1 Introduction
Sinclair Knight Merz Limited has conducted a 6-month pilot-scale trial of construction waste minimisation opportunities in Christchurch City. The project was funded by Christchurch City Council as part of the “Target Zero” waste minimisation programme. The main emphasis was on training 16 site foremen in identifying and segregating wastes “at the end of the pipe”.

Four construction projects by Hawkins Construction Limited (Hawkins) and The Fletcher Construction Company Limited (Fletchers) were studied, with capital value $0.9M to $9M. The project was successful, with both companies achieving reductions in waste disposal volumes of 20-40% and costs of 10-80%. Salient issues were uncovered regarding the current waste industry paradigm.

The objective of this paper is to discuss the findings of the waste case study and their wider implications for waste minimisation. An overview of the objectives, methods and results of the study will be presented, followed by discussion of the key findings.

In essence, the key findings of the study are:
♦ Construction waste minimisation is profitable for construction companies within the current cost framework for waste disposal in Christchurch City.
♦ Despite clear economic incentives, waste in many cases is not minimised.
♦ Lack of minimisation is associated with commercial imperative.
♦ Local authorities play a key role in overcoming initial barriers.
♦ Markets do exist for a wide range of recoverables, however they are under-utilised.
♦ The recycling industry infrastructure is not well established or integrated and potential participants have difficulty in obtaining information and making contact with recyclers.

2 Christchurch Construction Waste Minimisation Pilot Study

2.1 Objectives
The aims of the pilot study were to:
♦ Provide training for site foremen in waste minimisation techniques.
♦ Implement waste minimisation practices on a number of construction sites.
♦ Obtain data on the construction and demolition waste stream.
♦ Confirm potential environmental and economic benefits of waste minimisation.
2.2 Methodology
The focus of the study was practical implementation of waste minimisation procedures on construction sites. On-site segregation of recyclable and reusable materials was implemented. This is a well proven method of reducing solid waste disposal and has been trialled on construction sites in Auckland by the Regional Council (ARC). This study used the methods and lessons learnt from ARC and applied them in the local context.

Four case study sites were used and site foremen had the responsibility for waste minimisation. Sinclair Knight Merz’ role was to help to identify markets for materials and offer mentoring.

<table>
<thead>
<tr>
<th>Case Site</th>
<th>Brief Project Description</th>
<th>Cost ($m)</th>
<th>Project duration [duration in pilot study]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hagley Community College (Hawkins)</td>
<td>Interior demolition of old classrooms and refurbishment into new classrooms.</td>
<td>1.1</td>
<td>5 months [4]</td>
</tr>
<tr>
<td>St. Martins New World (Hawkins)</td>
<td>New supermarket, including office space, chillers and freezers, bakery, delicatessen.</td>
<td>3</td>
<td>7 months [4]</td>
</tr>
<tr>
<td>College of Education (Fletchers)</td>
<td>New apartment style accommodation facilities.</td>
<td>2.5</td>
<td>6 months [1]</td>
</tr>
<tr>
<td>St. Bedes College accommodation facilities (Fletchers)</td>
<td>New dormitory style accommodation facilities and refurbishment of existing dormitory style accommodation facilities.</td>
<td>0.9</td>
<td>6 months [3]</td>
</tr>
</tbody>
</table>

2.2.1 Information Sharing
Information sharing happened in both informal workshop sessions and on site with the foremen. Four, two hour, workshops were held at least one month apart over the five month programme. Workshops were used to:

♦ Educate and disseminate information to foremen and management about waste minimisation principles and the pilot study programme, using the ARC study for practical examples.
♦ Introduce local companies and organisations that transport waste and / or could help divert waste from landfills and cleanfills.

