycling behaviour (Thomos et al., 2004). Below is Figure 76, which illustrates the contamination level of recyclable materials, found in the large waste bin with photographs taken during the waste auditing process.

Figure 76, Examples of contamination of waste as found in the large waste bins

Based on the results obtained (which are shown in detail on pages 81, 98 and 131), the total amount of potential hazardous substances found in the bulk waste bin was considerable, especially in the location of Science Tower D and Social Science Tower (Trial II). The total percentage of hazardous substances found was approximately one fifth of the total materials during Trial II. The hazardous products found in these locations were mainly chemical products which were derived from laboratories. This incorrect disposal is an issue for both the environment, when they end up in landfills, and the campus community and waste contractors in terms of risks to human health (Tsai & Chou, 2004), so it is an important matter for Massey University to deal with. Figure 77 below shows examples of the potentially hazardous substances found during the large waste bin audit. It is important that Massey University takes the initiative to ensure that these are disposed of correctly in the future and this may involve working with PNCC or Horizons Regional Council as they will have hazardous waste disposal systems in place. It should also be noted that aerosol cans can actually be placed in the new kerbside recycling bins that PNNC provides to households, so the campus recycling system needs to be aligned with this in some way for these materials (PNCC, n.db). Depending on the annual quantity and types of hazardous substances there may be the need to develop a comprehensive programme between Massey and PNCC or Horizons Regional Council. An alternative approach to this issue is to contact the producers of the substances as in some cases they may have already developed recovery programmes for excess materials as well as containers. An example of this is the Agrecovery Rural Recycling Programme that was developed as an 'industry product stewardship scheme' for used agrichemical containers and other "on farm" waste issues, and has been operating since 2005 and includes the support of the many companies that produce agrichemicals (Agrecovery, 2011).

Figure 77, Examples of potentially hazardous substances as found in the large waste bins

Figure 78 below shows that the total amount of materials audited was quite similar across the three trials despite Trial III being conducted during summer semester when less students and staff would have been on campus. During the audit of Main Building and Riddet it was noted that there was a lot of mixed paper and mixed plastic disposed of in the large waste bin which contributed significantly to the total material. The paper seemed to be the result of an end of the university year clean out as it included papers and folders as can be seen in Figure 78, while the plastic was made up of bottles and the 55 litre black plastic bin bags that are used to collect the waste from the smaller internal bins. If facilities inside the buildings are improved and overall waste quantities reduced the amount of plastic bags should also be reduced.

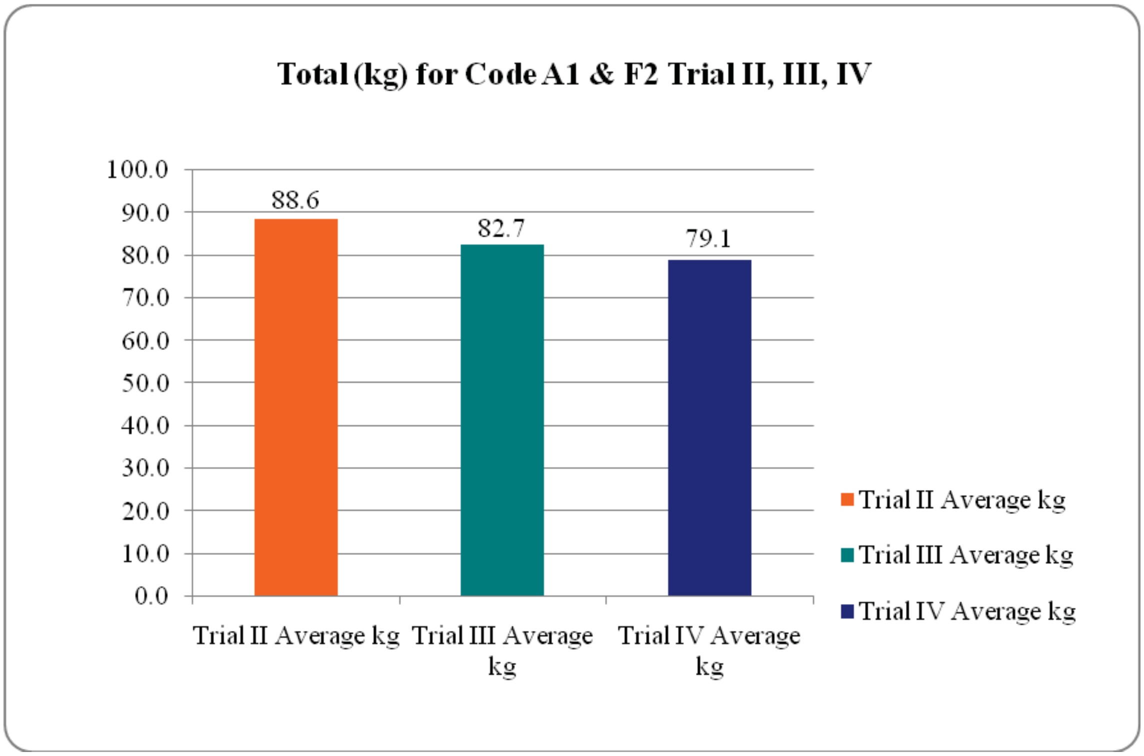

Figure 78, the average total (kg) of material audited during Trial II, III and IV, Code A1 and F2

By recategorising the materials from the 12 types based on the SWAP to the three categories of recyclable, compostable and waste it was possible to get a clearer picture of the types of resources being placed in the large waste bins. Figure 79 below compares the totals audited at each of the eight locations from all three trials.

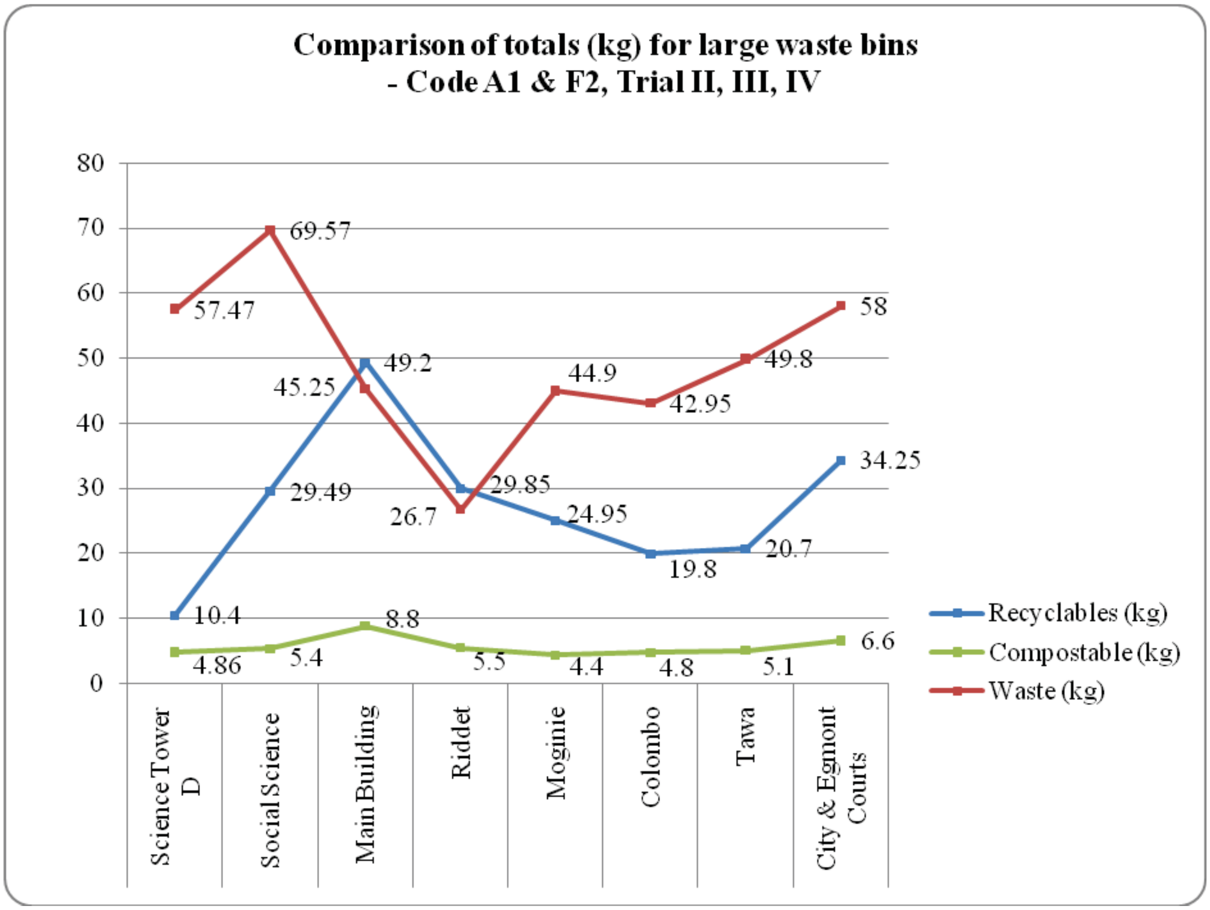

Figure 79, the comparison of totals (kg) for Code A1 and F2 Trial II, III and IV

This shows that particularly for Social Science during Trial I, Main Building and Riddet during Trial II, and the four student hostels (Moginie, Colombo, Tawa and Egmont and City Courts) the amount of recyclables in particular was higher when compared to Science Tower D. This reflects that poor recycling choices are being made by the people in these locations, and shows that potentially across the wider campus this may be happening as well. Because of the fact that most of the materials in the large waste bins come from the interior bins, in order to change the recycling behaviour the changes need to be focused on improving the interior recycling facilities. Figure 80 below displays the percentages of recyclables, compostable and waste for each location.

This shows that the percentage of waste found within the large waste bin audits ranged from around 43 to 70 %. Conversely, this means that the range of compostable and recyclable materials found in these bins ranged from 57 to 30 %. This confirms that a high percentage of resources is being lost by being disposed of incorrectly into these waste bins. By looking at these percentages a clearer picture can be gained of recycling and waste management practices than would be given by just looking at the amount of contamination shown in the dedicated recycling bins and this is important to consider for future audits. In view of the fact that the large waste bins are collected by commercial contractors internal audits are the only way to find out about these contamination levels.

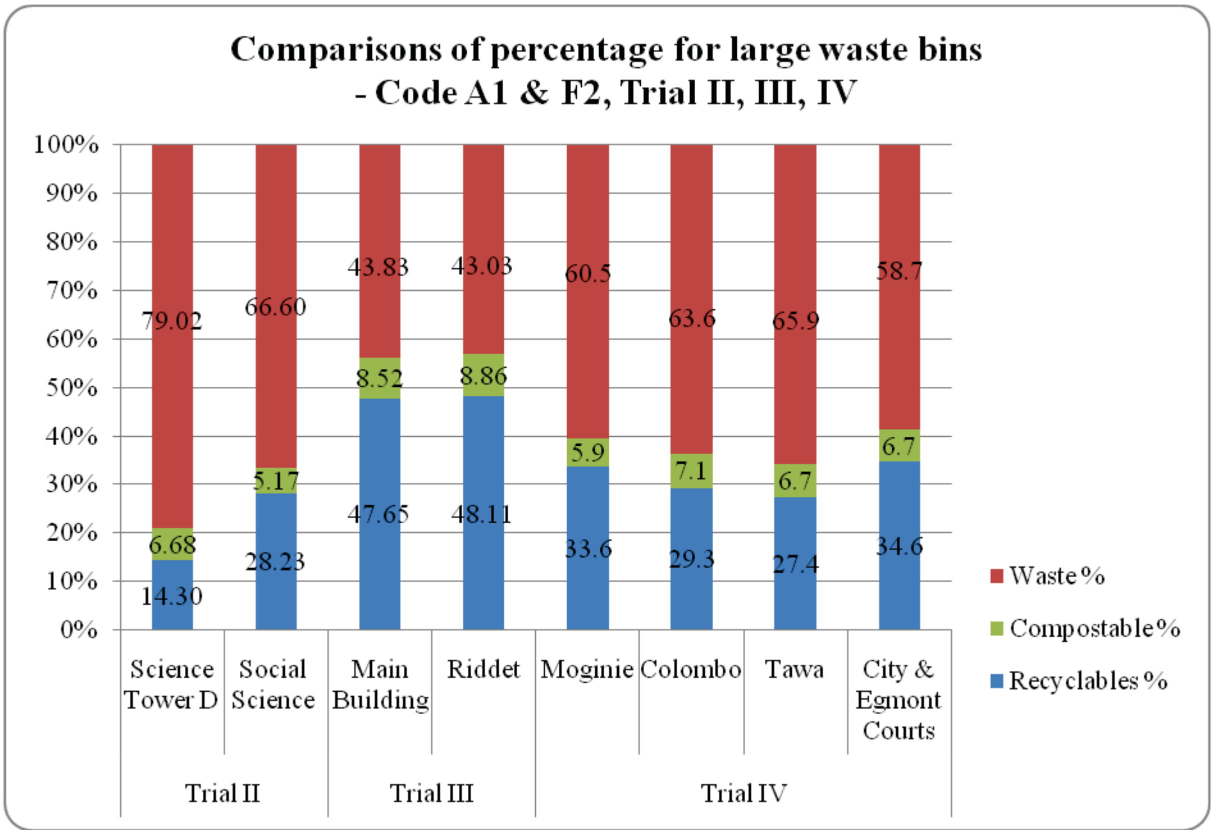

Figure 80, the comparison of the percentage of waste, recyclables and compostable waste for Code A1 and F2 across T II, III and IV

The barchart above also shows a comparison between the four hostel locations and at this stage we can consider the characteristics of these that may be relevant. Moginie Hall, Colombo Hall, Tawa Hall, and City and Egmont Courts are all mostly first year, domestic students.

Figure 81 below shows the average percentages of recyclables, compostable and waste based on the survey periods of the three trials. By using these averages and categories it is possible to illustrate the percentage of recyclable and compostable resources being discarded in the waste bins for each trial. The extent of this type of contamination was from 28.3 % in Trial II, 52.2 % in Trial III and 38.1 % in Trial IV. While you normally expect the contamination level to decrease during summer semester (Trial III) in this case the high quantity of papers and files discarded in the Main Building bin increased the amount of recyclables. For activities such as this (cleaning out files, etc) which may be seasonal in a university there may be a need to ensure that extra recycling facilities are provided and staff are reminded about the zero waste programme at Massey and the importance of recycling valuable resources. Additionally this graph shows the consistent amount of compostable waste that was generated and disposed of into the large waste bins. As another valuable resource that it being lost by being disposed of incorrectly there is a need to develop and improve the facilities for and recycling choices made for compostable waste. The compostable waste facilities were installed in the staff common rooms in March and April 2010 which was before these audits were conducted, and these results show that there needs to be further work undertaken to expand the use of these, whether it is through increased access or raising awareness.

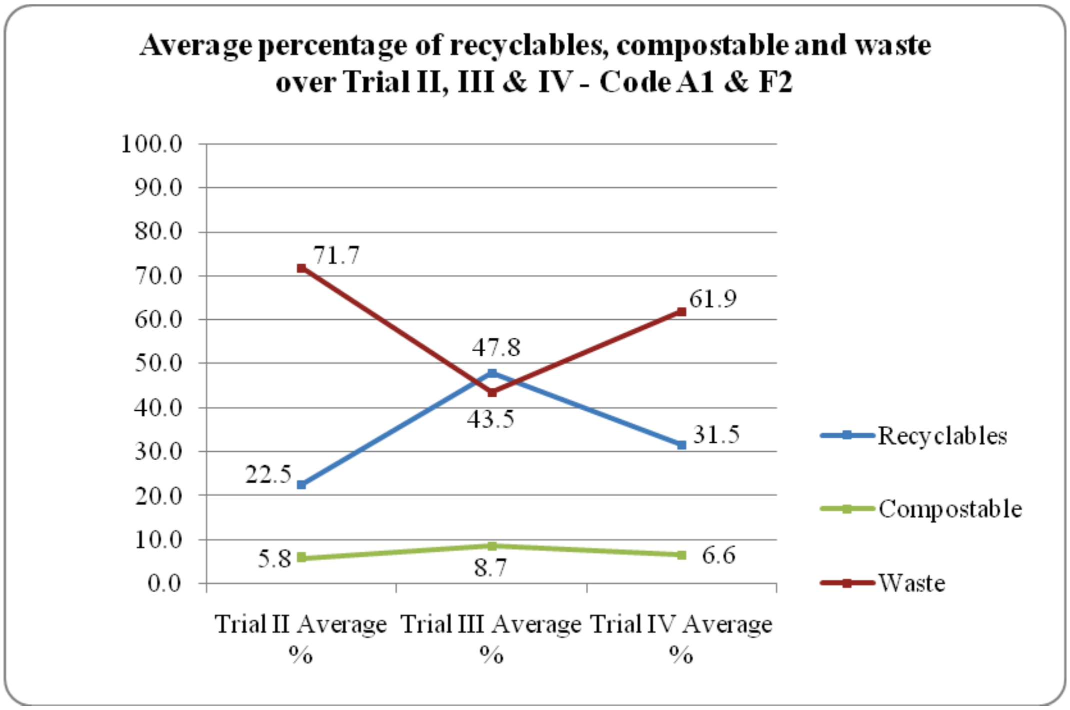

Figure 81, the average percentage of recyclables, compostable and waste, Code A1 and F2 Trial II, III and IV

The audit of the student hostels large waste bins revealed that 38.1 % of the contents was made up of recyclable and compostable material, and being disposed of incorrectly in the large waste bins. This contamination was a range of recyclable materials such as mixed paper and plastic and glass bottles, as well as organic food waste. There are no facilities provided for compostable waste at the student hostels, although there are recycling clusters supplied. However these facilities need to be improved in order to increase the use of them and make recycling choices for residents easier. Currently the signage for these recycling wheelie bins is ambiguous, and in some cases unreadable due to sun damage, or missing. In addition to this the way in which the waste is collected from the hostels is similar to the other buildings at Massey, which means that smaller interior bins are emptied into large waste bags and placed in the large waste bins by cleaners. This can be improved by providing interior recycling facilities within the student hostels, which would result in a decrease in the amount of resources being discarded into the large waste bins.

Figure 82 below displays the overall average percentage of recyclables, compostable and waste for all the locations and across all three audits. This shows that only 60 % of the materials of the large waste bins were disposed of correctly. If the recyclable and compostable materials were discarded of appropriately, there would be less contamination found in the large waste bins and as a result the amount of waste sent to the landfill would be reduced. In order for this to happen recycling and compostable facilities need to be improved and further developed to be clearer and more accessbile within locations such as university buildings and student hostels across Turitea campus. This result shows that it is necessary to influence current behaviours of those using this bin in order to facilitate achieving the goals of Massey Universities zero waste programme.

