Optimum Compaction Rate for Kerbside Recyclables

for

Zero Waste SA
and
Local Government Research and Development Scheme

Government of South Australia
Zero Waste SA

Local Government Association of South Australia

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DEFINITIONS

Commodity – the recyclable material sorted by product grade for market requirements.

Compaction density/setting – the weight (kg) per metre cubed of material in a collection vehicle, as adjusted by the vehicle operator.

Contamination – material placed in the recycling stream that is not accepted by the council for recycling, as defined in Table 1.

Non-recoverable recyclables – items that have been damaged during the collection and/or MRF sorting process that would otherwise be considered recyclable.

Table 1 – Accepted recyclables and contaminants

Accepted recyclables	Contaminants
Paper and cardboard	Plastic bags and soft pliable plastics such as cling film, bubble wrap, cellophane and packaging
Paper and envelopes	Nappies and other absorbent hygiene products
Magazines, brochures and newspapers	Items with composite materials such as toys, saucepans and gardening tools
Cardboard	Organic material
Liquid paperboard cartons	Batteries and car parts
Metal	Gas bottles
Cans – steel and aluminum	Mirrors, light globes or window glass
Aerosol cans (empty)	Eyewear, drinking glasses, jugs and ovenproof glassware
Paint tins (empty and dry)	Needles, syringes
Alfoil trays and alfoil rolled into a ball the size of your hand	Crockery including casserole dishes, cups, saucers, plates and bowls
Glass	Plastic strapping
Bottles and jars	Video cassettes, CDs and DVDs
Broken bottles and glass jars up to hand size	Expanded polystyrene foam
Plastic	E-waste
Empty rigid plastic containers (1–7)	Clothing, fabric and shoes
	Recyclables with food contamination or lids still in place
	Glass fines

Rejected materials – includes contamination, non-recoverable recyclables, glass fines and paper fines.

ACRONYMS

APC – APC Environmental Management
CDL – container deposit legislation
Hhld – household
LGA SA – Local Government Association of South Australia
LGR&DS – Local Government Research and Development Scheme
MGB – mobile garbage bin
MRF – materials recovery facility
SA – South Australia
ZWSA – Zero Waste SA

EXECUTIVE SUMMARY

Zero Waste SA (ZWSA) and the Local Government Authority South Australia (LGA SA) are seeking to determine the optimum compaction rate for the collection of kerbside recyclables in South Australia (SA). Recent changes to specified recyclables compaction rates have led to some concern over the rates of recoverable-materials loss. As this study will benefit the entire industry, a number of project stakeholders were involved. The study was jointly funded by ZWSA and the LGA through the Local Government Research and Development Scheme (LRG&DS) with in-kind support from Solo Resource Recovery, East Waste, Campbelltown City Council, City of Charles Sturt and Visy Recycling.

The LGA SA has recently revised the maximum compaction setting standard, outlined in its model *Waste and Recycling Collection Contract* from a rate not exceeding $170kg/m^3$ in 2009 to $200kg/m^3$ in 2011. Materials recovery facility (MRF) operators are also specifying load densities in an attempt to receive product that is not over-compacted, as the speed and ease of processing a delivered load is directly related to the degree of load compaction. MRFs have indicated the ideal compaction rate is $180kg/m^3$, however $200kg/m^3$ is acceptable. The current specified compaction rates appear to have little statistical basis. It is therefore timely for ZWSA to provide guidance to councils, their contractors and MRF operators on the impact that load density has on the loss of recoverable kerbside recyclables.

Compaction is one of a number of variables that can lead to issues with recovery. Others include the vehicle design, height of discharge of the bin, the speed of the lift cycle, the vehicle size, the depth and size of the paddle and the packing mechanism. The methodology for this project required that a collection vehicle from two different waste collection companies be used in two representative council areas. The kerbside recyclables were collected fortnightly, from the same households at five compaction settings.

The only key variable that changed for this study was the compaction setting (0, 150, 175, 200 and $225kg/m^3$) on the collection vehicles. The number of households collected, collection time and load weight increased steadily with increasing compaction levels. A total of 4,387 households' kerbside recycling was collected with a total weight of 49.2 tonnes.

Each load collected during the study was processed through the same MRF. The conveyor belt was slowed to recover the maximum amount of material. Materials were manually pushed onto the in-feed belt, creating minimal mechanised intervention that could impact the final results. Three residual bins were provided at the end of the MRF lines to collect all non-recovered material – residual waste, glass fines and paper fines bins.