Sinclair Knight Merz visited case study sites once a week from the start of the pilot study until the construction on each site was complete. Site visits were used to communicate directly with the foreman managing the job, and for Sinclair Knight Merz to gain an understanding of issues on a practical level. This type of method for information sharing and data gathering is at the core of Target Zero waste minimisation programmes. During site visits:

♦ Foremen were assisted with implementing waste minimisation on site;
♦ data was collected on waste types and volumes;
♦ details were recorded of achievements and issues with on site sorting.
'Tool box' meetings were attended on two occasions to educate staff and sub-contractors on waste minimisation and the sorting programme. Tool box meetings are existing forums for information sharing run by the foremen either weekly or fortnightly with all workers on site.

2.2.2 Waste Minimisation

Waste minimisation was primarily on-site sorting of leftover materials from construction that could be reused or recycled. Separate bins or piles were set up in designated waste storage areas for the segregated materials. It was the foreman’s responsibility to ensure segregation occurred, as this person was the site manager and had responsibility for the work of all staff and sub-contractors.

This method of on-site segregation was identified as the best method for maximising material recovery, as identified through the ARC project. The method had a benefit over off-site sorting of waste skips because there was always a visible reminder to all staff to consider leftover materials not just as waste.

Each foreman was given a list of companies and organisation’s that advertised recycling and reuse services, as identified by Sinclair Knight Merz. Initial opportunities included metal recycling, cardboard recycling, concrete crushing, solvent recycling and plastic recycling. In addition, plasterboard separation was set up, to measure the volumes of this material as a percentage of the total waste stream even though there was no recycling opportunity. Plasterboard was identified as a large volume of waste in the ARC trials.

As the project progressed further opportunities were identified:

♦ The Christchurch City Council kerbside recycling scheme for cans, bottles, newspapers etc.
♦ Timber reuse as firewood by community groups.
♦ The Warehouse soft plastic recycling programme.

Prior to the pilot study, Fletchers and Hawkins were already separating some materials from the waste stream prior to the pilot study:

♦ **Metal:** Reinforcement and demolition material was being recycled through metal recyclers.
♦ **Timber:** Offcuts were used around the site or made into pegs for concrete construction. Staff collected timber for firewood.
♦ **Hazardous and domestic waste:** Hazardous and domestic waste were separated from general waste on Hawkins sites to be disposed of at the Burwood Landfill (most other waste went to cleanfill).
♦ **Rubble:** Separated from general waste as waste contractors preferred it out of the general waste skips.
2.2.3 Data Collection
Uncompacted waste volumes were estimated during the site visits. Volumes of waste within skips were estimated visually. The volumes of piles of materials (mostly recyclable or reusable waste) were measured with a tape measure. This has resulted in an estimated margin of error of +/- 25%. The primary reason for this method, instead of weighing each type of material, was time efficiency, although practicality and safety were also issues.

3 Results and Discussion
All four case study sites successfully implemented on-site waste segregation and reduced waste volumes and disposal costs. Waste minimisation practises are detailed below, followed by a summary of volume and cost savings.

<table>
<thead>
<tr>
<th>Waste Minimisation Practises</th>
<th>Worked well</th>
<th>Did not work well</th>
</tr>
</thead>
<tbody>
<tr>
<td>♦ Timber was kept in piles around each site and either reused on site or taken for firewood by staff.</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>♦ Hazardous and domestic waste was separated into yellow bags provided by EnviroWaste on Hawkins sites.</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>♦ Cardboard recycling started as the electrical work began and interior fittings were brought to site. Piles or bins were set up and the recycling company would collect the cardboard for free when called.</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>♦ Plastic separation started at the same stage of construction but was stopped at all four sites when it was found that the plastic recycling contractor on the contact list would not accept plastic from construction sites. The plastic was too contaminated with dust and dirt.</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>♦ Soft plastic recycling through The Warehouse retail group was successfully implemented half way through the pilot study. A wool sack (provided by The Warehouse) was set up next to the waste skip and labelled. Sinclair Knight Merz collected the plastic and delivered it to a warehouse. While this worked well, a system of collection will need to be implemented to keep the process working.</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>♦ Kerbside recycling of domestic waste was trialled, however the foremen found it difficult to use the kerbside service successfully on an ongoing basis, mainly because there was no internal system for putting the bin onto the street and collecting it again. Additionally there was little perceived benefit in sorting small amounts of 'domestic' waste.</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>♦ Metal was diverted from the skips and kept in piles or bins. A metal recycler would collect and pay for the material when called.</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>♦ Gibboard was separated and measured but ultimately landfilled as there is no collection or recycling of the</td>
<td>✔</td>
<td></td>
</tr>
</tbody>
</table>
plasterboard at present.