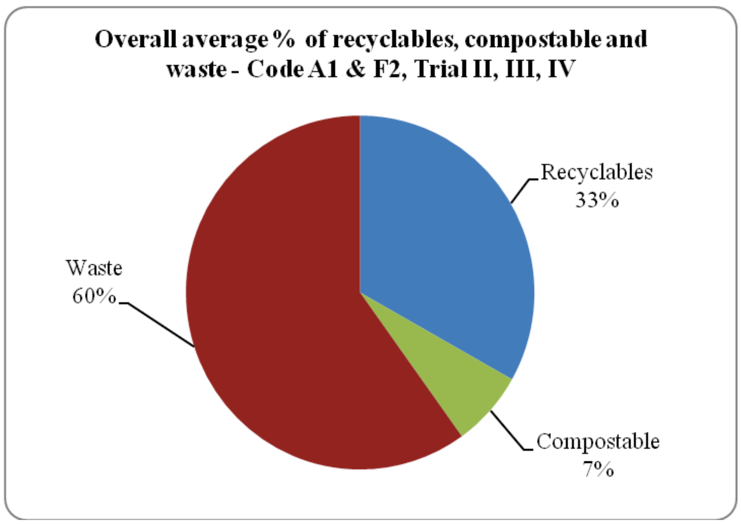

Figure 82, the overall percentage of recyclables, compostable and waste for Code A1 and F2, Trial III, III and IV

5.1.2 Paper/Cardboard Recycling Cage Bins (Sub-code A2)

For the paper/cardboard recycling cages three sudits were conducted with the first being located at the Green Bike Trust during Trial II (semester 2), and the second and third at Main Building and Riddet during Trial III (summer semester). The compiled audit results are shown in Table 33 below and Figure 83 illustrates the typical contents of these bins. This shows that most of the material found is papers and cardboard, as it should be in these cage bins.

Table 33, the Auditing result for Sub-code A2 Trial II and III

Code	Category	Trial	Location	Correct		Incorrect		Total (kg)
				(kg)	(%)	(kg)	(%)	
A2	Cardboard Recyclable	Trial II	GBT	224	99%	3	1%	227
		Trial III	Main Building	485	100%	0	0%	485
			Riddet	115	100%	0	0%	115
Total				**824**		**3**		**827**
Average %					**100%**		**0%**	

Figure 83, contents of the mixed paper recycling cage bins

While the contamination levels of the A2 bins were very low, the key conclusion from these audits was that a considerable amount of paper was being disposed of, especially taking into consideration that for Main Building and Riddet there was also a 40kg of mixed paper put into the large waste bins. As previously mentioned it seemed that the activities of the building occupants had a direct impact on the quantity of paper and cardboard found at Main Building, namely that there had been an 'end of the year clean out' taking place. In relation to the quantities of paper and cardboard produced this indicates that Massey University operates in a very similar way to an office environment and because of this faces the same challenges in reducing the amount of paper produced in day to day activities. Ideally there needs to be a campus wide programme implemented to reduce the amount of cardboard and paper produced, and this fits with the focus of zero waste which prioritises rethinking and reduction before recycling. Recommendations in relation to this will be made further on in this section.

5.1.3 Recycling Wheelie Bins (Code B and Sub-code F1)

This section discusses the findings of the audit of the wheelie bins located on the concourse and in the student Dining Hall (Code B) that were audited during Trial I, II and III, combined with those located at the student hostels (Sub-code F1). These are a part of the campus wide recycling clusters that are a key component of the Massey zero waste programme. The recycling wheelie bin system aims to provide disposal for recyclables into four categories in order to streamline the this waste disposal process and reduce the amount of recyclables going to landfill through increased recycling behaviour. The trials were conducted across the various survey periods which included the summer semester, when student numbers are greatly reduced, as well as semester two, when there are high numbers of students and staff on campus. While the Sub-code F1 bins were audited during an overall trial of the student hostels, the results are able to be compared to the Code B bins as the same process was carried out as for Code B trial I, II and III. The key findings from these audits will be discussed as follows.

Table 34, the Auditing results of correct vs. incorrect for the recycling wheelie bins (Code B & F1), Trial I, II, III and IV

No	Trial	Category										Total (kg)	Total Volume (m3)
		Mixed Plastic (B1)		Aluminium, Tin,& Cans (B2)		Mixed Paper (B3)		Mixed Glass Bottles (B4)		Waste (B5)			
		Correct (kg)	Incorrect (kg)	Correct (kg)	Incorrect (kg)	Correct (kg)	Incorrect (kg)	Correct (kg)	Incorrect (kg)	Correct (kg)	Incorrect (kg)		
1	Trial I	8.51	2.64	44.93	3.03	2.61	0.58	63.96	0.1	19.18	3.59	**149.13**	2.05
2	Trial II	20.75	1.14	11.55	0.43	65.55	15.13	66.85	0.33	17.32	20.7	**219.75**	2.33
3	Trial III	13.6	1.31	14.4	0.05	27.35	10.88	89.9	0.95	22.3	9.25	**189.99**	1.76
4	Trial IV	27.6	1.23	28.83	1.19	59.22	0.99	136.2	1.05	195.65	120.6	**572.56**	3.16
Total		**70.46**	**6.32**	**99.71**	**4.7**	**154.73**	**27.58**	**356.91**	**2.43**	**254.45**	**154.14**	**1131.43**	**9.3**
Average %		**91.8**	**8.2**	**95.5**	**4.5**	**84.9**	**15.1**	**99.3**	**0.7**	**62.3**	**37.7**		
												Correct	**Incorrect**
Overall % correct vs. incorrect for TI, II & III												**87.5%**	**12.5%**
Overall % correct vs. incorrect for T I, II, III & IV												**82.8%**	**17.2%**

Table 34 on the previous page shows the accumulated audit results for the correct vs. incorrect contents of the recycling wheelie bins from Trials I, II, III and IV, across the various locations. By looking at the results for each of the five categories you can see that the majority of the recyclables were disposed of correctly, with the range of contamination being from 0.7 to 15.1 % for the four categories of recyclables, with mixed paper and waste having the highest contamination levels. This shows the key areas of recycling behaviour which need to be addressed, and also highlights again the two areas of recycling behaviour. These are the making of correct choices when recycling, i.e. paper vs. plastic, and the decision to recycle rather than just place all materials into the general waste bin. The first of these behaviours may be enhanced through improved signage and facilities (Kelly et al., 2006; Thomas et al., 2004), while the second may take more effort and involve raising awareness about the importance of recycling and other zero waste strategies. An additional factor to consider is that the contrast between the recycling facilities provided at Turitea campus and the recently established household curbside recycling system which uses a single bin for mixed plastic, paper/cardboard and aluminium disposal may be causing confusion for some people. It is possible that others may feel some apathy in using the on campus facilities when they can see that there is a much simpler system being used elsewhere and don't understand why there is this difference between Massey and PNCC. This reinforces the need to redesign the recycling facilities provided on campus to align with those provided by PNCC, or at the very least to ensure that clear signage is installed to simplify choices for users.

Figure 84, examples of contamination of the mixed paper (B3) wheelie bins

Figure 85, examples of contamination of the waste (B5) wheelie bins (no signage)

In order to correctly assess the recycling behaviour overall the waste bin audit results were also included to see what percentage of the contents should have been recycled, and as can be seen in the table this was an average of 37.7 % of the contents. This was increased in large part by the Trial IV results from the student hostels. Because the facilities provided at the hostels are slightly different from the other recycling clusters in that the waste goes into large waste bins not wheelie bins, this would have some effect on the use of them, in particular that they are used by cleaners for waste disposal. However the results still stand and show that even discounting the large waste bins for Trial IV over 12.5 % of the waste from Trial I, II and III should have been recycled. When Trial IV is included the overall percentage increases to 17.2 %, which was determined by adding all of the incorrect totals together and calculating their percentage of the total. The following tables (35 and 36) show a comparison of the average correct vs. incorrect percentages for each trial both including the waste bins and excluding the waste bins. The general pattern was that incorrect recycling behaviour increased when the audit of the waste category was included. This shows that some people are choosing not to recycle and resources are being lost by going into waste bins which are disposed of into landfills.

Table 35, the comparison of average percentage, Code B and F1 Trial I, II, III and IV, without waste included

Comparison of average % without waste category for recycling wheelie bin - Code B & F Trial I, II, III, IV		
Code and Trial	Correct %	Incorrect %
Code B Trial I	95	5
Code B Trial II	91	9
Code B Trial III	92	8
Code F1 Trial IV	98.3	1.7

Table 36, the comparison of average percentage, Code B and F1 Trial I, II, III and IV, with waste included

Comparison of average % with waste category for recycling wheelie bin - Code B & F Trial I, II, III, IV		
Code and Trial	Correct %	Incorrect %
Code B Trial I	93	7
Code B Trial II	83	17
Code B Trial III	88	12
Code F1 Trial IV	78	22

In order to give a visual representation of these tables the following barchart (Figure 86) was created to highlight the difference between the analysis with the waste category included and the analysis without it.

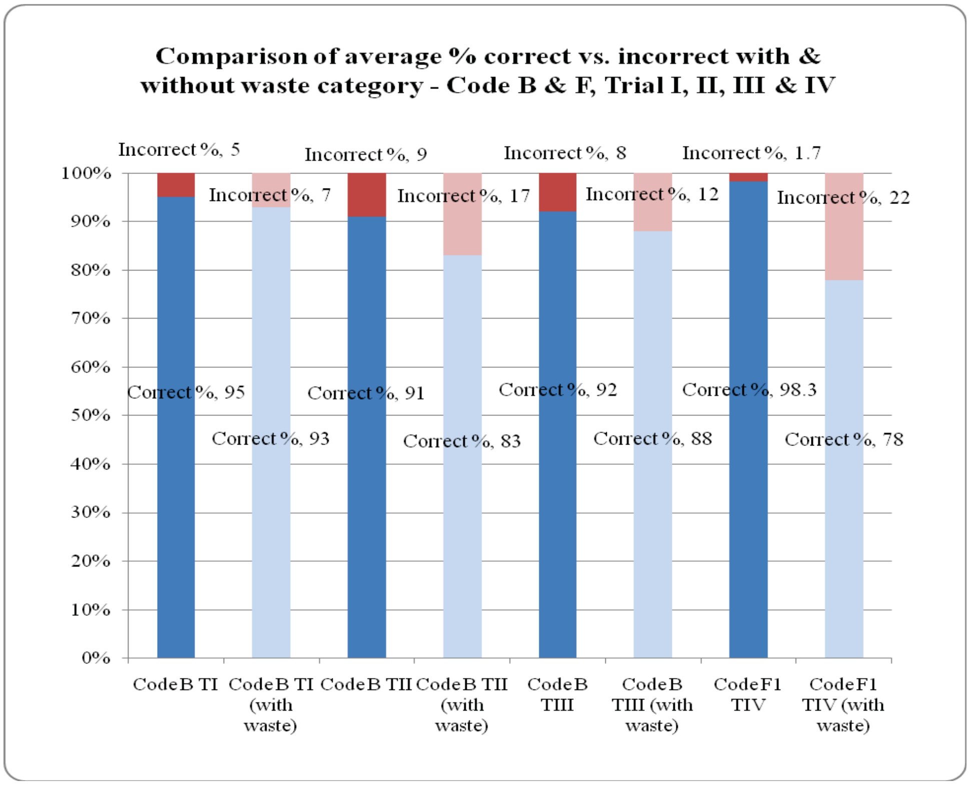

Figure 86, the comparison of average contamination for Code B and F1 acrosss Trial I, II, III and IV, both including and excluding waste category

While for Trial I the difference was minimal at 2 %, for Trial II and III the difference shown for incorrect disposal including waste was 8 % and 4 % respectively. However for Trial IV the difference was considerable with a 20.3 % increase in incorrect recycling behaviour when the waste bins were considered as well. In particular the Trial IV Code F1 result shows the importance of including the contamination found in the large waste bins in order to really understand the recycling behaviour going on at the student hostels. Without including the waste bins it would be easy to see the results just from the recycling wheelie bins and assume that the majority of the recycling choices being made were correct. This highlights the importance of the recycling and waste audit at the student hostels, particularly as places where eating and drinking take place (Mason et al., 2004), and recognises that it is a key part of any future redesign or redevelopment of the recycling facilities.

Figure 87 below shows the average percent of correct vs. incorrect across all four trials and clearly illustrates that the range of contamination is from 3 to 22 %. This confirms that there is a definite need to improve the current recycling cluster system to ensure that the amount of recyclable and compostable resources being disposed of incorrectly are reduced, and a part of this will be to develop a way to reduce contamination within recyclable category (sub-code B1, B2, B3 and B4) bins and so reduce the need to resort the contents as is currently carried out by the GBT. A development to the current system that will help to reduce the comtamination levels would be the provision of bins for the disposal of compostable organic food waste as this makes up a considerable part of the incorrectly disposed of materials in the mixed paper, mixed plastic and waste categories. This would need to be accompanied with a marketing campaign to raise awareness about the importance and ease of composting food waste. In 2010 the introduction of paper bowls for use in the Dining Hall did result in a reduction of mixed plastic materials, and this illustrated a re-thinking of the practice at the time while still working with the recycling facilities that were in place. It is important for factors such as this to be continually monitored as advances are made in production of biodegradable food containers, for example starch based bowls and plates (PotatoPak NZ Ltd, 2010), which may make them an economically feasible option in the future. If a comprehensive compostable waste system is put in place then this type of prospective change would also become feasible in terms of the disposal facilities' ability to manage this change. The results for Trial II and IV below also show that the contamination levels increase during semester one and two when more students and staff are on campus, which was expected.

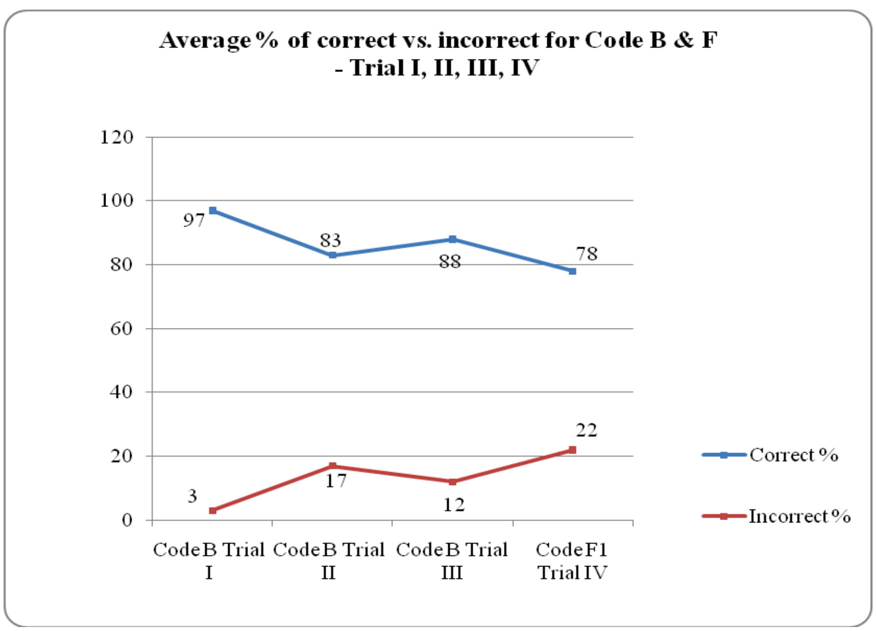

Figure 87, the average % of correct vs. incorrect for Code B, Trial I, II, III and Code F1, Trial IV

While the recycling wheelie bins at the hostels are a part of the campus wide system the results from the Trial IV audit provide detail that may be used to improve the recycling behaviour in relation to the characteristics of the individual hostels. The general characteristics are that:

- Moginie; mostly first year students, mostly domestic.
- Tararua and Ruahine; mix of first year and mature students, mostly international.
- Bindaloe; first year students, mostly domestic.
- Colombo; mostly first year students, mostly domestic.
- Tawa; first year students, mostly domestic.
- Matai; first year students, mostly domestic.
- City Court; first year students, mostly domestic.
- Kairanga Court; mature students, mostly international.
- Atawhai; mature students, mostly international.

These characteristics will be considered during the following discussion about the results of the student hostel recycling wheelie bins audited.

Figure 88 below shows the total amount of each category of recyclable found at each hostel during the audit of Trial IV. While these totals were relatively consistent there were a few noteworthy differences, namely that Bindaloe had a high total of mixed glass bottles, as did City Court, although Bindaloe's total was much higher. Generally mixed plastic and aluminium tins and cans had the lowest total for the type of recyclable found, and mixed glass was the highest. These differences may be attributable to the different characteristics of the hostel populations, such as age and whether or not they are first year students. During the audit, which was carried out on Tuesday and Thursday, it was observed that the majority of the recyclables in the student hostels were being produced on Thursday, Friday and Saturday and this resulted in excess amounts to be collected when the bins were emptied on Tuesday. On the other hand when the bins were emptied on the Thursday there was only a small amount of recyclables to collect. This made it clear that more thought needed to be given to the collection days and that Friday and Monday would be more suitable.

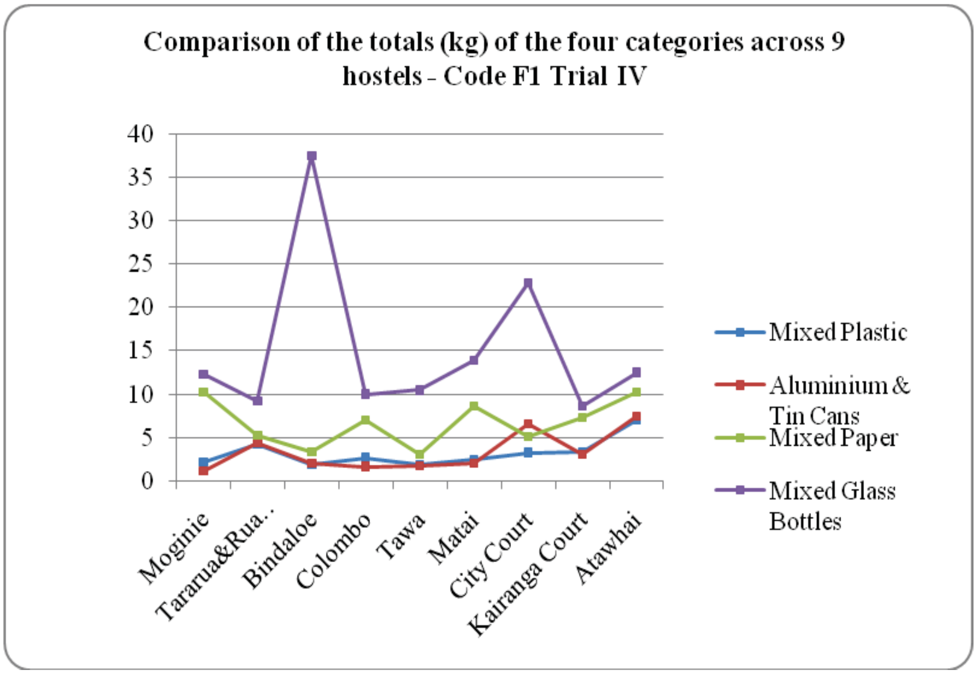

Figure 88, the comparison of totals per recyclable category for all 9 hostels by weight (kg)*, *Code F1 Trial IV

The following piechart, Figure 89, displays the percentage each hostel contributed to the overall total of recyclables audited for Code B Trial IV. These ranged from 7 to 17 %. This shows that all hostels are participating in the recycling programme to some extent. Bindaloe and City Courts contributed the highest percentage at 17 and 15 % respectively, while the contribution of the other seven hostels ranged from 7 to 10 %.