Results were analysed by individual council and overall (as an average of the two councils' results). There was no clear relationship between compaction levels and contamination, as this is a factor of human behaviour. In addition, the percentage of non-recovered recyclables and glass fines were not significantly correlated with compaction levels.

At the 150kg/m^3 setting there was an anomaly in the data from Council 2 that was removed from some parts of the analysis. After removing this outlier, there is a slight but statistically significant increasing trend with increasing compaction levels for the percentage of paper fines and total rejected recyclable materials (minus contamination). The study indicates that the increase in the proportion of rejected materials between the 150kg/m^3 and 225kg/m^3 compaction rates is 1% (from a predicted 10.4% to a predicted 11.4%).

For all material streams audited there was minimal difference between the 150kg/m^3 and 225kg/m^3 compaction settings. This implies that for the kerbside recyclables presented by South Australian councils, contamination, glass fines, paper fines and non-recovered recyclables are not significantly affected by vehicle compaction rates. Any significant materials loss is occurring at other stages of the collection and sorting process.

On this basis, South Australian co-mingled recyclables collection could be conducted using compaction levels of up to 225kg/m^3. This would maximise collection efficiencies with minimal additional materials loss from compaction. However, this study has not considered the implications of glass being embedded in paper or plastic at any compaction level, nor clumping of paper or compaction levels above 225kg/m^3.

There are potential cost benefits for councils that can decrease their fleet and staffing costs by increasing compaction rates. However, the savings for each council would need to be determined based on the costs for that area. For the two scenarios run in this model, a council with 50,000 households would save $125,000/year by increasing compaction from 150kg/m^3 to 175 kg/m^3 or $245,000/year by compacting up to 225kg/m^3. These savings result from reducing the vehicle fleet and staff numbers. A council with 20,000 households, however, would not make any significant savings using the assumptions in this scenario because they would still require the same number of vehicles and staff regardless of the compaction levels.

All councils increasing compaction could adjust their runs and staffing to make some savings. Significant savings are only seen, however, where there is enough of a reduction in collection runs to remove a vehicle and staff from the fleet.

On the basis of these findings, and in our opinion, recycling-collection contracts in South Australia (or where a deposit–refund scheme for beverage containers operates) could specify a standard compaction setting of 200kg/m^3 with an upper limit of 225kg/m^3 without compromising resource-recovery efforts. We recommend the LGA SA *Model Waste and Recycling Collection Contract* be modified to specify that *'the standard compaction settings of 200kg/m^3 be nominated with an upper limit of 225 kg/m^3'*.

It is hoped that these findings can inform and assist all stakeholders in the supply chain of kerbside-collected recyclables, including local government, collection contractors and the recycling industry, in gaining a greater understanding of the implications of compaction on recovery in South Australia.

1 INTRODUCTION

The ZWSA Waste Strategy 2011–2015[1] establishes a municipal solid waste target of 60% diversion from landfill by 2012 and 70% diversion by 2015. A priority area for municipal solid waste is to: *reduce contamination arising from collection vehicle compaction rates*.

ZWSA established a reference group comprising recycling collection contractors, local government representatives, LGA SA and a MRF operator (Visy) to develop a scope of works to undertake a project to quantify the impact of variable compaction settings on resource recovery. This project aims to determine the relationship between vehicle compaction rate and the contamination rate (including loss of recoverable materials) of recyclables presented at the MRF for processing.

This project is funded through a grant from the Local Government Research and Development Scheme (LGR&DS), with a contribution from Zero Waste SA. The project meets the principles of the LGR&DS by facilitating a sector-wide approach to minimising contamination of collected recyclables due to over-compaction, thereby reducing waste to landfill and taking cost–benefit into account.

It is assumed that unless compaction rates are prescribed in local government contracts, most collection contractors are operating their collection vehicles in the upper compaction rate range to maximise collection efficiencies. Recently, LGA SA and several metropolitan councils and MRF operators have specified compaction rates. All specified compaction rates are different and all appear to have little statistical basis. It is therefore imperative to provide some guidance to both councils and their contractors and determine the relationship, if any, that compaction has on kerbside recyclables as well as the ability for the MRF to recover recyclables for end markets.

The costs of disposal for materials rejected at MRFs are borne by the respective council customers. With the EPA Landfill Levy increasing, and tighter budgetary constraints, councils are endeavouring to minimise these costs as much as possible.