<table>
<thead>
<tr>
<th>Case Site</th>
<th>Waste to Landfill or Cleanfill (m$^3$)</th>
<th>Diverted Materials (m$^3$)</th>
<th>Net Cost of Waste Removal</th>
<th>Cost without Diversion of Materials [% saving]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hagley Community College</td>
<td>92</td>
<td>41 [% of total]</td>
<td>$310</td>
<td>$1920 [84]</td>
</tr>
<tr>
<td>St. Martins New World</td>
<td>240</td>
<td>68 [% of total]</td>
<td>$3340</td>
<td>$3720 [10]</td>
</tr>
<tr>
<td>College of Education</td>
<td>48</td>
<td>33 [% of total]</td>
<td>$1370</td>
<td>$2290 [40]</td>
</tr>
</tbody>
</table>

The above results are approximations of actual volumes due to the visual estimation method of data recording, but also because one site visit a week was not enough to record all of the waste that was taken off site. In addition, these results reflect only the period of the construction project that was part of the waste minimisation case study. Case studies had begun before the pilot study was implemented. Therefore the results would reflect different outcomes if the pilot study had captured complete projects.

The Hagley Community College case study saved 84% of the total potential waste bill by salvaging valuable materials to offset the waste disposal costs. Generally, salvage revenue is used for social club funds and would not show up in the profit for the project. The College of Education case study was completed before soft plastic recycling was available. Further savings could therefore have been achieved at this site.

The potential exists for even greater volumes of materials to be diverted from waste skips. On all four sites there was still significant amounts of recyclable and reusable materials recorded in the waste skips, even with segregation systems in place. This was a result of inadequate staff and subcontractor training, exacerbated by high turnover of subcontractors. It is estimated that with complete resource recovery using existing opportunities, greater than 50% of material could be diverted.

4 Key Findings
Overall, the results suggest good potential for minimising waste from the construction industry in Christchurch. Each case study reduced their overall waste volumes by 20-40% and, importantly to both construction companies, similar savings in costs.

The pilot study also highlighted several key factors regarding the current waste industry paradigm locally, critical to the ‘mainstream’ adoption of waste minimisation practises.
1) Construction waste minimisation is profitable.
All four case studies reduced their waste disposal costs as a result of practical, on-site, waste minimisation procedures. Savings were made because most recycling / reuse opportunities were free, i.e. there was no cost to have the materials removed from site.

In the construction industry, waste costs are directly related to profit margins, and so any cost saving is a direct increase in profit. Sinclair Knight Merz is aware that the industry is highly competitive, with most projects won through tender processes, therefore reducing waste costs is highly desirable to increase profit margins.

2) Despite clear economic incentives, waste in many cases is not minimised.
Apart from some separation of salvage materials (i.e. timber and metal) the overwhelming majority of leftover materials prior to the pilot study were considered ‘waste’ and disposed of into skips for removal by a single waste contractor.

This method was simple, convenient and conventional in terms of staff training, site management and invoicing. Time is a crucial factor in construction, and it is apparent that saving time is the priority with most projects. Therefore, waste disposal must be time efficient. Time pressures also mean that staff and management would not usually have time to investigate waste minimisation.

3) Lack of minimisation is associated with commercial imperative.
Along with the reasons of simplification and convenience, the main reason for not taking advantage of the savings associated with diverting waste from disposal is that the construction companies and their site managers lack information. The pilot study highlighted a general lack of knowledge in the Christchurch construction industry about the principles of waste minimising methods, of on-site material sorting and what facilities exist to assist them. As waste removal is not considered core to their business, nor considered a cost that can be reduced, there has been little incentive to find out more about waste minimisation.