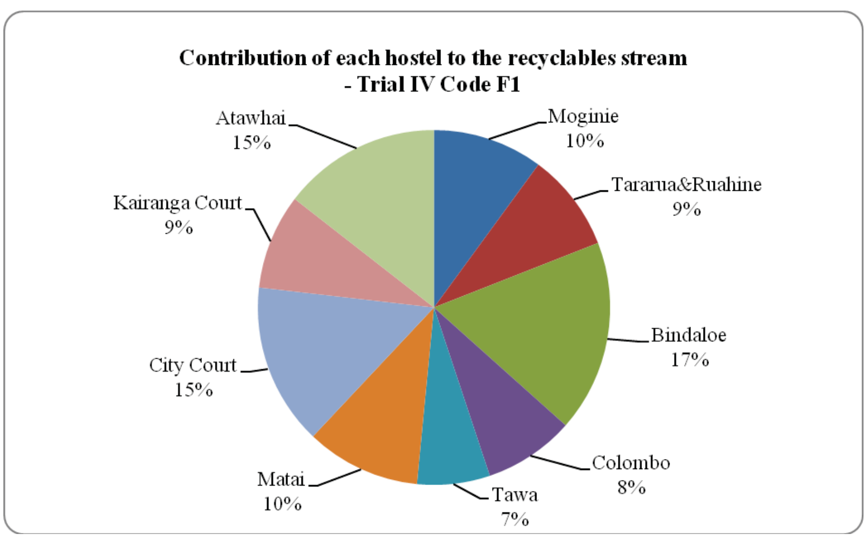

Figure 89, the contribution of each hostel to the recyclables stream, Code F Trial IV

Table 37 below displays the percentage of correct vs. incorrect that was calculated from the audit results for each sub-code for each hostel location. In addition to this it also shows the average percentage for each hostel which was calculated across the sub-codes, and the average percentage for each sub-code which was calculated by combining the results of all of the nine hostels. This shows that the range of incorrect disposal for the four sub-codes was on average from 0.87 to 4.36 %, and that the overall total for incorrect disposal for all nine hostels was 1.7 %. These figures are only the result for the recycling wheelie bins and so do not represent the amount of recyclables and compostable waste that is being disposed of incorrectly in the large waste bins. By considering these results it is possible to see whether the correct choices are being made when people are choosing to recycle, and relate this to the current recycling facilities that are provided. At 1.7 % incorrect disposal the recycling behaviour of the students living at these hostels is generally efficient, and the recycling clusters are being used as they should be. This level of contamination is much lower than that found during the Code B audits (17.2 %) across the rest of campus and this may reflect that the students living on campus have a better understanding of the recycling facilities and more buy in in terms of trying to reduce the amount of waste produced on campus. There is also the possibility that by living and studying on campus and having less exposure to the PNCC household recycling system there is less confusion about where the types of recyclables need to be deposited.

Table 37, Total (kg) correct vs. incorrect and correct vs. incorrect percentage calculations for the student hostels, Code F1 Trial IV

No	Code F1 - Student Hostels	% Correct vs. Incorrect								Total (kg) Correct vs. Incorrect	
		Mixed Plastic (B1)		Aluminium & Tin Cans (B2)		Mixed Paper (B3)		Mixed Glass Bottles (B4)			
		Correct	Incorrect	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect
1	Moginie	90.70	9.30	100.00	0.00	97.86	2.14	97.00	3.00	**36.65**	**0.56**
2	Tararua&Ruahine	93.53	6.47	93.89	6.11	98.08	1.92	100.00	0.00	**21.9**	**0.35**
3	Bindaloe	95.24	4.76	100.00	0.00	96.46	3.54	100.00	0.00	**37**	**0.79**
4	Colombo	97.01	2.99	100.00	0.00	98.56	1.44	100.00	0.00	**26.4**	**0.53**
5	Tawa	96.86	3.14	85.55	14.45	96.72	3.28	100.00	0.00	**16.73**	**0.41**
6	Matai	93.75	6.25	96.06	3.94	99.42	0.58	98.19	1.81	**21.1**	**0.18**
7	City Court	98.16	1.84	94.95	5.05	96.12	3.88	99.12	0.88	**44.17**	**0.21**
8	Kairanga Court	100.00	0.00	94.68	5.32	98.64	1.36	98.95	1.05	**22.35**	**0.64**
9	Atawhai	95.47	4.53	98.66	1.34	100.00	0.00	98.88	1.12	**25.1**	**0.79**
Average % across hostels		**95.64**	**4.36**	**95.98**	**4.02**	**97.98**	**2.02**	**99.13**	**0.87**		
Overall % correct vs. incorrect for 9 hostels TIV										**98.3%**	**1.7%**

In addition for this by calculating the average percentage of correct vs. incorrect disposal for each category (Figure 90 below) it was possible to see that contamination levels were the highest for mixed plastic and aluminium and tin cans, and lowest for mixed paper and mixed glass bottles. For mixed plastic and aluminium and tin cans this contamination for the most part consisted of organic food waste and mixed paper. The generally low levels show that for the most part correct recycling choices are being made for for all categories once people decide to use the recycling bins, but there are some incorrect ones being made resulting in the low level contamination.

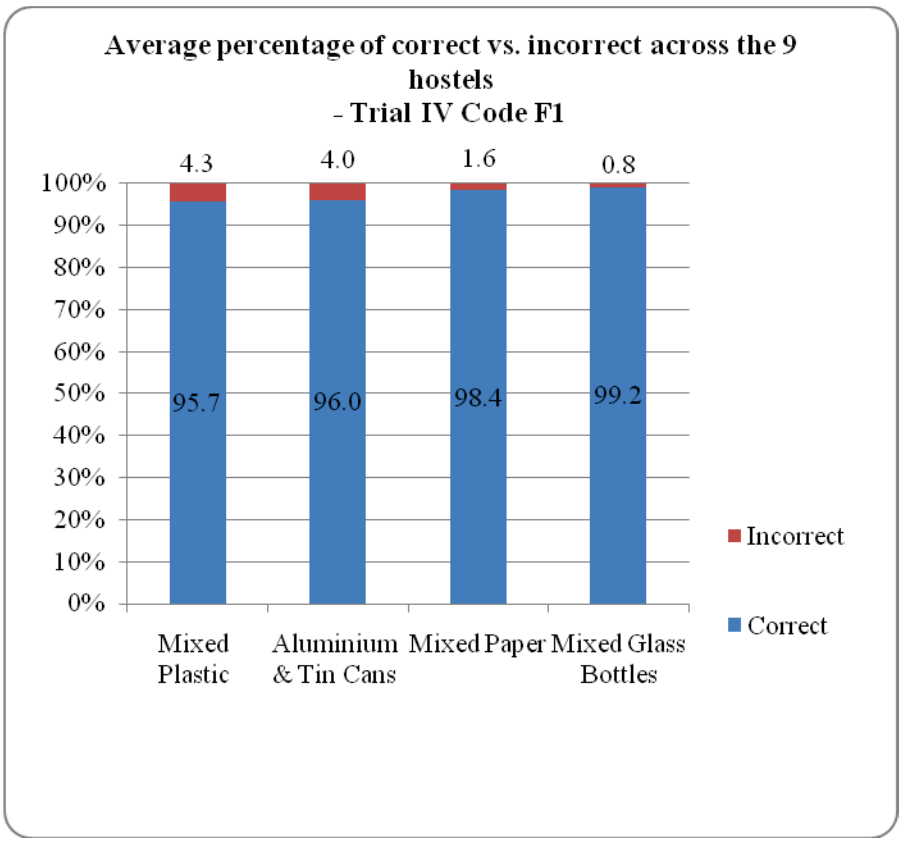

Figure 90, the average percentage of correct vs. incorrect disposal per category across 9 hostels Code F1 Trial IV

In overview of the percentage of correct vs. incorrect recycling choices being made for all of the categories and all of the hostels the only time this was greater than 10 % was for aluminium and tin cans at Tawa Hall (14.45 %), with the next closest result being for mixed plastic at Moginie Hall (9.3 %). This may highlight possible areas for further analysis if future audits find similar results.

In relation to the purpose of this study, the two key goals for the recycling system are to increase the number of people choosing to recycle, and then to ensure that the facilities provided enable the correct choice to be made as to where to dispose of waste and recyclables as easily as possible. It is important that any redesign of the current recycling facilities ensures that it becomes a part of the daily routines and a habit for the students and staff, which will motivate behaviour change (Thomas et al., 2004). In addition to this it is essential to remember the other key aims of zero waste programmes which are to re-think and reduce the consumption and use of resources rather than just relying on recycling as a solution. These are the factors that will be considered when developing the recommendations for the Massey University Turitea campus recycling and waste management system.

5.1.4 Small Waste Bins (Code C)

The auditing of the Code C or small waste bins that were located around the concourse area was conducted over Trial I, II and III. As previously noted the method for this audit varied slightly during Trial I, which was a pilot trial, and Trial II and III. This meant that the sorting of the bin contents was different with compostable waste being categorised as waste in Trial I but as recyclables in Trial II and III in order to draw attention to the importance of organic waste as a resource. The outcome of this is that the contamination results for each trial are not directly comparable so the focus of this discussion will be Trial II and III when it comes to correct vs. incorrect. These results are shown in Table 38 below, which gives the total kgs and the percentage of correct vs. incorrect for Trial I, II and III.

Table 38, the Auditing result, Code C Trial I, II and III

Code	Category	Trial	Correct		Incorrect		Total (kg)
			(kg)	(%)	(kg)	(%)	
C	Waste	Trial I	9.75	82%	2.14	18%	11.89
		Trial II	17.85	29%	43.69	71%	61.54
		Trial III	6.15	32%	13.25	68%	19.4
Total			**33.75**		**59.08**		**92.83**
Average %(not including Trial I)				**29.6%**		**70.4%**	

In particular this shows that the total amount of waste found varied considerably between summer semester (Trial I and III) and semester two (Trial II). This table also shows that the average percentage of correctly and incorrectly disposed of waste for last two trials was 29.6 % and 70.4 % respectively. This shows that the contamination level of recyclable materials and compostable waste in the waste bins is significantly high. Figure 91 below illustrates the difference in totals for each trial and obviously this would be considered when RFM manages the emptying of these bins.

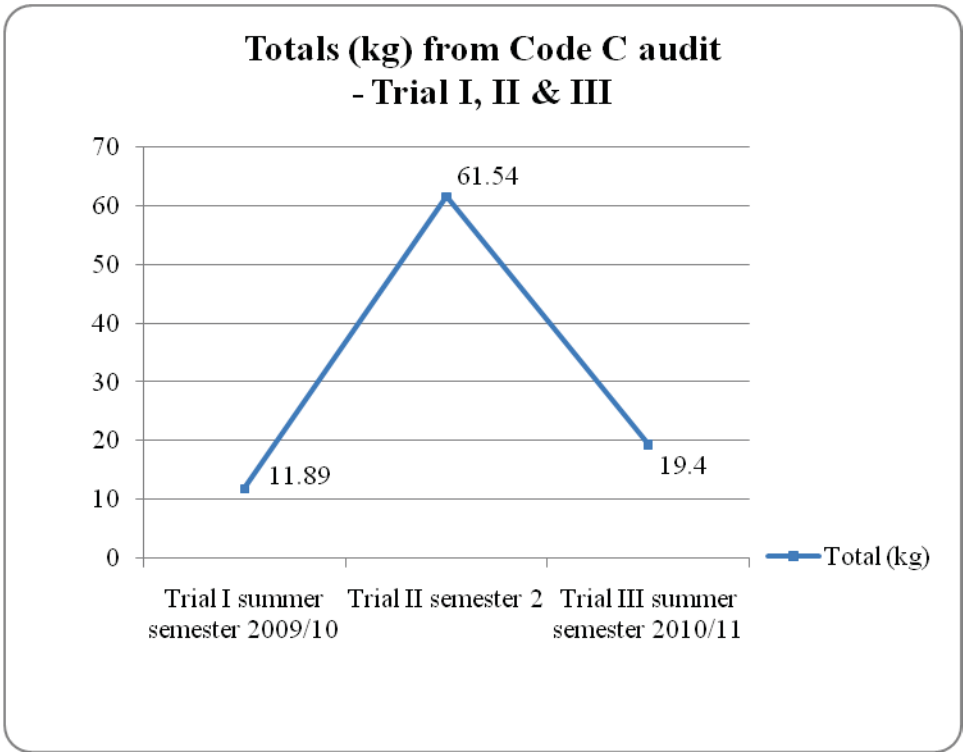

Figure 91, the totals in kg for Code C, Trial I, II and III

Based on the observations during data collection, the majority of waste produced in these bins is predominantly from MUSA shop, the student dining hall, and the coffee shop. Mason et al. (2004) identified that recycling may become an issue in areas that are associated with actvities such as eating, drinking and socialising, and recommended that education and training was a solution for this. The contamination of recyclable materials and compostable waste in the small waste bins is mostly from plastic bottles and organic food (e.g. bread, apples and banana skins), which should be disposed of in ways that facilitate their recycling. In part it can be assumed that the high level of contamination occurred due to the absence of organic bins around the concourse area. Figure 92 below illustrates the types of contamination found.

Figure 92, examples of compostable and recyclable contamination found in the small waste bins

The following chart (Figure 93) compares the correct vs. incorrect percentage across the two trials and shows that the contamination levels for the small waste bins was relatively equal for the second and third trials.

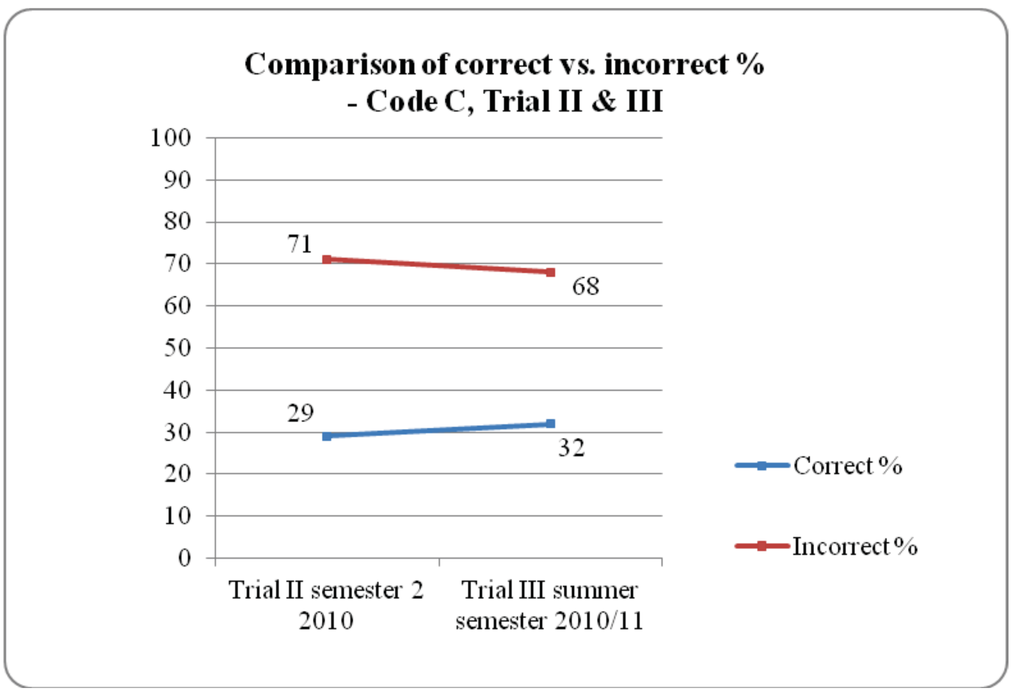

Figure 93, the comparison of correct vs. incorrect percentages for Code C Trial II and III

This shows that the lack of understanding about the function of the bins is constant regardless of how many students are present on campus. In addition to this the level of recyclable and compostable materials found in these bins was especially high with a range from 68 to 83 %. This undoubtedly shows that the purpose of these bins as being for waste only is not understood by the people using them, and when you consider that there is not any signage present to reinforce this it makes total sense. The addition of clear signage (Kelly, et al., 2006) would help to address the difficulties people had in deciding what could and could not be disposed of in these bins.

Next these percentages from Trial II and III were used to calculate the average percentage of correct vs. incorrect and this is shown in Figure 94 below. This found that on average just over half of the contents of the small waste bins audited was incorrectly disposed of and is to be considered contamination. This finding highlights the fact that these bins are being used as a one stop waste and recycling bin, not as a dedicated waste bin as they are meant to be, and identifies a strong need for these facilities to be upgraded and improved in order to improve the choices made by people about what to use them for.

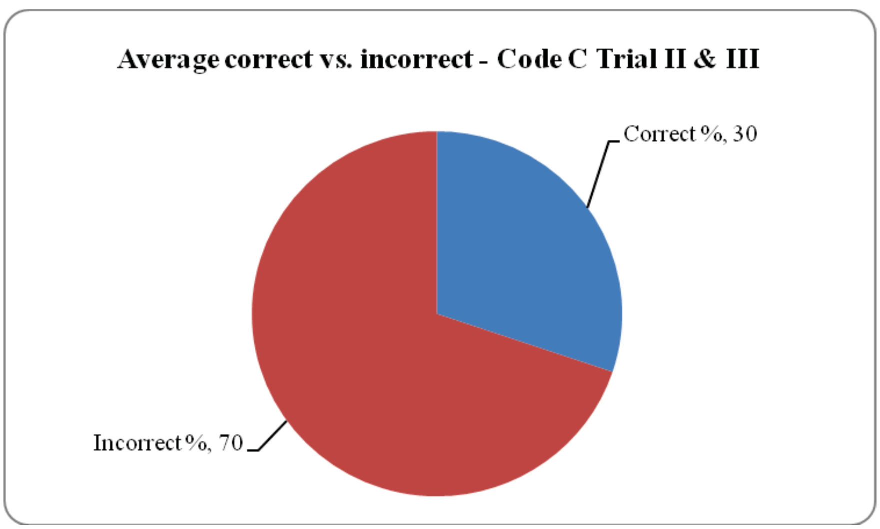

Figure 94, the average correct vs. incorrect for Code C across Trial II and III

5.1.5 Massey Dining Hall Bins (Code D)

This section discusses the findings of the audit of the Massey recycling bins (Code D) of which there were two which were located in the Dining Hall. As previously mentioned these bins were only audited in Trial I and II due to them being discontinued after Trial II after concerns about how they were being managed. The following discussion aims to provide insight into the waste and recycling being produced in the dining hall area as well as reflect the recycling behaviours of those using the bins while they were there. These results are shown in Table 39 below. From this table it is possible to see that the total amount collected increases significantly in Trial II which reflects the increase in students on campus. In addition to this it shows that the contamination of the landfill and plastic categories increased considerably for Trial II when more students were using the bins. The overall percentage of incorrectly disposed of materials was 22.7 % which meant that over one fifth of the bin contents were contaminants. However for glass and cans the contamination was zero or minimal, so the main issues were with the landfill and plastics categories and directly related to the location with the contamination being made up of food waste, and food containers. This issue is discussed more further on in this section.