In addition to contaminants entering the kerbside recyclables stream at the household level, recyclable materials become unrecoverable or unrecyclable at numerous steps throughout the recycling chain, including:

- Transfer from bin to collection vehicle
- Transport to the MRF for processing
- Discharge from the vehicle
- Processing within the MRF facility.

[1] Draft South Australia's Waste Strategy 2010–2015, Zero Waste SA, Consultation Draft, August 2010, accessed 28 July 2011 (http://zerowaste.sa.gov.au/About-Us/waste-strategy)

The level of contamination and non-recoverable recyclables from a MRF can be influenced by:

1. Consumer and community education
2. The type of collection system
3. The waste composition mix
4. The collection vehicle and mode of operation
5. The vehicle compaction rate
6. The sorting and recovery process at the MRF.

Each local government area has a slightly different socio-demographic profile and, as such, the consumption and disposal behaviours vary across metropolitan areas. If the audit sample was to include recycling vehicles from different local government areas each week the composition of each load would vary considerably and the results of the audit could not be legitimately compared.

It is not feasible to measure all of the elements outlined above and the range of combinations possible. Therefore, this project sought to measure, monitor and evaluate the effects of vehicle compaction rate on two similar socio-demographic areas in two different council areas only. The study used a different collection contractor for each council area, utilising different collection vehicles to collect recycling from a specific sample area each fortnight over five consecutive collection periods. Each collection occurred at a different load density. The nominated load densities for the project were zero, 150, 175, 200, 225kg/m^3.

Solo Resource Recovery and East Waste agreed to support the project by providing the required collection services. The contractors, in consultation with their councils, nominated areas most typical and representative of the local government areas. Visy owns and operates all MRFs in metropolitan Adelaide and supported this project by offering their North Plympton facility for processing and auditing.

2 BACKGROUND

Co-mingled recyclables are collected from kerbside mobile garbage bins (MGB) using compactor vehicles. These vehicles deliver the collected materials to a MRF where recyclables are sorted into various commodity streams. The compaction rate of the collection vehicle influences the load density and the time the collection vehicle spends on the road, which has a direct operational cost implication for councils.

Load density can also directly affect the quality of the collected recyclables because over-compaction can lead to difficulties for the MRF in recovering materials into their commodity streams, for example glass breakage increases and paper and cardboard recovery can decrease. MRF operators estimate that up to 10% of resources being sent to landfill can be attributed to compaction and over-compaction of kerbside-collected materials.

South Australia's landfill diversion rate in 2010/11 was 79.9% – the highest recorded over the past six years and the highest of any Australian state[2]. South Australia's Waste Strategy states that increasing the economic value of recovered recyclables for commodities such as paper and plastics remains an area for future infrastructure development and investment.

South Australia is one of only two states to have Container Deposit Legislation (CDL), which places a value on certain types of used beverage containers and therefore creates a different kerbside recycling composition to other Australian states and territories. Co-mingled recycling in SA tends to have lower levels of glass than other states, meaning that the results of the study may not be transferrable to different jurisdictions.

In NSW, where the product mix contains higher proportions of glass containers, a Glass Compaction Study (2004–5[3]) found that most collection contractors were operating their collection vehicles in the upper compaction rate range of around 195kg/m^3. The economic modelling showed that modest reductions in load densities of 20 to 30kg/m^3 could be achieved with only a marginal increase in total collection costs (less than 1%0. However, if the aim was to minimise glass breakage, then reductions in load density of 60kg/m^3 or more would be required to enable operation at around 140kg/m^3 density. This would inevitably require the use of additional collection vehicles, increasing collection costs by between 5% and 25%.

If the average recycling service in Sydney costs $50 per household per year, a transition to lower compaction densities would mean an increase of approximately $5 to $7 per year. Using an assumption that there were one million households in Sydney, this would mean an increased cost of $5 to $7 million per year. The study suggested that other technologies were likely to be more efficient and cost-effective in managing the glass breakage issue. The recycling industry in NSW has since invested in optical-sorting technology that can colour-sort glass down to a 5mm size fraction.

[2] Government of SA, May 2012, SA Recycling Activity Report 2010–11, Rawtech http://www.zerowaste.sa.gov.au/upload/resource-centre/publications/reuse-recovery-and-recycling/Recycling%20Activity%20Survey%20SA%202010-11.pdf .