The lack of information regarding waste minimisation is considered to be a result of waste contractors being the only organisations in regular contact with construction companies in relation to waste disposal. The waste contractors will only communicate to their clients the services they provide.

The waste contractors offer economic incentives in the form of penalties and / or reduced fees in order for companies to manage their waste in a particular way. For example Hawkins staff separate domestic and hazardous waste from cleanfill waste. Fletchers and Hawkins separate rubble as it is considered too heavy for the large skips. However, since segregating waste at source for recycling or reuse is not a priority for waste contractors, it has not been part of communication with construction companies.
The status quo will remain until there is a change in the direction of the waste contractors or until there is intervention from other organisations or impetus from the construction industry themselves.

4) **Local authorities play a key role in overcoming initial barriers.**
This pilot study was a direct intervention of the Christchurch City Council into the way construction companies manage their waste. Information sharing during the pilot study has lead to Hawkins and Fletchers:

♦ Understanding the principles of waste minimisation.
♦ Developing methods for practical, easy on site sorting materials.
♦ Gaining knowledge of recycling and reuse markets and how to best use them.
♦ Realising the potential for bottom line financial savings.

The Christchurch City Council has therefore helped the construction companies overcome the initial barriers to waste minimisation primarily increasing knowledge and giving practical solutions.

5) **Markets do exist for a wide range of recoverables**
The pilot study has identified several local opportunities for materials to be reused or recycled. This includes the well-established salvage industry and metal and cardboard recycling industries. Also identified was soft plastic recycling, set up as an internal system at The Warehouse. Community groups were found to have demand for materials such as firewood, curtains and insulation.

Although not used by case study sites, further markets for waste materials from construction sites were identified during the pilot study and include relocation of mature trees and shrubs, reuse of insulation, concrete crushing for on-site reuse and solvent recycling. Further opportunities have been discovered during the pilot study that may exist in the near future, such as plasterboard, hard plastic and polystyrene recycling.

6) **The recycling industry infrastructure is not well established or integrated.**
The Christchurch recycling and reuse industry has a low profile and is fragmented. A wide range of organisations (commercial and non-commercial) provide services in an ad hoc manner. The industry is therefore less effective than the waste disposal industry, which is very well organised.

As an example, there is a lack of co-ordinated transport services to the various recycling facilities, unlike the waste disposal industry. During the pilot study there was only one small company prepared to offer skip and transport services for recyclables, a service not offered by the two major waste disposal companies. This meant that Hawkins and Fletchers were left with the responsibility of transporting materials themselves or meant that they had to deal with more than one contractor.
Community groups lacked resources to organise collection and redistribution of firewood and other sought after materials. The groups were often difficult to get hold of and could not make decisions quickly. This created a problem for the foremen who required a reliable service to collect materials on demand.

Furthermore, it was noted during the study that there is little marketing and advertising in the local recycling industry. Some commercially viable markets such as salvage, metal recycling and cardboard recycling are well known, however it is difficult to get information on what services are available in industries such as plastic recycling or concrete crushing. This lack of self promotion further contributes to the lack of knowledge of potential services to the construction industry.

5 Conclusion
The pilot study of construction waste minimisation in Christchurch has highlighted key issues within the local waste industry. Economic incentives exist to divert construction waste from the skip. Waste disposal contractors are the key contacts to construction companies regarding waste management, and to date this has not included waste minimisation principles. However, intervention by the Christchurch City Council, via this pilot study has successfully given Hawkins and Fletchers practical solutions to minimising waste and maximising cost savings.

Mainstream implementation of waste minimisation is unlikely to occur until the recycling and reuse industry is more proactive, waste contractors provide essential services that support segregation and information regarding waste minimisation is effectively disseminated through the construction community.

Further work with the construction industry is likely to focus on methods 'up the pipe' to reduce the production of waste, along with encouraging other construction companies to learn about and implement waste minimisation. Further work will also include strengthening the local recycling and reuse industry.

6 Acknowledgements
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