Table 39, the Auditing result for Code D, Trial I and II

Code	Trial	Landfill (D1)				Plastic (D2)				Glass (D3)				Cans (D4)				Total (kg)	Overall % correct vs. incorrect	
		Correct		Incorrect		Correct		Incorrect		Correct		Incorrect		Correct		Incorrect				
		Kg	%	Kg	%	Kg	%	Kg	%	Kg	%	Kg	%	Kg	%	Kg	%		Correct	Incorrect
D	Trial I	5.89	96	0.3	4	0.6	70	0.3	30	0.38	95	0	5	4.1	100	0	0	11.57	**95**	**5**
	Trial II	8.16	55	6.8	45	1.4	41	2	59	10.8	100	0	0	0.7	100	0	0	29.86	**70.5**	**29.5**
Total (kg)		**14.1**	-	**7.1**	-	**2.0**	-	**2.3**	-	**11.2**	-	**0**	-	**4.7**	-	**0**	-	**41.43**	-	-
Average %		-	**76**	-	**25**	-	**56**	-	**45**	-	**97.5**	-	**2.5**	-	**100**	-	**0**	-	**77.3**	**22.7**

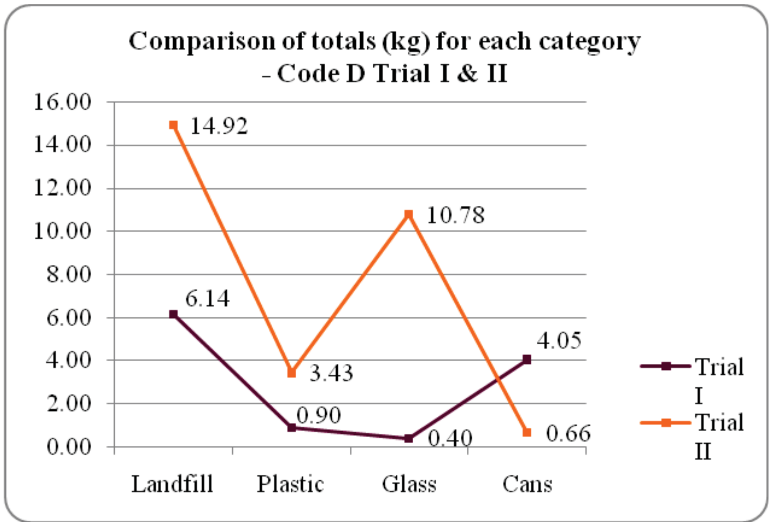

Figure 95, the comparison of the totals produced for each category for Code D Trial I and II

As is shown in Figure 95 above the totals for each category increased with the exception of cans. Also the increase in glass and landfill was considerable, for example more than twenty times for glass. This is a direct reflection of the increased use of the Code D bins and these totals need to be considered when placing or developing recycling and waste facilities in the Dining Hall so that demand can be met during peak periods as well as non-peak periods.

Figure 96, examples of contamination found in the Massey recycling bin (Landfill D1 and Plastic D2)

Figure 96 above illustrates the types of contamination found in the landfill and plastic bins during the auditing process. For the landfill sub-code the contamination was a combination of organic food waste, paper, plastic and cans, particularly relating to food storage, while for the plastic sub-code the contamination was mainly organic food waste. The high amount of food waste reflects the fact that bins for compostable waste were not provided at the time of Trial I and II. In 2008 the survey carried out by MUSA highlighted that students wanted facilities to be provided for organic food waste. Figure 97 below shows the comparison of correct vs. incorrect for each category in Trial I and II.

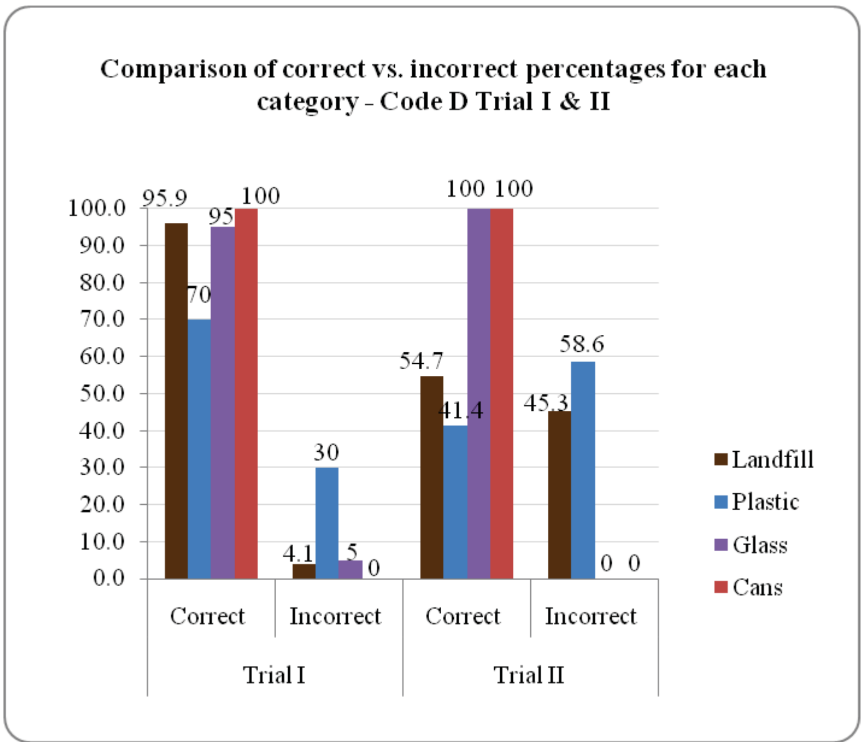

Figure 97, the comparison of correct vs. incorrect for Code D Trial I and II

By comparing this it can be seen that while the glass and cans categories were used correctly for the most part, the landfill and plastic categories had an increase in contamination through incorrect use. This, when combined with the earlier description of the types of contamination found for the landfill and plastic sub-codes, highlights the importance of having relevant and clear waste and recycling facilities in place in the Dining Hall particularly during semester one and two of the university year when use will be high. Similar to the outside environment of the concourse the facilities provided in the dining hall are important in addressing issues with recycling in locations were eating and drinking are taking place (Mason et al., 2004).

5.1.6 Staff Common Room Waste, Organic and Recycling Bins (Code E)

This section discusses the findings of the audit of the Staff Common Room compost, recycling and waste bins (Code E) that were audited during Trial II and III. As previously described the method of auditing these bins was improved for Trial III and this is reflected in the following Table 40 in which the waste category (E3) is shown as n/a (not applicable) for Trial II. The facilities provided in the staff common rooms were upgraded in early 2010 to include the compostable waste bins, and the recyclables facilities are a mixed recycling bin which is unique in terms of the other recycling facilities provided across campus.

Table 40, the Auditing result for Code E Trial II and III

Code	Trial	Category						Total (Kg)
		Compostable (E1)		Recyclables (E2)		Waste (E3)		
		Correct (Kg)	Incorrect (Kg)	Correct (Kg)	Incorrect (Kg)	Correct (Kg)	Incorrect (Kg)	
E	Trial II	78.5	0	41.84	0	n/a	n/a	120.34
	Trial III	119.75	0	68.05	0	15.5	2.3	205.6
Total		**198.25**	**0**	**109.89**	**0**	**15.5**	**2.3**	**325.94**

Using the results in Table 40, the average weight of compostable waste produced every week in the staff common rooms can be calculated at 99.1kg. This total is similar to that found during audits carried out by the contractor, Helen May, who developed and manages the compostables disposal system which was an average of 115 per month for April, May and June 2010 (Mays, 2010). The average amount of recyclables was 54.9kg. The high amount of compostable waste reflects the function of the common rooms as meal consumption areas and shows that the staff and students using the areas were taking advantage of the opportunity to use compostable waste facilities which weren't available in any other parts of the university. In Trial III when waste was audited as well it was found that the level of contamination for this category was 13 %, which consisted mainly of recyclables that should have been placed in the bin provided and were food containers made of plastic and tin cans, and paper towels which should have been placed in the compostable bin.

Figure 98 below compares the total amount of compostable waste and reyclables collected across the two trials, the first of which was conducted during semester 2 while the second was during summer semester.

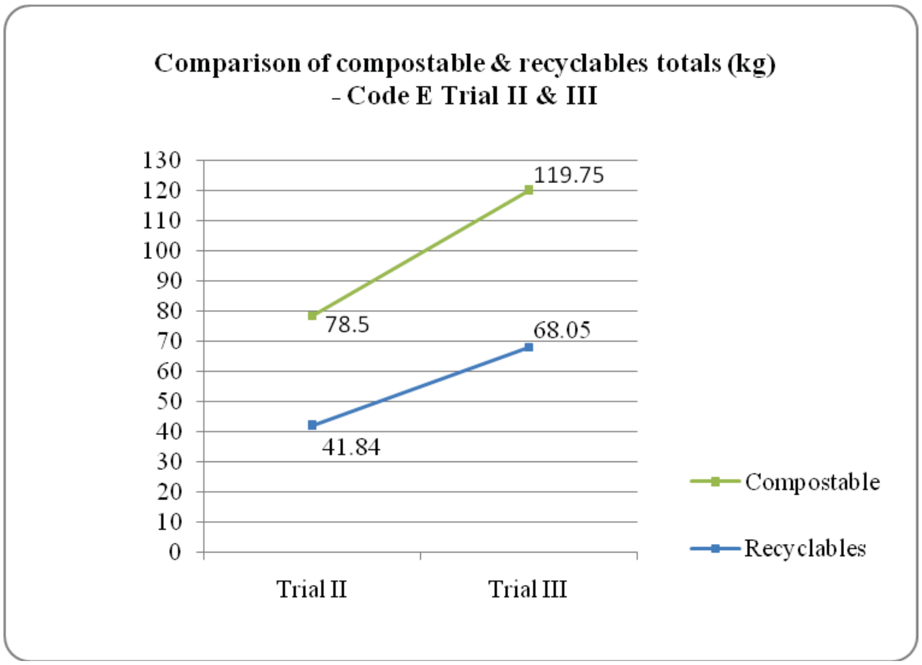

Figure 98, the comparison of compostable waste and recyclables for Code E Trial II and III

This showed that the amount of both had increased considerably despite there being less students and staff on campus. This in part reflects the fact that the staff common rooms are used by staff and post graduate students who are more likely to remain on campus in higher numbers during the summer semester. In addition to this is can be expected that more staff and students were choosing to use these relatively new facilities as time passed and their understanding of them increased. However because the waste category was only audited for the second of these trials this cannot be confirmed through decreasing totals of contamination levels. With regard to the minimal contamination found in the compostable and recyclable bins it has also been noted that in some instances staff may be taking the initiative to remove any materials that have been wrongly placed in them, resulting in the impression that all of the choices being made about what to place in them are correct. It could easily be assumed that the presence of staff and mature students resulted in these low levels when in fact quality control is taking place.

In terms of comparing the type of facilities (compostable bins and all in recycling bins) provided in the staff common rooms with the other recycling facilities (single type recyclable bins and few opportunities for compostable waste) it seems that those provided in the staff common rooms provided clearer and more comprehensive opportunities for people to make the correct recycling choices. However in order to confirm this further research would need to be conducted and ideally trials would be placed in the dining hall area which mimic the waste, all in recyclable and compostable bin system. It would also be important to gather more information about the quality control that may be taking place in the staff common rooms perhaps through surveys in order to determine the frequency and degree at which this is taking place.

5.2 Summary of Discussion

The waste and recycling options provided around the concourse area and dining hall, the recycling wheelie bins (Code B), small waste bins (Code C) and Massey dining hall recycling bins (Code D), had varying levels of contamination and overall there was a pattern of there being some uncertainty about the categories/labels used and issues with signage.

- Of these three codes the most serious issues were with the small waste bins (Code C), and the average contamination levels of 70 % showed that the understanding of these as waste bins with recyclable materials needing to be disposed of in other places such as the wheelie bin clusters was minimal. This can be attributed to a lack of signage and the fact that they seem to be positioned in isolation from the recycling facilities provided.
- Within this location the use of the Massey dining hall recycling bins (Code D) also showed a need for improvement although as these have since been discontinued this issue may have already been addressed in part. The average contamination levels of 45 % in the plastic category and 25 % found in the landfill category indicated that the labelling was not assisting people in easily making the correct recycling choices and the amount of organic food waste

found showed the real need for compostable waste facilities to be provided in the dining hall.

- The recycling wheelie bins (Code B) around the concourse were the campuses most visible demonstration of the zero waste programme, and the audit showed that while they are functioning well to a degree improvements could be made. Over the period of Trial I, II and III 12.5 % of the contents of these bins was incorrectly disposed of which shows a reasonable number of incorrect recycling choices were made. This is why the sorting of these bins by the GBT takes place before the contents are sent to the recycling centre. The contamination of organic food waste again indicates the need for compostable waste facilities in this location where the main food supply is located.

The large waste bins (Code A1) that were located at various places across campus were found to contain considerable amounts of recyclable and compostable resources at 42 % of the total materials. These bins are a part of a system that involves waste being collected from inside buildings for disposal, and because of this to reduce this contamination the recycling behaviour of the people inside the buildings needs to be addressed. While recyclable and compostable facilities are provided in the staff common rooms (Code E) these are not accessible by everyone. This trend is also shown in the large waste bins at the student hostels (Code F2) with 38 % of the contents being recyclable and compostable.

The facilities provided for waste, compostable and recyclables in the staff common rooms were particularly interesting in that they demonstrates that the compostable bins provided can succeed. This provides a prototype system that can be further developed to be used in other parts of campus. The use of an all in recycling bin also seemed to be successful and this aligns with the PNCC residential recycling system so may also be an option to be developed further for the wider campus community.

The contamination levels of the recycling wheelie bin clusters (Code F2) at the student hostels were low for the most part, however as previously mentioned, a considerable amount of recyclable and compostable resources are being lost by being disposed of into the large waste bins (Code F1). This shows that some people are opting out of recycling, but that those that are recycling are making the correct choices for the most part.

The following section will describe the recommendations in relation to the key issues found during the waste and recycling audit conducted in this research.

5.3 Implications and Recommendations

In general, the recycling programme at Massey works relatively well. Nonetheless, However, there are several key issues which need to be considered, in order to build on this good performance. For instance;

- The signage of the wheelie bins is unclear and potentially confusing for new and international students.
- In many cases signage is UV damaged and missing.

Recommendation 1: Signage upgrade and create brand for recycling programme.
This involves redesgning and improving the existing signage to ensure that it is visible, clear and concise, and long lasting. When labelling of general waste bins is undertaken it could be emphasised that this waste will be going to landfill and that this is not a desired outcome. This needs to consider current commonly used symbols for recycling throughout New Zealand. Ensuring clarity in the choice of bins for people to use will increase the speed at which decisions can be made and this may increase use as well as reducing contamination. In addition to this the creation of a brand for the programme will aid in increasing awareness of and participation in recycling at Turitea campus, by using clear instructions and messages such as posters, as well as linking to the broader sustainability programme that Massey has developed. This could incorporate wider aspects of waste management associated with behaviour change, such as the importance of individuals and groups considering their patterns of consumption and attempting to create less waste and use resources efficiently through awareness in their purchasing. By incorporating elements such as this into the awareness raising people will receive a more comprehensive education about Zero waste. This is particularly important in fulfilling Massey University’s role as a place of higher education and can result in well

informed students that have attained an education beyond the scope of their chosen field of study.

- The number of recycling bins across the campus is relatively low. As a result, many of the recyclable materials are going into general waste bins, and as a consequence of this will be going to landfill instead of being recycled.
- In addition to this the recycling system is quite dated and does not link to the new recycling collection system implemented by PNCC. Also on campus the indoor recycling system does not match the outdoor cluster system. These factors may be adding to the confusion and negatively impacting on participation in the recycling programme. The indoor recycling system also needs to be further developed in order to address the high amount of recyclables being lost through disposal into the large waste bins. For the most part this is a result of the way that waste and recycling is being handled in offices, classrooms and rooms in student hostels. The branding of the programme needs to include a way to get the message about the importance of recycling to these people.

The report prepared for RFM (appendix 1) provides potential designs for aspects of this recommendation.

Recommendation 2: Campus Recycling system makeover.

This would include the brand development concept previously mentioned in recommendation 1, as well as try to align the cluster system with more recently developed systems. A key part of this would involve working with PNCC to ensure the system fits the requirements of their recycling centers. In addition to this will be the opportunity to increase the number of recycling facilities provided across the campus to include areas which are currently not covered.

- There is a lot of contamination of potentially recyclable organic resources in both the waste and recycling bins. In many cases this relates to the fact that a bin for compostable waste is not provided for use, despite the system in the Staff Common Rooms having proven successful.

The report prepared for RFM also (appendix 1) provides potential designs for aspects of this recommendation.

Recommendation 3: Expand the current Organic Recycling system to become a consistent part of the campus Recycling system.

Increasing the current organic recycling system from just the staff common rooms to include the student hostels and outdoor collection points, for example around the concourse area, in association with general recycling collection is likely to further reduce waste to landfill. This would involve redesigning the current indoor system to suit and outdoor environment as well as increased quantities.

- This research project has focused on Turitea campus in Palmerston North and so does not include the other Massey campuses in Wellington or Auckland. In order to develop a true Massey wide zero waste programme this will need to be addressed, which will involve working with the host city and local recycling service providers.

Recommendation 4: Conduct a feasibility study and establish targets to create a Massey University recycling network across the three campuses.

This will provide the opportunity for knowledge and expertise to be shared across the institution as lessons are learned from previous experiences in order to develop a comprehensive and customised system for each campus. There may also be the opportunity to reuse equipment.

- In order to redevelop the current facilities it is best to have a body of knowledge about how well they are functioning in relation to both management and the recycling behaviour of students and staff on campus. Regular waste and recycling audits are a way of monitoring this as well as the effect of any changes made.

Recommendation 5: To undertake regular waste and recycling audits, which involve a process of evaluation to develop improvements in how they are carried out.

This will aim to use student research projects to add to the existing body of knowledge as well as investigate areas not yet examined, such as tracking the source of the different types of waste and recycling being produced in a department or building in order to develop advanced indoor facilities.

5.4 The performance of the waste and recycling audit

This section provides an assessment of the auditing process that was used during this research. This aims to provide information about what was learned during this process in order to aid future audits that will be carried out. Generally the auditing method utilised in this study went relatively well in terms of the steps used to obtain the data (refer to section 3.4.1 in Chapter 3 page 49). However, there were a number of obstacles and limitations identified which need to be addressed for future audits and these are outlined below.

1. Communication with stakeholders in relation to the waste and recycling management at Massey's Turitea campus (i.e. RFM). With a stakeholder such as RFM that played such a major role it was crucial to establish communication early on in the process. This communication should include factors that relate to the operational carrying out of the audit, as well as overall audit design that may be developed to fulfil requests and requirements of the stakeholder. In addition to this other stakeholders need to be contacted and communicated with regularly throughout the process, such as GBT, and PNCC in relation to Turitea campus. While communication was carried out reasonably well during this research it was identified that earlier more in depth communication with stakeholders would have improved the audit process.
2. Designing a research timeline to further explore the seasonality of waste and recycling produced throughout the year. Because of the complexities of the current waste and recycling system determining the annual quantities produced was very difficult, and it would be essential to obtain any available data from the stakeholders to assist with this. By further exploring the seasonality it may be possible for collection schedules and facilities provided increased in efficiency.
3. Establishing the necessary support before conducting the research. For instance to provide help for collecting and sorting out the waste, to set up the location for sorting out the materials.
4. Designing the audit methodology in order to ensure that all types of waste and recycling bins used in the location are covered in order to provide an accurate picture. For Turitea campus the range of bins used made this process quite

complicated and this relates to the way in which the campus wide system has been developed.

5. Data analysis. There are numerous data analysis approaches that can be used in order to measure waste quantification and the level of contamination in both waste and recycling bins. For future research it is recommended that a full statistical analysis is considered (using programmes such as SPSS or excel).