[3] Glass Compaction Study for NSW Jurisdictional Recycling Group, A Prince Consulting, June 2004 (http://www.packagingcovenant.org.au/documents/File/Glass_Compaction_Report_Final.pdf)

Some councils have a direct contract with a MRF operator for the processing of recyclables. These councils have a financial interest in reducing contamination because they have to pay the cost to landfill all rejected materials, including non-recoverable recyclables and contamination. For councils where waste contract arrangements have the collection contractor owning recyclables, the additional costs of contamination and non-recoverable recyclables being disposed of to landfill may be passed back to councils in the form of higher service fees. Therefore, a clear understanding of the impact of compaction on contamination rates will assist with future contract negotiations.

The NSW Government *Model Waste and Recycling Collection Contract 2012* set the recommended maximum compaction limit for recycling at 170kg/m^3. The LGA SA *Model Waste and Recycling Collection Contract* is based on the NSW document and specified that *'Compaction rates should not exceed one-hundred-and-seventy kilograms (170kg) per cubic metre'*[4] in April 2009. This was the limit stated by Zero Waste SA in the project scope, however our research and contact with the LGA SA confirms that the current contract version from 2011 states *'Compaction settings should not exceed 200kg per/m^3'*.[5]

Two metropolitan Adelaide councils have recently set load-limit densities at 200kg/m^3 in their waste-collection contracts while other contracts specify higher or no specified compaction rate. MRF operators are also specifying load densities in an attempt to receive product that is not over-compacted, as the speed and ease of processing a load is directly related to the degree of compaction. One contractor currently states that the ideal compaction rate is 180kg/m^3, however 200kg/m^3 is acceptable.

From an environmental perspective, the waste management objective is to reduce waste to landfill. By lowering the amount of contamination and non-recoverable recyclables as well as increasing resource recovery, councils can achieve greater diversion rates to assist in meeting the waste targets set by ZWSA.

[4] Model Waste and Recycling Collection Contract. Section D Specification, Part 3: Recyclables Specification, April 2009.

[5] LGA SA Model Waste and Recycling Collection Contract. Section D Specification Part 3: Recyclables Specification, November 2011 http://www.lga.sa.gov.au/site/page.cfm?u=267

3 METHODOLOGY

3.1 Project inception meeting

A project inception meeting was held with the reference group to discuss in detail the operational issues and constraints of the project.

3.2 Literature review

APC undertook a desktop literature review of studies in relation to load densities and compaction. Most of the references found are related to the impact of compaction on glass breakage. South Australia has a different recycling composition due to the container deposit scheme and the absence of light-weight beer bottles from collection bins. Therefore, the transferability of other studies is limited.

The reference list of related studies and reports is provided in ***Appendix A.***

One of the key studies identified was the York Region Collection and Processing Optimization Study, by Stewardship Ontario (2006). It found that there was no consistent policy or procedure defining the optimal level of compaction during collection, or for effective MRF operations, across North America. The differences in compaction rates between jurisdictions are so great that the results of the survey identified no standard practice for collection or MRF processing.

The *average compaction* value among the 33 jurisdictions studied was 217kg/m^3. Six of the jurisdictions had average compaction rates of over 300kg/m^3. Eight jurisdictions had average compaction rates less than 160kg/m^3. The mean *upper limit* for compaction was 320kg/m^3, with 17 councils having upper compaction limits over 300kg/m^3.

The York Region conducted a similar trial to that conducted by APC for this study. The material stream contained a similar portion of glass to South Australia's, however the material was collected in crates, not mobile garbage bins. The compaction rates used were higher than those used in the audit conducted by APC. The baseline was 190kg/m^3, with the other compaction rates at a higher level. This study measured compaction as a ratio, using rates of 2.4:1, 2.8:1 and 3:1 rather than in kg/m^3 in this study, as that was the unit measurement method specified in their performance contract.

The findings were that while the survey provided valuable information regarding the issue of compaction, it did not provide any direction as to the establishment of a compaction rate that maximizes collection efficiency while maintaining an efficient MRF operation.

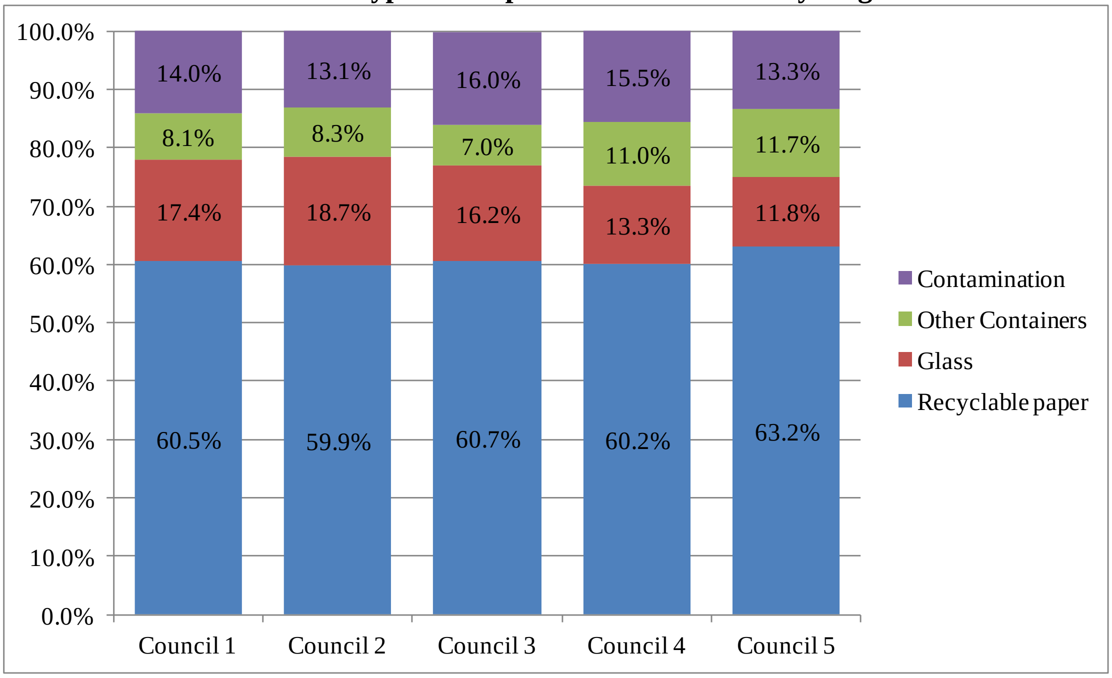
An additional consideration identified through desktop research is that paper mills recover up to 150 tonnes of glass and sand from paper pulpers at current compaction settings. While some of this sand would come from the pulping of cardboard, glass embedded in mixed paper presents a number of critical issues to the paper mills, including decreased quality of new manufactured paper and substantial increases in maintenance and wear of all equipment, which can double subject to glass levels. The impact of glass embedded in paper, however, was outside the scope of this report.

3.3 Desktop composition analysis

APC conducted a domestic waste audit of three Adelaide metropolitan and one rural regional council in May 2012. A review of this data was undertaken to determine current recycling stream composition and contamination levels. This data was used to validate the data obtained in this project to ensure the recycling streams and levels of contamination found are typical.

Error! Reference source not found. shows the result of four APC kerbside waste audits of South Australian councils conducted in 2012 and one Council audit from 2009. Councils 1–4 are metropolitan councils and council 5 is from regional SA. The level of contamination is relatively consistent, ranging from 13% to 16%, with the amount of glass ranging from 12% to 19%.

Chart 1– Typical composition of kerbside recycling



This compares with the standard composition of fully co-mingled recycling systems without CDS systems where glass is closer to 25% of the recycling stream.

3.4 Timing

To ensure the audits were as 'typical' as possible, certain events were avoided. Auditing was timed to avoid the month of April as Easter and Anzac Day both occurred during that month. Due to fortnightly collection cycles, this affects three of the four weeks in April. The audit was therefore conducted from 1 May to 27 July, 2012.

3.5 Collection area

The main criterion for area selection in this study was that the socio-demographic characteristics of the households needed to be relatively homogenous. This was to ensure that household recycling generation characteristics, and consequently the profile of the recycling sample collected, were similar.

A number of key socio-demographic indicators were used to compare Council 1 and Council 2 with the Adelaide Statistical Division using the *2011 Australian Bureau of Statistics (ABS) Population Census* data.

The key indicators used were:

- Households by dwelling structure
- Household characteristics
- Person characteristics
- Income.

The results of this comparison are shown in the Table 2 below.