CHAPTER 6
CONCLUSION

6.1 Introduction

This research undertook a waste and recycling audit at Massey University's Turitea campus in order to investigate the performance of the zero waste programmes and make recommendations for the improvement of the recycling and waste facilities. This final chapter will summarise the findings of this research as they relate to this aim, including a short section detailing potential areas for further research.

6.2 Summary of Findings

The waste and recycling audits conducted during this research identified incorrect and poor recycling behaviour using contamination levels as an indicator, in the various facilities provided across the campus.

The key findings were:

- Code A1, the large waste bins had an average of 41 % of the contents across Trials II, III and IV was incorrectly disposed of and consisted of resources that should have been recycled or composted.
- Code B, the recycling wheelie bins had an average of 17.2 % incorrectly disposed of materials across Trial I, II, III and IV. This consisted of recyclables being placed in the wrong bins, such as other recyclable bins and waste bins, as well as compostables being placed in the recycling and waste bins.
- Code C, the small waste bins had an average of 70 % incorrectly disposed of materials across Trial II and III, which consisted of recyclables and compostable waste.
- Code D, the Massey dining hall bins had an average of 22.8 % incorrectly disposed of materials across Trial I and II, which was mostly in the plastic and landfill categories and consisted of recyclables and compostable waste.
- Code E, the staff common room waste, organic and recycling bins had minimal levels of contamination in the organic and recycling bins across Trial II and III,

and had 12.9 % incorrect materials placed in the waste bin in Trial III. This consisted of recyclables such as plastic food containers and compostables such as paper towels.

- Trial IV which focused specifically on the student hostels found that the recycling wheelie bins had low levels of contamination at 1.7 % on average, although the large waste bins had high levels of contamination at 38 % on average.

Overall these findings highlighted the need for the current facilities to be redeveloped in order to improve the recycling behaviour and increase the effectiveness of the recycling programme on campus. With this in mind a number of specific recommendations were made:

1. Signage upgrade and create brand for recycling programme.
2. Campus Recycling system makeover.
3. Expand the current Organic Recycling system to become a consistent part of the campus Recycling system.
4. Conduct a feasibility study and establish targets to create a Massey University recycling network across the three campuses.
5. To undertake regular waste and recycling audits, which involve a process of evaluation to develop improvements in how they are carried out.

These five recommendations aim to provide an increase in the positive recycling behaviour already taking place at Massey University’s Turitea campus by improving the waste and recycling infrastructure. In cases such as the organics disposal facilities these improvements supplement the current facilities, while other improvement focus on providing a clearer and simpler recycling system. These will also contribute to enhancing the Massey zero waste programme and therefore reducing the amount of resources being discarded of incorrectly and going to landfill.

6.3 Future Research

The following future studies are recommended:

- Undertake surveys of staff and students about their use of and thoughts regarding the recycling facilities. This could include the expansion of the organic/compostable waste bins, the design of recycling bins for inside university buildings and potential ways to increase use of recycling facilities. This survey should be larger in scope than the one conducted by MUSA in 2008.
- Focusing future audits to get a clearer picture of the seasonality of the campus location so that infrastructure and collection schedules can be increased in efficiency.
- A waste and recycling audit that uses statistical analysis to determine the annual totals of waste and recyclable materials produced across Turitea campus.
- Conduct waste and recycling audits of the other Massey campuses such as Hokowhitu, Albany (Auckland) and Wellington to gather baseline data which can be used to create a recycling network across the campuses.
- Undertake studies that focus on reducing the amount of waste being produced across the campus, i.e. paper, and investigate how well recent initiatives such as compostable plates and bowls, and compostable bins are understood by users.
- An investigation into the current waste and recycling management costs for Massey University, at both campus and institutional levels, and how these can potentially be reduced through improved recycling practices.

REFERENCES

Agapitidis, I. & Frantzis, I. (1998). A possible strategy for municipal solid waste management in Greece. Waste Management & Research, 16(3), 244-252.

Agrecovery. (2011). Agrecovery supporters. Retrived 7 May, 2011, from http://www.agrecovery.co.nz/about/agrecovery-supporters/.

Alshuwaikhat, H. M. & Abubakar, I. (2008). An integrated approach to achieving campus sustainability: assessment of the current campus environmental management practices. Journal of Cleaner Production 16(16), 1777-1785.

Al-Salem, S. M., Lettieri P., et al. (2009). Recycling and recovery routes of plastic solid waste (PSW): A review. Waste Management 29(10), 2625-2643.

Annegrete, B. (2001). Factors influencing solid waste generation and management, Journal of Solid Waste Technology and Management, 27, 156–162

ANU. (2011). Recycling and waste management at ANU. Retrieved 2 April, 2011, from http://www.anu.edu.au/anugreen/index.php?pid=52.

ARIES, (2009). Macquarie University innovation award- Innovation towards sustainability. Retrieved April 11, 2011, from http://www.aries.mq.edu.au/news/innovations_award/.

Armijo de Vega, C., Ojeda Benítez, S., et al. (2008). Solid waste characterization and recycling potential for a university campus. Waste Management, 28, S21-S26.

Ashwood, K., Grosskopf, M. & Scheider, E. (1996). Conducting a waste audit and designing a waste reduction work plan. Pulp Paper Can, 97(9), 84–86.

Bai, R. & Sutanto, M. (2002). The practice and challenges of solid waste management in Singapore. Waste Management, 22(5), 557-567.

Begum, R. A., Siwar C., et al. (2009). Attitude and behavioral factors in waste management in the construction industry of Malaysia. Resources, Conservation and Recycling, 53(6), 321-328.

Belkin, N. L. (1995). Reduce, Reuse, Recycle. AORN, 62(3), 333-333.

Bellhouse, D.R. (1988). Systematic sampling, in *Handbook of Statistics*. In P.R. Krisnaiah & C.R. Rao (Eds.) (pp. 125-146). Amsterdam: North Holland-Elsevier.

Biswas, A., Licata, J.W., McKee, D., Pullig, C., & Daughtridge, C. (2000) The Recycling Cycle: An Empirical Examination of Consumer Waste Recycling and Recycling Shopping Behaviours. Journal of Public Policy & Marketing, 19(1), 93-105.

Boyle, C. A. (2000). Solid waste management in New Zealand. Waste Management, 20(7), 517-526.

CBEC. (2011a). Clean Stream Northland. Retrieved 2 April, 2011, from http://www.cbec.co.nz/Clean_Stream.cfm.

CBEC. (2011b). CBEC Recycling and Refuse services. Retrieved 15 March, 2011, from http://www.cbec.co.nz/CBEC_Recycling.cfm.

Chang, N. B. & Davila, E. (2008). Municipal solid waste characterizations and management strategies for the Lower Rio Grande Valley, Texas. Waste Management, 28(5), 776-794.

Chowdhury, M. (2009). Searching quality data for municipal solid waste planning. Waste Management, 29(8), 2240-2247.

Christman, M. C. (2009). Sampling of Rare Populations. Handbook of Statistics. C. R. Rao, Elsevier, 29(1), 109-124.

Clay, S., Gibson D., et al. (2007). Sustainability Victoria: influencing resource use, towards zero waste and sustainable production and consumption. Journal of Cleaner Production, 15(8-9), 782-786.

Concordia University. (2011). Waste and recycling audits. Retrieved 15 March, 2011, from http://sustainable.concordia.ca/ourinitiatives/r4/rethink/audits/.

Eriksson, O., M. Carlsson Reich, et al. (2005). "Municipal solid waste management from a systems perspective." Journal of Cleaner Production, 13(3), 241-252.

Delgado, O. B., Ojeda-Benítez S., et al. (2007). Comparative analysis of hazardous household waste in two Mexican regions. Waste Management, 27(6), 792-801.

Demirbas, A. (2011). Waste management, waste resource facilities and waste conversion processes. Energy Conversion and Management, 52(2), 1280-1287.

Department for Environment Food and Rural Affairs (Defra 2007). Waste strategy for England. Retrieved February 5, 2011, from http://www.defra.gov.uk/environment/waste/strategy/strategy07/index.htm.

DEFRA. (2007). Waste strategy for England 2007 Executive Summary. London: DEFRA. Retrieved 25 March, 2011, from http://archive.defra.gov.uk/environment/waste/strategy/strategy07/documents/waste07-strategy.pdf.

DEFRA. (2008). Waste strategy annual progress report 2007/08. London: DEFRA. Retrieved 25 March, 2011, from http://archive.defra.gov.uk/environment/waste/strategy/strategy07/documents/waste-strategy-report-07-08.pdf.

DEFRA. (2009). Incentives for household recycling. Retrieved 20 April, 2011, from http://archive.defra.gov.uk/environment/waste/strategy/incentives/

Department of Environmental Protection Pennsylvania. (2011). Conducting a Waste Audit. Retrieved February 18, from http://www.dep.state.pa.us/dep/deputate/airwaste/wm/recycle/facts/ComRec.htm. Retrieved 18 February 2011.

Dowie, W., McCartney, D., & Tamm, J. (1998). A case study of an institutional solid waste environmental management system. Journal of Environmental Management, *53*(2), 137-146.

Duan, H., Huang Q., et al. (2008). Hazardous waste generation and management in China: A review. Journal of Hazardous Materials, 158(2-3), 221-227.

Dutta, S. & Das, A. (2010). Analytical perspective on waste management for environmental remediation. Trends in Analytical Chemistry, 29(7). Retrieved 17 April, 2011, from http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V5H-502GGWD-1&_user=572227&_coverDate=08%2F31%2F2010&_rdoc=1&_fmt= high&_orig=gateway&_origin=gateway&_sort=d&_docanchor=&view=c&_acct=C000029098&_version=1&_urlVersion=0&_userid=572227&md5=64c6f6f6af827e116f84cc8f4542046a&searchtype=a

Eichner, T. & Pethig, R. (2001). Product Design and Efficient Management of Recycling and Waste Treatment. Journal of Environmental Economics and Management, 41(1), 109-134.

European Commission. (2003). Waste generated and treated in Europe, European Commission. Office for official publication of the European Communities, Luxembourg.

European Environment Agency. (2003). Europe`s Environment. The third assessment. European Environment Agency, Copenhagen.

Eurostat (2009). Half a Ton of Municipal Waste Generated Per Person in the EU27 in 2007. Eurostat Press Office. Retrieved 29 November, 2010, from http://epp.eurostat.ec.europa.eu/cache/ITY_PUBLIC/8-09032009-BP/EN/8-09032009-BP-EN.PDF.

Environment Waikato Regional Council (2011), Solid Waste. Retrieved February 15, from http://www.ew.govt.nz/environmental-information/Solid-waste.

Enzler, E., Fischer, K., & Teale, M. (2006). Improvement in recycling habits and waste disposal through increased awareness and education. Recycling patterns on edgwood campus.

Eurobodalla Shire Council. (2001). Eurobodalla Shire Council Waste Minimisation Strategy. Retrieved 2 February, 2011, from http://www.zerowaste.co.nz/assets/intern ational/Eurobodalla_Shire_Council.pdf.

Evison, T. & Read, A. D. (2001). Local Authority recycling and waste -- awareness publicity/promotion. Resources, Conservation and Recycling, 32(3-4), 275-291.

Far North District Council. (2011). General information: Refuse contractors. Retrieved 19 April, 2011, from http://www.fndc.govt.nz/services/water-wastewater-and-refuse/rubbish-and-recycling/general-information.

Greyson, J. (2007). An economic instrument for zero waste, economic growth and sustainability. Journal of Cleaner Production, 15(13-14), 1382-1390.

Gómez, G., Meneses M., et al. (2009). Seasonal characterization of municipal solid waste (MSW) in the city of Chihuahua, Mexico. Waste Management, 29(7), 2018-2024.

Hannon, J. (2005). Massey University practical zero waste program – current and future initiatives. Palmerston North: Massey University.

Hannon, J. (2008). Massey University practical zero waste program-current and future initiatives. Palmerston North: Massey University.

Hannon, J. (2009). The campus sustainability report. Palmerston North: Massey University.

Hargreaves, J. C., Adl M. S., et al. (2008). A review of the use of composted municipal solid waste in agriculture. Agriculture, Ecosystems & Environment, 123(1-3), 1-14.

Hasnain, M., Isa, et al. (2005). Solid waste collection and recycling in Nibong Tebal, Penang, Malaysia: a case study. International Solid Waste Association. Published by: http://www.sagepublications.com. Malaysia.

Hasome, H., Tachio K., et al. (2001). Studies on the evaluation of municipal waste management systems. Waste Management & Research, 19(1), 2-11.

Hassan, M.N., Rahman, R.A., Chong, T.L., Zakaria, Z., & Awang, M. (2000) Waste recycling in Malaysia: problems and prospects. Waste Management & Research, 18, 320-328.

Henry, R. K., Yongsheng Z., et al. (2006). Municipal solid waste management challenges in developing countries - Kenyan case study. Waste Management, 26(1), 92-100.

Hristovski, K., Olson L., et al. (2007). The municipal solid waste system and solid waste characterization at the municipality of Veles, Macedonia. Waste Management, 27(11), 1680-1689.

Hu, K., Hipel K. W., et al. (2009). A conflict model for the international hazardous waste disposal dispute. Journal of Hazardous Materials, 172(1), 138-146.

IISD. (2000). Declarations for sustainable development: the response of universities. International Institute for Sustainable Development, Winnipeg, Canada. Retrieved February 21, 2011, from http://iisd.ca/educate/declare.htm.

Imam, A., Mohammed B., et al. (2008). Solid waste management in Abuja, Nigeria. Waste Management, 28(2), 468-472.

Juhasz, A. L., Magesan, G., & Naidu, R. (2004). Waste Management. Science Publisher. Plymouth, UK.

Kassim, S. M. & Ali, M. (2006). Solid waste collection by the private sector: Households' perspective--Findings from a study in Dar es Salaam city, Tanzania. Habitat International, 30(4), 769-780.

Kelly, T.C., Mason, I.G., Leiss, M.W., & Ganesh, S. (2006) University community responses to on-campus resource recycling. Resources, Conservation and Recycling, 47(1), pp. 42-55.

Keniry, J. (1995) Ecodemia: Campus Environmental Stewardship at the turn of the 21st century. National Wildlife Federation Washington.

Khoo, H. H. (2009). Life cycle impact assessment of various waste conversion technologies. Waste Management, 29(6), 1892-1900.

Kollikkathara, N., Feng, H. & Stern, E. (2009) A purview of waste management evolution: Special emphasis on USA. Waste Management, 29, 974–985.

Laustsen, G. (2007). Reduce-Recycle-Reuse: Guidelines for Promoting Perioperative Waste Management. AORN, 85(4), 717-722, 724, 726-728.

Lu, L.-T., Hsiao T.-Y., et al. (2006). MSW management for waste minimization in Taiwan: The last two decades. Waste Management, 26(6), 661-667.

Magrinho, A., Didelet F., et al. (2006). Municipal solid waste disposal in Portugal. Waste Management, 26(12), 1477-1489.

Mahwar, R. S., Verma N. K., et al. (1997). Environmental auditing programme in India. Science of The Total Environment, 204(1), 11-26.

Manga, V. E., Forton O. T., et al. (2008). Waste management in Cameroon: A new policy perspective? Resources, Conservation and Recycling, 52(4), 592-600.

Mason, I., A. Oberender, et al. (2004). Source separation and potential re-use of resource residuals at a university campus. Resources, conservation & recycling, 40(2), 155-172.

Mason, I. G., Brooking A. K., et al. (2003). Implementation of a zero waste program at a university campus. Resources, Conservation and Recycling, 38(4), 257-269.

Massey University. (2002). Massey University Environmental Policy. Retrieved 5 April, 2011, from http://www.massey.ac.nz/massey/fms/PolicyGuide/Documents/University%20 Management/Environmental%20Policy.pdf.

Massey University. (2003a). Zero Waste Academy: Partners. Retrieved 16 April, 2011, from http://zwa.massey.ac.nz/partners.htm.

Massey University. (2003b). Zero Waste Academy: Practice. Retrieved 7 April, 2011, from http://zwa.massey.ac.nz/practice.htm.

Massey University. (2011). Road to 2020. Retrieved 16 April, 2011, from http://www.massey.ac.nz/massey/fms/About%20Massey/Documents/Defining-road-to-2020.pdf

Matete, N. & Trois, C. (2008). Towards zero waste in emerging countries – A South African experience. Waste Management, 28, 1480–1492.

Matsumoto, S. (2011). Waste separation at home: Are Japanese municipal curbside recycling policies efficient? Resources, Conservation and Recycling, 55(3), 325-334.

McCartney, D. M. (2003). Auditing non-hazardous wastes from golf course operations: moving from a waste to a sustainability framework. Resources, Conservation and Recycling, 37(4), 283-300.

MfE. (2002). The New Zealand Waste Strategy: Towards zero waste and a sustainable New Zealand. Retrieved 30 March, 2011, from http://www.mfe.govt.nz/publications/waste/waste-strategy-mar02/.

MfE. (2007). Environment New Zealand 2007. Retrieved 22 August, 2010, from http://www.mfe.govt.nz/publications/ser/enz07-dec07/.

MfE. (2009a). Composition of solid waste. Retrieved 12 April, 2011, from http://www.mfe.govt.nz/environmental-reporting/waste/solid-waste/composition/.

MfE. (2009b). Rubbish. Retrieved 15 April, 2011, from http://www.sustainability.govt.nz/rubbish.

MfE. (2010). The New Zealand Waste Strategy: reducing harm, improving efficiency. Retrieved from http://www.mfe.govt.nz/publications/waste/waste-strategy/wastestrategy.pdf.

MFE. (2011a). Waste Minimisation Act 2008. Retrieved 28 March, 2011, from http://www.mfe.govt.nz/issues/waste/waste-minimisation.html.

MfE. (2011b). Basel Convention. Retrieved 27 March, 2011, from http://www.mfe.govt.nz/laws/meas/basel.html.

MfE. (2011c). Montreal Protocol. Retrieved 21 March, 2011 from http://www.mfe.govt.nz/laws/meas/montreal.html.

MfE. (2011d). Product stewardship. Retrieved 25 March, 2011, from http://www.mfe.govt.nz/issues/waste/product-stewardship/index.html.

MfE. (2011e). Reduce your rubbish - A successful model for future collaboration. Retrieved 26 April, 2011, from http://www.mfe.govt.nz/issues/waste/waste-pilot/.

MfE. (2011f). The New Zealand Waste Strategy: Reducing Harm, Improving Efficiency. Retrieved 19 December, 2011, from http://www.mfe.govt.nz/publications/waste/waste-strategy/index.html.

Miswaco Envirocenter. (2004). R5 waste hierarchy. Retrieved 16 March, 2011, from http://www.touchoilandgas.com/download.cfm?step=2&type=art&type_id=152.

M. Hasnain Isa, et al. (2005). Solid waste collection and recycling in Nibong Tebal, Penang, Malaysia: a case study. Waste Management and Research, 23, 565-570. Retrieved 19 February, 2011, from http://wmr.sagepub.com/content/23/6/565.full.pdf.

Monash University. (2009). Recycling and waste. Retrieved 15 April, 2011, from http://www.mrs.monash.edu/environment/recycling-waste/index.html

Musa, Massey University. (2008). Musa environment officer student survey-recycling/ sustainability. Unpublished report: Massey University.

New South Wales Government (2011). Doing a Waste Audit. Retrieved 18 February, 2011, from http://www.environment.nsw.gov.au/resources/wrapp/01118wasteaudit.pdf.

Ngoc, U. N. & Schnitzer, H. (2009). Sustainable solutions for solid waste management in Southeast Asian countries. Waste Management, 29(6), 1982-1995.

Nilsson, J., Bjuggren C., et al. (1998). Greening of a campus restaurant at Stockholm University: sustainable development audits by means of the SDR methodology. Journal of Environmental Management, 52(4), 307-315.

NZBCSD. (2011). Zero waste: Introduction. Retrieved 15 April, 2011, from http://nzbcsd.org.nz/zerowaste/content.asp?id=24

NZWS. (2010). New Zealand Waste Strategy: Reducing harm, improving efficiency. Retrieved 15 November, 2010, from http://www.mfe.govt.nz/publications/waste/waste-strategy/wastestrategy.pdf.

OECD. (1991). Environmental indictors, a preliminary set. organisation for economic co-operation and development. Paris.

OECD, (2002). Environment Data: Compendium 2002. Retrieved 12 February, 2011, from http://www.oecd.org>.

OECD, (2007). Environmental performance review of New Zealand. Retrieved 12 April, 2011, from http://www.oecd.org/document/10/0,2340,en_2649_34307_37915274_1_1_1_1,00.html.

Oskamp, S. (1995) Resource Conservation and Recycling: Behaviour and Policy. Journal of Social Issues, 51(4), 157-177.

Parizeau, K., V. Maclaren, et al. (2006). Waste characterization as an element of waste management planning: Lessons learned from a study in Siem Reap, Cambodia. Resources, Conservation and Recycling, 49(2), 110-128.

Pearson, R. (2002a). Waste audits as a management tool. Waste Management and Environment, October, 2002, 25-28.

Pearson, R. (2002b). Step by step waste audit. Waste Management and Environment, December, 2002, 25-28.

Pitchel, J. (2005). Waste management practices. Municipal, hazardous, and industrial. Taylor and Francis Group; New York.

Phillips, P. S., T. Tudor, et al. (2011). A critical review of a key Waste Strategy Initiative in England: Zero Waste Places Projects 2008-2009. Resources, Conservation and Recycling, 55(3), 335-343.

PNCC. (2009). Waste Management and Minimisation Plan. Retrieved 15 October, 2010, from http://www.palmerstonnorth.com/content/107635/Waste%20Man%20%20Min%20Plan%202009web.pdf?now=2010-04-07T09:03:28.

PNCC. (n.d.a). New recycling service. Retrieved 19 October, 2010, from http://www.pncc.govt.nz/ServicesAndFacilities/CommonServices/Recycling/Detail.aspx?id=108478.

PNCC. (n.d.b). The A to Z of household recycling. Retrieved 2 May, 2011, from http://www.pncc.govt.nz/content/144154/A-Z%20Recycling%20for%20Web.pdf.

PotatoPak NZ Ltd. (2010). Our environment. Retrieved 2 May, 2011, from http://www.potatoplates.com/our-environment/.

Samakovlis, E. (2004). Revaluing the hierarchy of paper recycling. Energy Economics, 26(1), 101-122.

Seadon, J. K. (2010). Sustainable waste management systems. Journal of Cleaner Production, 18(16-17), 1639-1651.

Sidique, S. F., F. Lupi, et al. (2010). The effects of behavior and attitudes on drop-off recycling activities. Resources, Conservation and Recycling, 54(3), 163-170.

Slater, R., J. Frederickson, et al. (2007). A critical evaluation of partnerships in municipal waste management in England. Resources, Conservation and Recycling, 51(3), 643-664.

Snyman, J. & Vorster, K. (2010). Towards zero waste: a case study in the City of Tshwane. Waste Management & Research.

Solid Waste District (2011). How to conduct a Waste Audit. Retrieved February 18, 2011, from http://www.solidwastedistrict.com/information/stats.htm.

Springett, D.V. (1995) Environmental responsibility: an agenda for tertiary education: guide for environmental action. New Zealand Natural Heritage Foundation, Massey University, Palmerston North, New Zealand.

Suttibak, S. & Nitivattananon, V. (2008) Assessment of factors influencing the performance of solid waste recycling programs. Resources, Conservation and Recycling, 53, 45–56.

TalInlI, I., R. Yamantürk, et al. (2005). A rating system for determination of hazardous wastes. Journal of Hazardous Materials, 126(1-3), 23-30.

Tammemagi, H. (1999). The waste crisis. Landfills, incinerators, and the search for a sustainable future. Oxford university press, New York.

Taufiq, T. (2010). Characteristics of fresh municipal solid waste. United States -- Texas, The University of Texas at Arlington. 115.

The Solid Waste Policy Group, At Rutgers the State University of New Jersey (2011). Life Cycle; Waste Audit. Retrieved February 18, 2011, from http://aesop.rutgers.edu/~envpurchase/basics_cycle_audits.htm.

Thomas, C. Yoxon, M. Slater, R & Leaman, J. (2004, Sept). Changing recycling behaviour: An evaluation of attitudes and behaviour to recycling in the Western Riverside area of London. Paper presented at the Waste 2004 Integrated Waste Management and Pollution Control Conference, Stratford-upon-Avon, UK. Retrieved 15 April, 2011, from http://oro.open.ac.uk/7647/.

Timaru District Council. (2007). Waste management report for waste audit. June 2007. Timaru District Council.

Timlett, R. E. & Williams, I. D. (2008). Public participation and recycling performance in England: A comparison of tools for behaviour change. Resources, Conservation and Recycling, 52(4), 622-634.

Tinmaz, E. & Demir, I. (2006). Research on solid waste management system: To improve existing situation in Çorlu Town of Turkey. Waste Management, 26(3), 307-314.

Tsai, W. T. & Chou, Y. H. (2004). Government policies for encouraging industrial waste reuse and pollution prevention in Taiwan. Journal of Cleaner Production, 12(7), 725-736.

U.C. Santa Barbara. (2009). Campus sustainability plan. Retrieved April 11, 2011, from http://sustainability.ucsb.edu/plan/docs/SustainPlanExecSumm_Final.pdf.

UN Decade of Education for Sustainable Development (UNDESD). (2011). The Scotish Government. UN Decade of Education. Retrieved April 12, 2011, from http://www.scotland.gov.uk/Topics/Environment/SustainableDevelopment/UNDecade.

UNESA. (1992). Agenda 21. Retrieved August 15, 2010, from http://www.un.org/esa/sustdev/documents/agenda21/.

USEPA. (2001). Waste- Liquid waste. Retrieved, April 12, 2011, from http://www.epa.gov/ebtpages/wastliquidwaste.html.

US Environmental Protection Agency (2006). Definition of Solid Waste for RCRA Subtitle C Hazardous Waste**.** Retrieved February 17, 2011, from. http://www.epa.gov/osw/hazard/dsw/.

Waste management and environment. (2002). Step by step waste audit. Retrieved January 21, 2011, from http://www.wme.com.au/magazine/downloads/WasteAudit_dec2002.pdf.

Waste Recycling Group Ltd. (2010). Energy from waste. Retrieved 15 April, 2011, from http://wrg.co.uk/page.php?article=637&name=Energy+from+Waste&preview=true.

Watson, M. (2009). Waste Management. International Encyclopedia of Human Geography. K. Rob and T. Nigel. Oxford, Elsevier, 195-200.

Wei, M. S. & Huang, K. H. (2001). Recycling and reuse of industrial wastes in Taiwan. Waste Management, 21(1), 93-97.

Williams, T. P. (2005). Waste treatment and disposal. (2nd ed). The University of Leeds, UK: Jhon Wiley & Sons.

Wilson, E. J. (2002). Life cycle inventory for municipal solid waste management. Waste Management & Research, 20(1), 16-22.

Wilson, D.C., Whitemen, A. & Read, A.D. (2003). Strategy planning for solid waste management; an interactive toolkit for developing countries. Waste Management World, 55-60.

WRAP. (2011). About WRAP. Retrieved 15 April, 2011, from http://www.wrap.org.uk/wrap_corporate/about_wrap/our_impact.html.

Van Der Ryn, S. & Cowan, S. (1996). An introduction to ecological design. Washington DC: Island Press. Pp 17-32.

Vencatasawmy, C.P., Öhman, M., & Brännström, T. (2000) A survey of recycling behaviour in households in Kiruna, Sweden. Waste Management & Research, 18, 545-556.

Young, C., S. Ni, et al. (2010). "Working towards a zero waste environment in Taiwan." Waste Management & Research, 28(3), 236.

Zhang, N., Williams I. D., et al. (2011). "Greening academia: Developing sustainable waste management at Higher Education Institutions." Waste Management. In Press, Corrected Proof.

Zhuang, Y., S.-W. Wu, et al. (2008). Source separation of household waste: A case study in China. Waste Management, 28(10), 2022-2030.

ZERI. (2010). Zero Emissions Research and Initiatives. Retrieved 20 October, 2010, from http://www.zeri.org.

Zero Waste Inc. (n.d.). Zero waste philosophy. Retrieved from http://www.zwinc.org/philosophy.html.

Zero Waste SA. (2011). Zero Waste SA. Retrieved 15 April, 2011, from http://www.zerowaste.sa.gov.au/.

ZWA. (2002). Memorandum of Understanding. Zero Waste New Zealand Trust, Palmerston North City Council & Massey University.

Zero Waste International Alliance (ZWIA). (2007). The establishment of ZWIA. Retrieved April 14, 2011, from http://www.zerowaste.co.nz/default,134.sm.

ZWIA. (2009). Global principles for zero waste communities. Retrieved 15 April, 2011, from http://ambientefuturo.org/wp-content/uploads/2009/02/global-principles-of-zw.pdf.

ZWIA. (2010). Zero Waste International Alliance: About us. Retrieved 16 April, 2011, from http://zwia.org/joomla/index.php?option=com_content&view=article&id=1&Itemid=2.

ZWNZ Trust. (1999). Funding Application Form. Zero Waste NZ Trust, Auckland, New Zealand.

ZWNZ Trust. (2001). Zero waste resources: Australia. Retrieved 15 April, 2011, from http://www.zerowaste.co.nz/default,136.sm.

ZWNZ Trust, (2008). Climate change, sustainability, and waste. Retrieved April 13, 2011, from http://www.zerowaste.co.nz/default,766.sm.

ZWNZ Trust. (2011a). Australia. Retrieved 19 April, 2011, from http://www.zerowaste.co.nz/default,250.sm.

ZWNZ Trust. (2011b). Businesses. Retrieved 19 April, 2011, from http://www.zerowaste.co.nz/default,13.sm .

ZWNZ Trust. (2011c). Community Business & Environment Centre (CBEC). Retrieved 19 April, 2011, from http://www.zerowaste.co.nz/default,198.sm .

ZWNZ Trust. (2011d). Councils. Retrieved 19 April, 2011, from http://www.zerowaste.co.nz/default,councils.sm.

ZWNZ Trust. (2011e). Far North District Council. Retrieved 18 April, 2011, from http://www.zerowaste.co.nz/default,83.sm.

ZWNZ Trust. (2011f). Fonterra. Retrieved 18 April, 2011, from http://www.zerowaste.co.nz/default,495.sm.

ZWNZ Trust, (2011g). Palmerston North City Council. Retrieved 18 April, 2011, from http://www.zerowaste.co.nz/default,98.sm.

ZWNZ Trust. (2011h). Some other examples. Retrieved 18 April, 2011, from http://www.zerowaste.co.nz/default,365.sm.

ZWNZ Trust. (2011i). What is the Zero Waste Academy?. Retrieved 18 April, 2011, from http://www.zerowaste.co.nz/default,academy.sm.

ZWNZ Trust. (2011j). What's happening on-campus. Retrieved 20 April, 2011, from http://www.zerowaste.co.nz/default,82.sm.

ZWNZ Trust. (2011k). Zero Waste NZ Trust. Retrieved 20 April, 2011, from http://www.zerowaste.co.nz/default,808.sm.

APPENDIX I

Research Briefing and Recommendations

'Enhancing Waste and Recycling Infrastructure and the Awareness and Participation of the Campus Community at the Massey University-Turitea Campus-Palmerston North'

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<u>Introduction</u>

Over the last few decades, waste has become a major concern and has threatened the sustainability of our environment and impacted on human health (Manga, Forton et al. 2008; Watson 2009). For these reasons, successive national governments and Non-Governmental Organisations (NGOs) have been exploring ways to minimise waste, and to lessen the adverse impacts of waste on our environment, and on human health (Waste Minimisation Act, 2008). In 1999, a zero waste programme was established at Massey University Palmerston North by the School for Environmental Engineering (Mason, Brooking et al. 2003; Mason, Oberender et al. 2004). The main objective in establishing the zero waste programme was "to provide a way of responding to the growing interest and concern relating to practical environmental management of the campus". Secondary objectives were to promote ongoing research, education for sustainability (EFS), alongside raising environmental awareness and responsibility among the campus community.

Since its establishment, several Massey research projects (Springett 1995, Strauss 1996, Brown et al 1999, Navarro 2000, Hannon 2000, Mason 2001, Brooking et al. 2003, Hannon 2004, Oberender et al. 2004) and have contributed information designed to inform and support zero waste – and more broadly sustainability - programme development. This project follows that precedent, with the addition that it was structured to include the development and presentation of recommendations to Facilitates Management, thereby emulating a professional consultative setting for the student. This model of research provides an opportunity to pilot the idea of the campus providing a 'living laboratory' where sustainability related, 'real world' issues are studied with the view of designing solution based sustainability programme developments for Massey University. This concept presents a potential win-win for Massey. Opening up the campus as 'living laboratory' creates an array of value added learning and research opportunities in a setting which emulates the professional context for which students are being prepared. Over time, the knowledge base built up by this focussed student research programme (supported by staff expertise) will provide high quality feedstock for the ongoing decision making and investment needed to drive Massey's sustainability programme.

This latest research project involved undertaking a series waste and recycling audits to provide detailed and up to date information on the performance of the zero waste programme at Massey University's Turitea campus. The specific aim of this research report is, having analysed the existing recycling program, to combine this with a directed study of relevant international best practices and to, informed by these findings then, develop and present a series of recommendations for improving campus zero waste management.

This briefing report is based upon two parts. Part I describes the basic waste and recycling infrastructure across the campus, alongside the key findings from auditing this programme. This baseline report was presented in a meeting with Massey's Facilities Management staff. As a result of the discussion and feedback, further research questions were identified and additional work was undertaken. This second body of work forms Part II and presents the key findings from the audit of the recycling and waste in the student hostels, as well as addressing the required volumetric component for this project.

This briefing report has also been developed so as to provide a quick introduction and overview of zero waste at Massey. This design element was included in response to staffing changes brought about by the 'shared services' restructuring, which highlighted the need for succession planning and to have documentation in stock, via which any new staff member could pick up and read to gain a quick start understanding of the zero waste programme history, scope - and issues and opportunities.

<u>Part I</u>

Part I of this report presents key findings from the examination of concourse (central keynote part of the campus) waste and recycling infrastructure. The audit process was undertaken in a planned series, which sought to encompass the 'seasonality' of the university community as well as being designed to capture a snapshot of a key element of the wider campus waste and recycling network in statistically appropriate way. Key results are discussed below.

Collection System in Massey University, Turitea Campus

Massey has a number of existing recycling, waste, and organic resources collection points and associated bin types, which are placed at a variety of different sites. At present, Massey uses a variety of different types of bins around the campus. Each bin is designed for a different purpose and this is reflected in the characteristics and size of each bin. These bins range from rather small to extremely large. The following is a detailed description regarding the existing bin types and locations as well as the key issues and list of recommendations.

1. **'Wheelie' Bins / Mobile Garbage Bins (MGBs)**

   The following is a detailed illustration of location and type of wheelie bins on campus.

a. Inside the Dining Hall

b. Concourse area (opposite dining hall entrance)

c. The Library main entrance d. The Concourse Area (Northern corner of library)

e. Concourse area behind the Dining Hall f. The Social Science Lecture Theatre

f. Inside the Dining Hall g. Recreation Centre

h. Campus Accommodations (hostels)

Figures 1, Recycling Wheelie Bins in the Concourse, the Dining hall area, and the Student Hostels. NB: these MGBS have been adapted for recycling with the use of recycling lids.

The above figure 1 illustrates the type of wheelie bins which are located adjacent to the concourse area, in the student dining hall, student accommodation, and recreation centre. The size or volume of the wheelie bin is 240 litres and there are a total of 26 clusters. Each cluster is colour coded, for instance the red colour is for aluminium and tin cans; and the green colour is for plastics and bottles.

The process of removing the recyclable materials from the wheelie bin clusters is coordinated by Green Bike Trust (GBT). This is undertaken twice a week on Tuesday and Thursday. The collection and transportation of recyclable materials in the wheelie bins is done by using the small truck (See Figure 2 below). Because of contamination issues the recycling still needs to be hand sorted on campus prior to be transported to the PNCC Awapuni Sustainable Development Centre (ASDC).

Figure 2, Green Bike Trust (GBT) truck (left) and RFM tractor and trailer (right) used for emptying respectively recycling wheelie bins and waste in Massey

Aside from external recycling clusters, there are also three new organic food waste collection wheelie bins which are recently placed inside the student dining hall. These wheelie bins are dedicated for organic waste collection. However these are not clearly signposted as such (See Figure 3).

Figure 3, the picture of organic waste bin in the Dining Hall area.

2. Waste Collection (Small Waste bins).

There are two types of small waste bins around campus. These are either round or square shapes. The round shape is a new model whereas the square is an older model (NB: there is a significant price difference between the two and it appears Massey is in the process of replacing old with new). In total there are 12 round bins and 8 square bins located in the concourse area. These waste bins are placed in a variety of sites adjacent to the concourse area and the student dining hall.

There are significant issues with the level of contamination in the waste bins (i.e. all types of recyclables and organic resources are placed in waste bin instead of the recycling collection system). The average percentage of contamination was found to be 64%.

Figure 4: Illustrates the two types of the small waste bin (round or square) emptied by truck and the large general waste bin which is used for amalgamating and storing bulk waste at convenient sites around the campus. The network of large bins are emptied / serviced by a front load truck operated by an external contractor.

These waste bins are dedicated for waste only collection but this distinction is not well supported by accompanying signage. The Regional Facilities Management (RFM) office is responsible for managing the emptying of these bins. The process of emptying the waste is carried out daily by ground keeping staff using a small tractor (See Figure 2). The collected waste which is contained in plastic bags is subsequently 'dumped' into the bulk waste bins which are located around the campus (See Figure 4). The use of plastic bin liners assists in keeping both waste and recycling bins clean, but as a practice in itself creates additional waste.

3. **Large: Paper (1) and Polystyrene (2) Recycling Cages, Glass Bins (3), Scrap Metal Bins (4).**

These bins are the largest waste and recycling bins used at Massey University. The illustration of the large bins collection is shown below in Figure 5.

1. Recycling cage bin

2. Polystyrene Cage

3. Glass bin

4. Scrap Metal bin

The bulk waste bins used at the Turitea campus range in size from 1.5m^3, 2m^3, 3m^3 to 4.5m^3 (Massey Regional Facility Management RFM, 2010). In total, there are 40 bins used at the Turitea campus. These consist of twenty bins of 1.5m^3, one bin of 2m^3, five bins of 3m^3, and thirteen bins of 4.5m^3. These bins are located in various places around Turitea campus and Massey student halls or hostels. The detailed information with regard to location, size, and total number of large waste bulk collection is appended as Table 1 as part of Appendix 1.