Table 2 – Key Demographic and Social Indicators in Study Areas Compared

Indicator	Council 1	Council 2	Adelaide Statistical Division
Total population	104,981	48,162	1,225,235
Households by dwelling structure			
Separate house	72.2%	79.5%	77.2%
Semi-detached, row/terrace, townhouse, etc.	15.7%	10.6%	12.1%
Flat, unit or apartment	11.9%	9.8%	10.4%
Total occupied private dwellings	91.4%	92.3%	91.9%
Household characteristics			
Own their own dwelling	35.6%	39.4%	31.5%
Purchasing their dwelling	29.1%	30.2%	36.4%
Renting – public housing	31.2%	25.8%	28.1%
Average household size (persons)	2.3	2.5	2.4
Children per family	1.8	1.8	1.8
Person characteristics			
Overseas born	31.9%	36.5%	29.8%
Median age	41	41	39
Income			
Median weekly individual income ($)	524	517	554
Median weekly household income ($)	1,019	1,069	1,106

(Source: *ABS 2011 Census of Population and Housing*)

Both councils are reasonably close to the Adelaide average for most indicators and are therefore representative of Adelaide.

3.6 Sample collection

Five collections were undertaken in each council area. For each collection the required compaction rate was increased, resulting in an increased number of bins being collected per load until the vehicle was at capacity for that compaction level.

The same trucks collected recycling for each sample, commencing at the same starting point, collecting the same streets and houses as the previous occasion and extending the collection further each time to obtain the required additional number of bins to fill the vehicle. In Council 1, the same truck was used to collect all five (5) loads. In Council 2, the same truck was used to collect four (4) loads, but for the load involving a compaction level of 225kg/m^3, a substitute truck was used.

Table 3 – Council collection vehicles

Council	Truck registration	No. of collections	Body size
Council 1	SB22DU	5	30m^3
Council 2	XLK706	4	29m^3
Council 2	XEI300	1	29m^3

During each collection an APC observer accompanied the driver in the cabin of each collection vehicle to add to the robustness and integrity of the study. The observer performed two main tasks:

- Ensured the same base households were collected each time and recording the collection route for the following fortnight
- Recorded the number of bins collected rather than rely on the truck bin counter, which on occasion double-counts bins if items are jammed and the bin is difficult to empty.

The following activities were undertaken by the APC observer during the collection phase:

- Completion of a data collection sheet including date, day, compaction setting, council name, service provider, truck registration, weight of the empty vehicle prior to collection and time when leaving depot. An example of the data sheet is provided in ***Appendix C***.
- Travel to the same area as previous fortnight and start in the same street.
- Mark each street off a map provided with each week colour-coded and note collection start time.
- Use the tally counter to count the number of bins collected.
- Note street name and time when truck is full.

The trucks were weighed over a weighbridge and the weight recorded at the end of each collection. The tables below show the compaction setting, number of households, collection time, net load weight and average weight of recycling bins.

Table 4 – Characteristics of collected loads – Council 1

Compaction level	Number of households	Collection time (mins)	Load weight (tonnes)	Average weight of bins (kg)
Zero	200	119	2.34	11.7
150kg/m^3	446	172	5.10	11.4
175kg/m^3	499	190	5.86	11.7
200kg/m^3	603	221	6.86	11.4
225kg/m^3	601	229	7.12	11.8
Total	**2,349**	**931**	**27.28**	**11.6**

In Council 1, a total of 2,349 households' recycling was collected over 931 minutes of collection time with a total weight of 27.28 tonnes of material.

Table 5 – Characteristics of collected loads – Council 2

Compaction level	Number of households	Collection time (mins)	Load weight (tonnes)	Average weight of bins (kg)
Zero	200	119	2.22	11.1
150 kg / m^3	356	180	3.84	10.8
175 kg / m^3	467	208	4.96	10.6
200 kg / m^3	437	201	4.74	10.8
225 kg / m^3	578	249	6.18	10.7
Total	**2,038**	**957**	**21.94**	**10.8**

In Council 2, a total of 2,038 households' recycling was collected over 957 minutes of collection time with a total weight of 21.94 tonnes of material.

The load weight and number of households collected for Council 1 is higher than Council 2, but is reflective of the larger truck body used (30m^3 compared with 29m^3).