In total there are nineteen paper recycling cage bins placed across the campus. There are three colour separated glass bins (clear/flint, green and brown) plus polystyrene recycling cage and one scrap metal recycling bin located up at the GBT base at the ‘boiler house’. The emptying and removal of the waste and recycling from within the large bins and cages is handled by a variety of contract service providers managed by RFM. For example: waste - via a ‘Waste Management Ltd’ front load truck, paper - via ‘Fullcircle’, glass - via ‘Cairns Bins’, polystyrene - via ‘Genesis Trust’ and the scrap metal bin is emptied via a local scrap metal dealer.

4. The Staff / Common Room Recycling, Waste, and Organic Resource Collection System.

The Massey waste and recycling system utilises three different types of bin in the staff common room recycling programme. These are waste, ‘all in’ general recycling, and organic resource bins (see figure 6). The process of emptying recycling and waste is carried out on demand by RFM, whereas organic recycling collections are carried out routinely twice a week (Wednesday and Friday) by an independent contractor working in synergy with the Green Hub. Detailed information with regard to location and total number of waste, general and organic resource recycling bins is shown below in Table 2 as part of Appendix 1

Figure 6, types of general recycling, waste, and organic collection receptacle in the staff common room.

General Observation of Collections Management:

The servicing arrangements of the waste and recycling infrastructure is spread across a wide variety of internal and external service providers. These appear to have proliferated as new elements of the system have been added in. Whilst there is a certain degree of resilience in this diversity there may be advantages in simplifying the service provision so as to reduce the management demand and possibly cost. There would appear to be value in timing the examination of collection service arrangements alongside that of the recycling system design as a whole so that if any changes are forthcoming they can be implemented in synergy.

Discussion of Key Audit Findings:

The audit highlighted performance issues with the cluster model of recycling. This is indicated by there being an average contamination level of 15% by weight (i.e. all types waste and organic materials in the recycling, and misplaced recycling in the wrong bin). A key issue related to the potential cause of contamination in the wheelie bins is unclear/UV degraded and or missing signage (see Figure 1 above). Aside from signage issues, the Massey contamination levels may be derivative of the fact that the existing cluster system necessitates additional drop-off choices (i.e. which bin do I put my material in?) which may confuse or demand more thought from customers than they are prepared to put into this action.

As it stands the current level of contamination means that the material has to be hand re-sorted on-campus by the Green Hub - rather than being able to be taken directly up to the Material Recovery Facility (MRF) at the Awapuni Sustainable Development Centre (ASDC). This quality assurance (QA) problem exists in spite of the fact the PNCC have adopted an all-in[1] recycling MGB based curb-side recycling system, whilst Massey retains a separation at source model (e.g. people have to pick which bin in the cluster they need to deposit into).

[1] NB The PNCC curb-side recycling system does facilitate separate glass collection into 60 L crates on alternate weeks. All other mixed recyclable paper, aluminium and steel cans, cardboard and all plastics go into the 240 L MGB

Whilst currently the recyclable material collected on campus feeds off into the city MRF processing system this is where the programme alignment ends. In the past the city's household source separated plastic bag contained was conceptually aligned with the similar cluster model on campus, in terms of both systems requiring participants to action choices based upon awareness of how the system works. Now that the city has introduced 'all in' curb-side MGB system, the city and campus models are out of sync. Given that staff and students who live in the city are now experiencing this new simpler recycling system, the disconnect between this and the outmoded on campus system may be a source of confusion, and or pushback antagonism resulting in excessive contamination. It could be argued that if anything Massey's 'separation at source' derived recyclables should be of higher quality than the general 'all-in' curb-side recyclables collected by the PNCC. However this appears not to be the case.

Figure 7: Illustration of the old PNCC curb-side recycling system vs. the new. Left: The old 'source separated' curb-side bags. Right: All-in recycling MGB with a separate glass crate. *NB: the implementation of the new system has resulted in a increase in recycling participation from approx 30% to 90% of households.*

A second form of on campus recycling system misalignments occurs in that the indoor staff common room recycling system does not match that employed outdoors. Ironically the indoor system employs in large part the same conceptual model as the PNCC new all-in curb-side system. This on-campus system mismatch may also be a source of confusion/ frustration related contamination. Currently the in-door organic resource collection and recycling system has not been rolled out uniformly around the whole campus. The waste audit findings show that organics resources are a major contaminant in the concourse waste system. Introducing an outdoor organics recycling system on-campus so as to match what is working indoors is likely to reduce waste to landfill as well as provide a sense of cohesion to the zero waste programme.

Part II

Part II of this report presents the key findings of a waste audit which was conducted in the student hostels. This supplementary work request resulted from the initial meeting with RFM, where they considered understanding the hostel recycling scenario critical to any decision making regarding the recycling programme as a whole. RFM also sought clarification as to the volumetric rate at which recyclables were deposited into the concourse recycling system. An understanding of volume considerations is critical to aligning any possible changes in bin configuration/size with the servicing interval at which time the recycling bins are emptied. Get this factor wrong and recycling bins might overflow and potentially cause an aesthetic and practical nuisance.

The hostel waste and recycling audit was undertaken by drawing upon the methodology established for the previous auditing work. The volumetric considerations were addressed by developing a Massey weight to volume conversion factor. This will allow all previous weight based waste and recycling audit data to be converted to volume data. Given that all waste and recycling audits have been undertaken over a fixed time period – aligned to current service intervals – this means some informed discussion can be entered into regarding the rates at which recyclables are generated and deposited, hence what bin volumes and configurations may be appropriate to encompass these flows.

As a result, the following table of Massey's weight to volume conversion factors – based on recyclable commodity type has been created. See Table 3 Appendix 1.

Brief findings of the quantity and weight of recyclables and waste generated, as well as the level of waste and recyclables contamination in the student hostels.

There are a total of 17 hostels across the Turitea campus. These hostels can be said to be comprised of four different groupings (Moginie Village, Turitea, The Courts, and Atawhai Village) with varying population characteristics, such as a high percentage of first year vs older or international students. Accordingly, a number of samples of this study were selected using a systematic random sampling based on the four different groups. Table 4 in Appendix 1 below shows in a highlight (yellow) of which nine hostels were chosen using systematic random sampling.

The data presented in following Table 5 of Appendix 1 is the data collected, which relates to a one week period. The actual data was collected on March 8th and 10th 2011 during semester one, 2011, which is when students are on campus. The data obtained is weight by each category of recyclables and the percentage of audit result, correct and incorrect recycling based on each location of student hostel. Following is the auditing result of the final trial.

In total, from nine hostels sampled (ref Table 5 – Appendix 1) a total of 256.31 kg of recyclables was generated. Utilising the conversion factors allowed us to estimate the volume of this material as 3.16 m^3. Currently in the hostels the recycling contamination % is a very creditable 1.7% which is a very positive outcome. In the research report further analysis of these results is undertaken in order to drawn a more complete picture of the relative differences in per person recycling generation, as this may relate to the demographic variance in the hostel system. These findings may support further developments in environmental communication and social marketing to encourage ongoing participation.

Alongside auditing the hostel recycling system, the situation with general waste was also examined and taken into account in conducting waste audit in the student hostels. In this case, only four locations were chosen using a systematic random sampling (Moginie hall, City Court, Colombo and Tawa hall). Based on the data obtained, the average contamination (i.e. recyclables found in the waste bin via the auditing process) is 38%, which can be considered significant. The complete findings developed from waste auditing the four selected – representative - hostels are shown in Table 6 of Appendix 1.

This contrasting picture tells us that whilst when people do actually recycle they do so in an accurate manner, making few ‘separation at source’ errors/omissions, which results in very low contamination. However it appears many people opt out and do not participant in recycling, which results in a significant amount of recyclable material entering the waste stream. It can be presumed that because there is no organic recycling programme in the hostel, that a portion of this waste will be potentially recyclable organic resources. However, given that hostel students to a large degree frequent the centralised student dining centre – in which organic recycling is established, that not all of the recyclables currently in the waste can be attributed to this factor.

In summary, whilst the waste and recycling audit process has quantified some very positive outcomes, this work has also highlighted some issues relating to recycling in the hostels, which is an important element of the overall zero waste programme on this campus. It is clear that any consideration of options for a zero waste programme 'make-over' which involves a redevelopment of the recycling infrastructure and servicing, needs to factor in the whole variety of locations and niche circumstances – including the hostels - which exist on campus.

Key Issues and Corresponding Recommendations.

In general, the recycling collection system at Massey University Turitea campus works relatively well. However, there are several key issues which need to be considered, in order to build on this good performance. For instance;

- The signage of wheelie bins is unclear and is potentially confusing for international students;
- There is no signage on some of the wheelie bins and the existing signage is sun (UV) damaged.

Recommendation 1: Programme Brand and Signage Makeover.

Upgrade the Massey institutional, all-campus recycling system brand and hierarchy of instructional signage to ensure the motivational messages and key instructions are clearer and definitively linked to the broader sustainability programme. (For a mock-up example of 'programme branding' see Appendix 2). Additionally, there would be considerable value in reconsidering the interrelationship between the application of the New Zealand recycling symbols (which are currently used) and the incorporation of other national recycling branding in particular the ‘LOVENZ’ national public spaces recycling brand. Finally consideration should be given to acknowledging and incorporating common international student languages.

- This Massey Turitea campus recycling ‘cluster’ system is relatively old (arguably based on an outdated idea) and out of sync with the city’s new recycling collection model, which is managed by the PNCC. Additionally, Turitea’s campus outdoor vs indoor recycling systems are out of sync. This culminates in confusion, which potentially undermines effective participation in the zero waste programme. The issue of contamination has been red flagged by the findings of the waste and recycling audits undertaken as part of this research project.

Recommendation 2: Institutional / Campus Recycling System Makeover

For finalising and implementing an institutional recycling infrastructure and servicing system redesign this research project has initiated discussion around two redevelopment options. However, the scope of this research project is confined to the Turitea campus (and hence Palmerston North as the host city). It needs to be recognised that, in line with the recommended whole of institutional brand make-over the other two campus / host city scenarios need to be factored in – in arriving at a final overarching redevelopment plan. Locally improved recycling system alignment – within the campus in and out-door spaces and between city and campus models appears to be a commonsense redevelopment avenue which will facilitate the opportunity to leverage value added social marketing benefits off any given host city’s ongoing municipal recycling education programmes.

- There is a lot of contamination of potentially recyclable organic resources in both the waste on and recycling bins. In large part it might be argued that this has arisen from the fact Massey has adopted biodegradable food packaging (as opposed to the previous non recyclable polystyrene containers in the student dining area without necessarily facilitating and communicating the corresponding organic recycling this change created a need for.

Recommendation 3: Complete the 'Roll-out' of Organic Recycling as a Uniform Part of the Campus Recycling System.

Expanding the current organic recycling system from just the staff common rooms to include the student hostels and outdoor collection points in association with general recycling collection, is likely further reduce waste to landfill and mitigate a significant contamination issue (paper food plates mistakenly put into paper recycling). The current use of bio-bags and boxes which works well in an indoor environment needs to be examined for effectiveness in an outdoor context.

- The scope of the current Turitea campus recycling network has remained static for several years. In adopting a waste and recycling audit approach the research has inherently focussed on parts of the University where recycling exists. Of equal importance is to understand the fate of recyclable resources in parts of the campus not currently covered by the recycling services. Depending on future investment in recycling infrastructure and services further gap analysis type research work may be warranted.
- This research project has specifically not been expanded to include in its scope the zero waste programmes of other Massey campuses. Again this is an important consideration which warrants further exploration. Ideally Massey will illustrate a high level of zero waste programme alignment in terms of infrastructure (conceptual model, bin types and network coverage), communications and servicing, across all of its campuses. A key factor is achieving positive alignment with host city / and local recycling service providers.

Recommendation 4: Explore the practicalities of - and then set a goal for - establishing whole of campus recycling networks, based upon a uniform institutional and locally appropriate approach in each of Massey's key locations.

At the Turitea campus, such an expansion will ensure that a greater number of strategic locations are covered, thereby creating a truly campus wide recycling network. Depending on which if any redevelopment option is selected, an examination of all campuses recycling programmes as a single institutional programme may throw up opportunities to reuse equipment between campuses thereby generating costs savings and synergy.

<u>Proposed Recycling Re-development Options:</u>

In order to progress the required, 'where to from' here discussion, the following two redevelopment options have been profiled for the Turitea campus:

Option I: Synergy with the PNNC recycling model.

One way can be achieved is by using the collection system which is similar to the PNCC model (wheelie bins and crates, see figure 7 below). This provides the advantages of being able to draw upon the value of the PNCC brand and potentially also cost savings from the economies of scale they enjoy.

Figure 7: An illustration of the new recycling collection system and branding in Palmerston North – a 240 L MGB and a 60 L glass recycling crate – NB: collected on alternate weeks. (Source PNCC 2010)

Synergising with the PNCC recycling collection system within Massey is likely to increase effectiveness of the programme due to the campus community having familiarity with the PNCC`s system design, function and behaviour change messages.

Accordingly, the performance of campus recycling programme, in terms of increasing recycling volumes (equal less waste disposal costs) and reducing contamination levels (equals lower or hopefully zero on-campus resorting costs) is likely to improve. Aside from the advantages mentioned above, there are also a number of potential disadvantages such as the cost of the bin housing design (see figure 8: below) and the cost of purchasing new recycling collection bins.

This model option will reduce the choices required of any given participant whilst maintaining a separate glass collection, which is a major safety and quality assurance consideration. This model adopts the all-in general recycling collection as per household recycling in the city. The use of the same bin types will draw upon people's familiarity with the city's programme rules (i.e. what goes where) and this familiarity can be supported by a unique Massey branding communications signature.

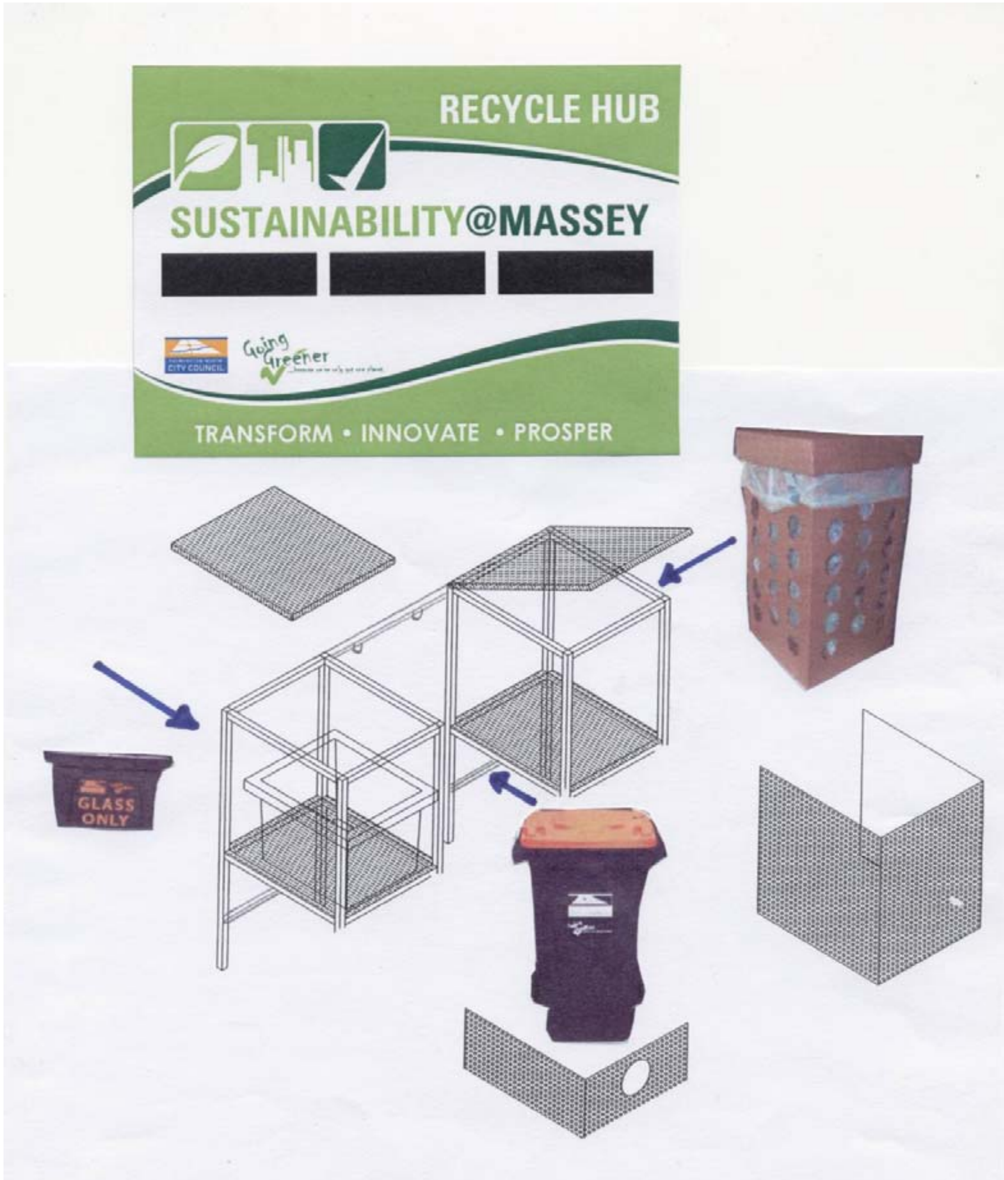


Figure 8: A model of campus recycling based upon utilising the PNCC model (i.e. all-in general recycling in a 240 L MGB and a separate 60 L glass recycling crate) alongside incorporating an organic resource recycling system and an institutional brand make-over with reworked signage.

In developing Massey's redeveloped branding and communications strategy, it should also be possible to draw upon other leading national and international recycling related programmes / brands in order to produce a clear, powerful, user friendly and effective communications framework in support of the collections infrastructure.

In shifting from a 'cluster' format (up to 5 similar MGBs in a single location) to a single all-in general recycling model this potentially reduces the collection volume available for the combined; plastics, paper and metal cans collection. This issue can be offset by:

- Increasing the emptying/servicing frequency (NB: this may be required anyway in order to manage the challenges associated with organics recycling collections),
- Increasing the number of recycling stations in high usage zones (NB: if recommendation 4 is adopted this will to a degree happen anyway),
- Configuring a double-up of identical general recycling bins into a single recycling station.

If the this option is selected for further detailed analysis and costing then the volumetric information will provide a way of determining which of the above options might be required to optimise the system design and to calibrate the requisite servicing.

Option II: Reusing and Reformatted Existing Recycling Collection.

The idea behind this option is to modify and re-present the 'cluster' model, i.e. the existing selection of wheelie bins, in a new and upgraded configuration. Figure 9 below illustrates some design work Massey had previously commissioned to explore this line of thinking. In reality any one of several hybrid ideas could be compiled under the guise of this option. For example: Separate glass collection and or organics recycling could be developed usingexisting 240 L MGB. The all-in general recyclables PNCC 240 L MGBs could be inserted into this configuration, which would allow the existing MGB owned by Massey to be reincorporated in a modified updated context.

This option has the advantage of making use of existing equipment arguable retaining some of the benefits of this system, for example the familiarity and buy-in the campus community has built up with this model. This option can also be applied around recommendation 1 – 4, the only apparent down side is that for, what is likely to be similar cost implications, this option may engender less of a high impact sense of being a complete system 'make-over' and hence attract less attention from staff and students, which is a valuable currency in terms of social marketing and communication.

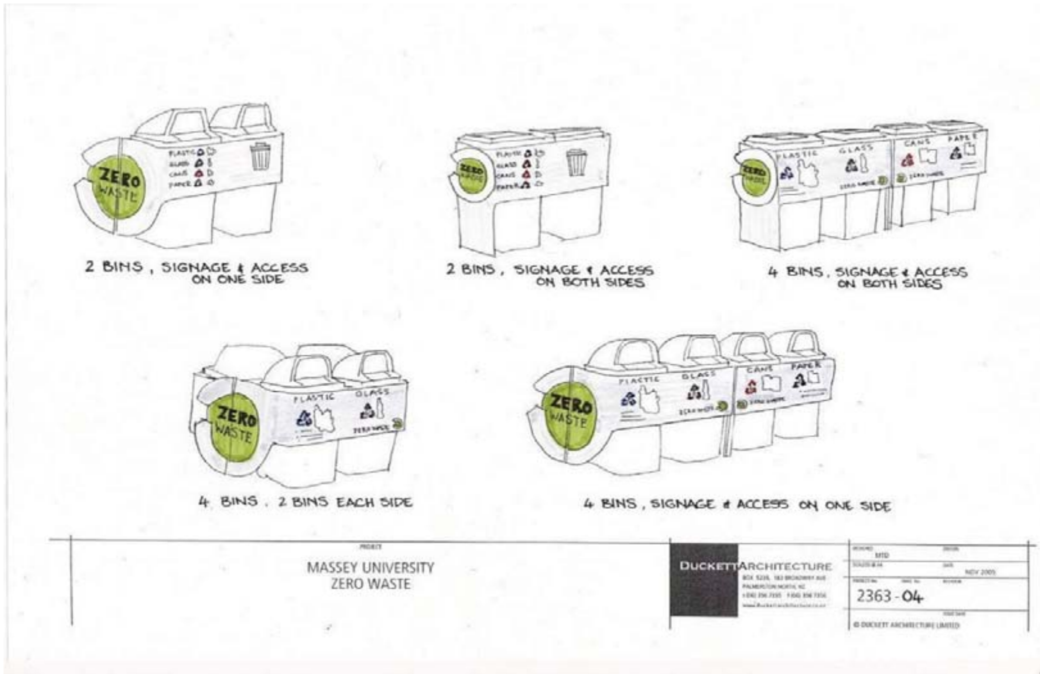


Figure 9: Design work illustrating a remodelled / upgraded cluster concept.

Option III: Start from scratch and explore the variety of new recycling bin systems.

I do not, for reasons of cost and continuity, advocate this approach. However Appendix 3 contains a variety of images of the 'wide world' of recycling bin design, which may act as a prompt stimulating further discussion as to which options will work best for Massey going forward.

Summary of Key Ideas:

1. Complete the Turitea campus recycling collection network by increasing the number and distribution of outdoor sites[2].
2. Redesign the model of individual recycling hub or station so as to incorporate the latest ideas.
3. If possible synergise with PNCC (or that any host city) systems (e.g. MGB bin design/type, separate glass collection crate).

[2] Appendix 3 contains an illustration of prospective new recycling sties that might be considered important as key focal points for new recycling collection on the Turitea Campus so as to create a complete campus network.

4. Brand, launch and reinforce this upgraded recycling collection system with a new look/signage and ongoing communication strategy which links back to 'Sustainability at Massey'.
5. Introduce into the system dedicated outdoor organic recycling collection systems to complement the successful existing indoor staff common organic recycling option.

Appendix 1:

Table 1: The location, size and total number of the bulk waste bin in Turitea campus

No	Waste bin Location	Size (m^3)
1	Bernard Chambers Carpark, off Library Rd	1.5
2	Vet Tower, outside gate to yard, off University Ave into Ag Eng car park	4.5
3	Vet Clinic Garage, by Vet Clinic Garage	1.5
4	Library, beside loading Bay back of library, Library Rd	4.5
5	Science Tower D, loading Bay Science Tower D, end of Riddet Road	3
6	Social Science Tower, car park to right of SST Building, University Ave	4.5
7	Wharerata, Wharerata car park, University Avenue	1.5
8	Mognie Hall	4.5
9	Craig Lockhart & Walter Dyer Halls	1.5
10	Tararua & Ruahine Halls	4.5
11	AgHort B	1.5
12	AgHort C	1.5
13	Green Bike Trust (GBT)	4.5
14	Boiler House	3
15	Maori Studies, Bourke Road, Maori Studies building loading bay	1.5
16	Creche car park	1.5
17	Maori Studies, Bourke Road, Childcare	1.5
18	Printery, car park behind Printery, off Collinson Rd	4.5
19	Prac Teach Agrom, compound behind building, off Collinson Rd	1.5
20	Riddet Compound, Riddet Rd, (between Riddet bldgs)	1.5
21	Kairanga Court, second bin in Workshop Rd	4.5
22	City Court Hostel, first bin in Workshop Rd	4.5
23	Rotary Court, University Ave	3
24	Matai & Kiwitea Halls	4.5
25	MacHardy Hall	1.5
26	Refectory, Refectory Rd, behind Refectory building	1.5
27	Business Studies, University Ave, car park behind Bus. Studies Central	1.5
28	International Office	1.5
29	University House, Japanese Theatre	1.5
30	Main Building, adjacent Old Registry	4.5
31	Dining Hall	4.5
32	Science Tower A, Colombo Rd, back of Science Tower A	3
33	Tawa Hall	1.5

34	Residential service office (RSO), Colombo Rd	1.5
35	RFM, inside W&S courtyard, Colombo Rd	1.5
36	Colombo Hall, outside Colombo Hall	3
37	Food Technology	4.5
38	Riddet 2, off University Ave, between Colombo & Riddet Roads	1.5
39	Riddet labs, between Riddet and Computing Services bldgs	1.5
40	Sport Complex, Orchard Rd behind Sports centre	2

Table 2: The location and total number of general recycling, waste, and organic recycling bins as part of the staff common room recycling programme at the Turitea campus.

No	Location	Organic	Recycling	Waste
1	International Office			
2	Research Management Service			
3	University House			
4	Japan Lecture Theatre			
5	Humanities Building			
6	HR Reception			
7	Business Studies			
8	Refectory building			
9	Communication building			
10	Registry Building Level 1			
11	Registry Building Level 2			
12	Social Science Tower Level 1			
13	Social Science Tower Level 6			
14	Geographic Building Level 3			
15	Library Level 2			
16	Library Level 3			
17	Radio Fm			
18	Maori Studies			
19	Vet-Equine Blood			
20	Vet-Common Room			
21	Aghort Common Room			
22	Riddet-School of Engineering			
23	School of Engineering			
24	I.T Common Room			
25	RFM			
26	Riddet			
27	Wool Building			
28	Recreation Centre			
29	Printery			
30	NSAT			

Table 3, Massey's conversion factor.

Category	Volume ($0.1m^3$)
Plastic & Bottles	2.1 kg
Aluminium & Tin Cans	4.10 kg
Mixed Paper	10.9
Glass	25.76
Organic Food	18.40kg

Table 4, Student hostels in Massey University, Turitea campus

No	Location	Hostel	
1	Moginie	1	Moginie
		2	Craiglockhart
		3	Bindaloe
		4	Walter Dyer
		5	Tararua & Ruahine
2	Turitea	1	McHardy
		2	Colombo
		3	Matai
		4	Totara
		5	Miro
		6	Tawa
		7	Kiwitea
3	The Courts	1	City Court
		2	Egmont Court
		3	Kairanga Court
		4	Rotary Court
4	Atawhai	1	Atawhai

There are a total of nine hostels selected as a sample for waste auditing. They are Moginie, Bindaloe, Tararua & Ruahine, Colombo, Matai, Tawa, City Court, Kairanga Court, and Atawhai.

Table 6: Summary findings of the hostel waste audit.

Code	Trial	Location	Correct		Incorrect		Total (kg)
			(kg)	(%)	(kg)	(%)	
F (Waste)	Trial IV	Moginie Hall	44.5	61%	28.6	39%	73.1
		City Court	57.2	59%	40.3	41%	97.5
		Colombo Hall	42.2	63%	24.6	27%	66.8
		Tawa hall	49.8	66%	25.8	34%	75.6
Total			**193.7**	**62%**	**119.3**	**38%**	**313**

Table 5, the overall recyclables composition of the nine student hostels

No	Student Hostels	Category								Total (kg)	Total Volume (m^3)
		Mixed Plastic (B1)		Aluminium & Tin Cans (B2)		Mixed Paper (B3)		Mixed Glass Bottles (B4)			
		Correct (Kg)	Incorrect (Kg)	Correct (Kg)	Incorrect (Kg)	Correct (Kg)	Incorrect (Kg)	Correct (Kg)	Incorrect (Kg)		
1	Moginie	1.95	0.2	1.15	0	10.05	0.22	11.95	0.37	25.89	0.26
2	Tararua&Ruahinie	3.9	0.27	4.15	0.27	5.1	0.1	9.2	0	22.99	0.38
3	Bindaloe	1.8	0.09	2.05	0	3.27	0.12	37.5	0	44.83	0.32
4	Colombo	2.6	0.08	1.65	0	6.85	0.1	10	0	21.28	0.31
5	Tawa	1.85	0.06	1.48	0.25	2.95	0.1	10.45	0	17.14	0.19
6	Matai	2.25	0.15	1.95	0.08	8.6	0.05	13.6	0.25	26.93	0.29
7	City Court	3.2	0.06	6.2	0.33	4.95	0.2	22.65	0.2	37.79	0.44
8	Kairanga Court	3.3	0	2.85	0.16	7.25	0.1	8.5	0.09	22.25	0.32
9	Atawhai	6.75	0.32	7.35	0.1	10.2	0	12.35	0.14	37.21	0.65
Total recycling		**27.6**		**28.83**		**59.22**		**136.2**		**256.31**	**3.16**
Total contamination			**1.23**		**1.19**		**0.99**		**1.05**	**4.46**	

Currently in the hostels the recycling contamination % is a very creditable 1.7%

APPENDIX 2 : Some examples of potential keynote locations which might be included in an extended campus wide recycling network.

1. Registry Building 2. Massey Main bus Stop 3. Geography Building

4. Aghort Lecture Theater 5. Science Tower B 6. Science Tower A

7. Footpath behind Sc.Tower C 8. Behind Sc. Tower B. 9. Science Tower C.

10. Footpath in front of the lake 11. the road to Library 12 the road behind Library

13. School of Philosophy

14. Social Science Tower

15. International Office

16. University House

17. Medical Centre

18. Business studies

19. the Centre

APPENDIX 3: A mock-up of a Massey 'recycling and sustainability' brand, alongside the LOVENZ national public spaces recycling brand, plus other potentially relevant brands which may form synergy with 'sustainability at Massey' – the UK's 'WRAP' love food hate waste branding, 'zero waste' and the national recycling symbols.

Appendix 3B: A wide range of recycling bin types and applications on display.


What recycling goes in when you're out
LOVE NZ


Recycling
Only
LOVE NZ
RECYCLE WITH CARE
Glass
Only
LOVE NZ
RECYCLE WITH CARE

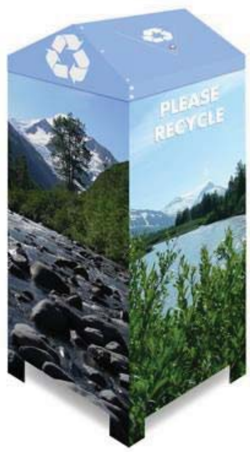

KERTAS SAHAJA
PAPER ONLY
纸 张
FIKIR DULU
SEBELUM BUANG
KACA SAHAJA
GLASS ONLY
玻 璃
FIKIR DULU
SEBELUM BUANG
PLASTIK DAN ALUMINIUM SAHAJA
PLASTIC AND ALUMINIUM ONLY
铝 和 塑 胶
FIKIR DULU
SEBELUM BUANG


Plastic
Waste
All Glass
Plastic
Cans
LOVE NZ


Specialists:
Recyclables


plastic bottles
mixed glass bottles & jars
mixed paper & card


recycle your empty aluminium drink cans here
0800 262465
RZ
RECYCLING ZONE
www.recyclingzone.info
RECYCLING ZONE


PLEASE RECYCLE


Recycling


GLASS BOTTLES

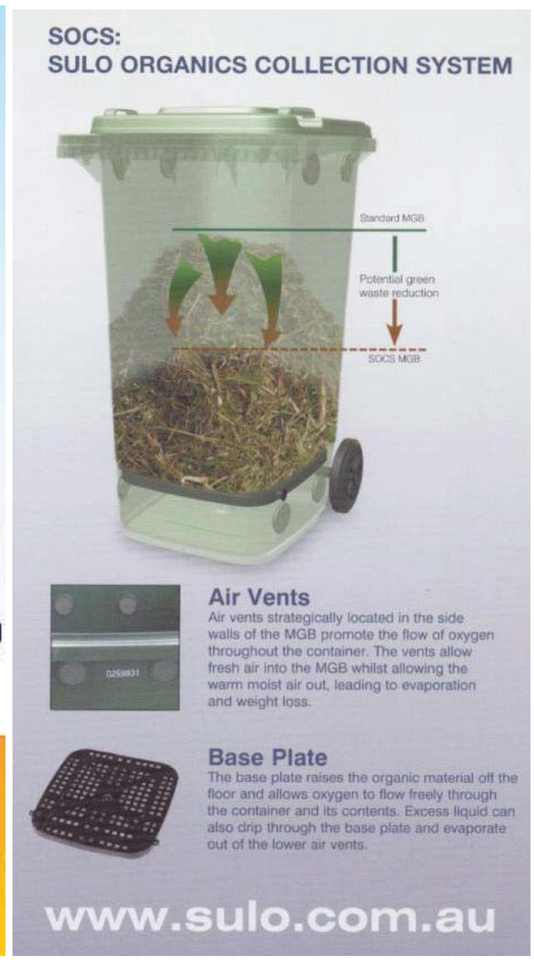

Please Recycle
give it back


Waste
Recycle
Station
Rubbish
Paper
Waste
Rubbish

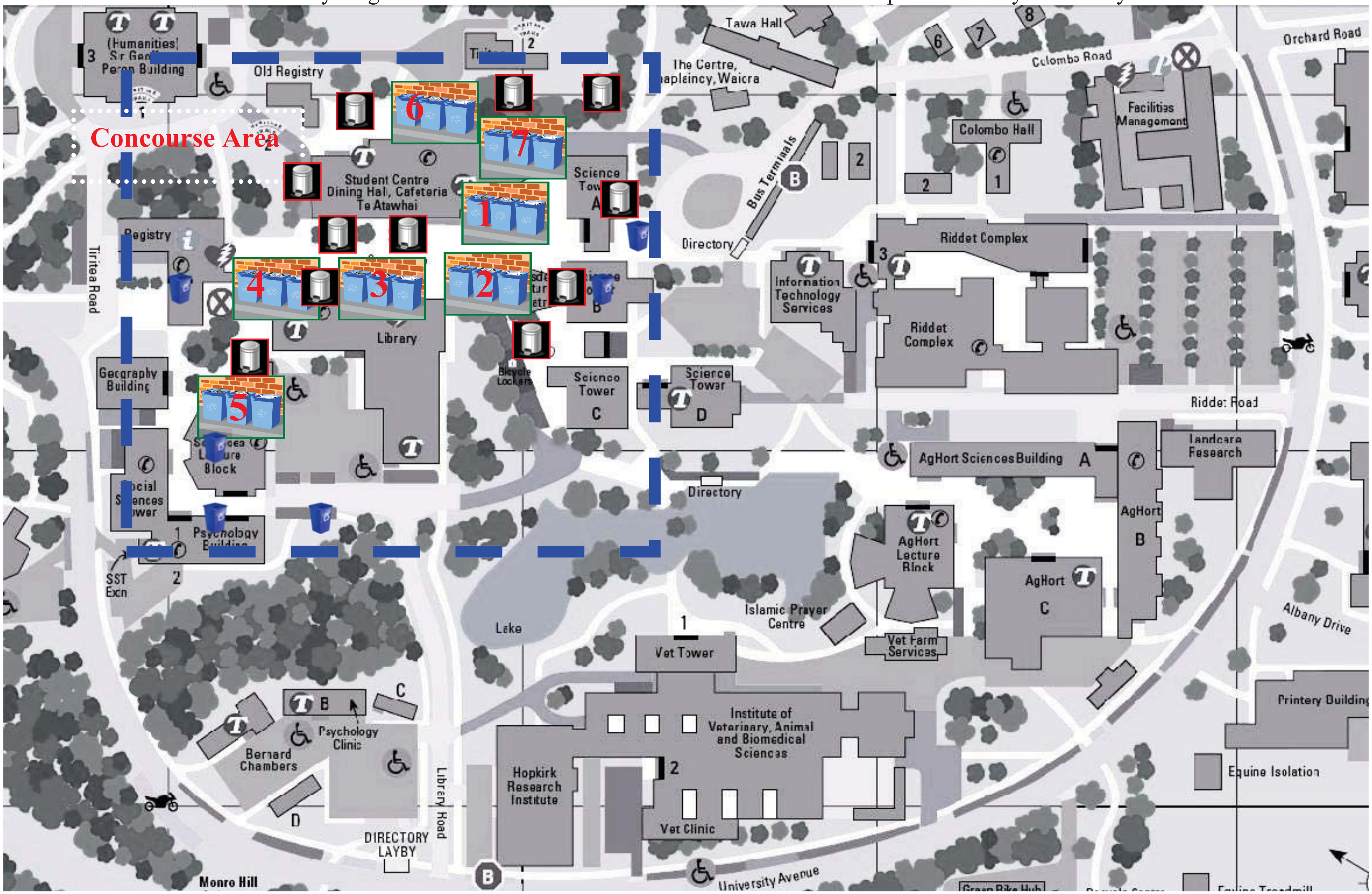

Waste
Recyclable


EXIT


NEWSPAPER
PENRITH
CITY COUNCIL
PENRITH
CITY COUNCIL
PENRITH
CITY COUNCIL


SOCS:
SULO ORGANICS COLLECTION SYSTEM
Standard MGB
Potential green waste reduction
SOCS MGB
Air Vents
Air vents strategically located in the side walls of the MGB promote the flow of oxygen throughout the container. The vents allow fresh air into the MGB whilst allowing the warm moist air out, leading to evaporation and weight loss.
Base Plate
The base plate raises the organic material off the floor and allows oxygen to flow freely through the container and its contents. Excess liquid can also drip through the base plate and evaporate out of the lower air vents.
www.sulo.com.au

APPENDIX 4: Outline of the recycling cluster locations in the concourse area of Turitea campus of Massey University.



Legend

1. 

Inside Dining Hall Area

2. 

The Concourse area (opposite dining hall entrance)

3. 

The Library main entrance

4. 

The Concourse Area (Northern corner of library)

5. 

Concourse area behind the Dining Hall

6. 

The Social Science Lecture Theatre

7. 

Inside the Dining Hall

8.  **The Concourse Area and the student dining hall area**

9.  Waste Bin (The small round waste bin)

10  Waste Bin (The small square waste bin)