Table 6 – Characteristics of collected loads – average of two councils

	Average of two (2) loads			
Compaction level	**Number of households**	**Collection time (mins)**	**Load weight (tonnes)**	**Average weight of bins (kg)**
Zero	200	119	2.28	11.4
150kg/m^3	401	176	4.47	11.1
175kg/m^3	483	199	5.41	11.2
200kg/m^3	520	211	5.80	11.2
225kg/m^3	590	239	6.65	11.3

Overall, a total of 4,387 households' recycling was collected over 31 hours and 22 minutes of collection time with a total weight of 49.22 tonnes of material. Due to the large number of households collected, this can be considered to be a robust sample.

The average weight of individual household bins was fairly constant over different compaction levels, as could be expected. The overall average weight of bins in the whole study was 11.2 kg or 5.6 kg/hhld/week.

The number of households collected, collection time and load weight increased steadily with increasing compaction levels, as depicted on the following three charts.

Chart 2– Average number of households collected per load by compaction level

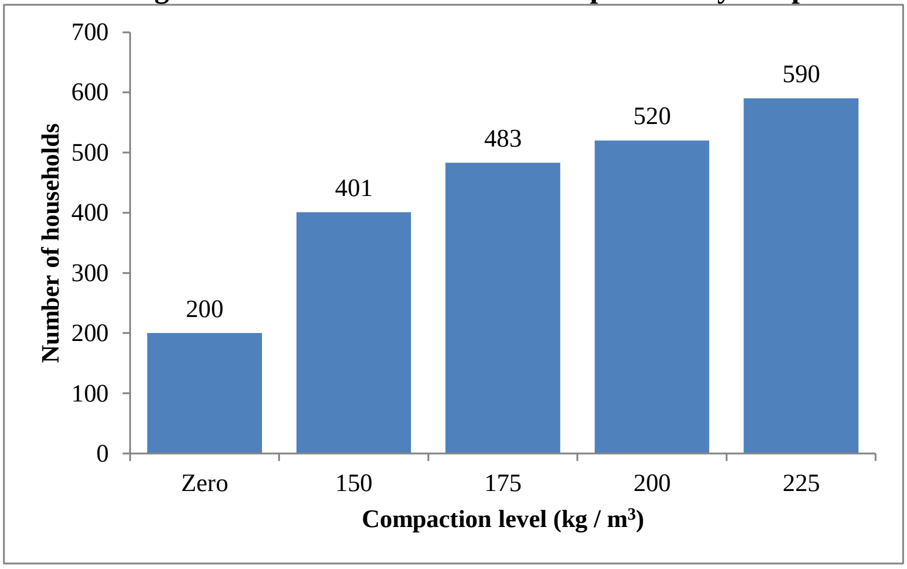


Chart 3 – Average collection time (minutes) by compaction level

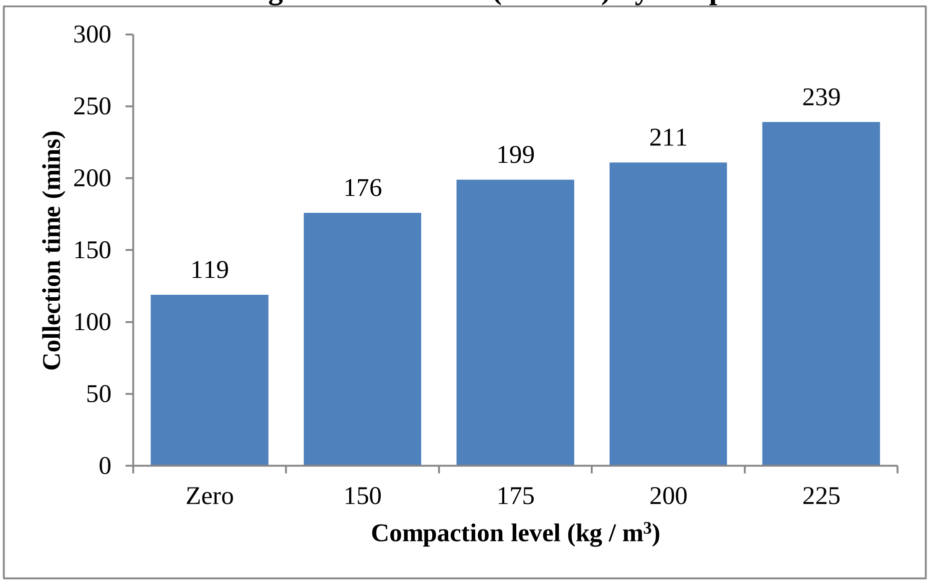
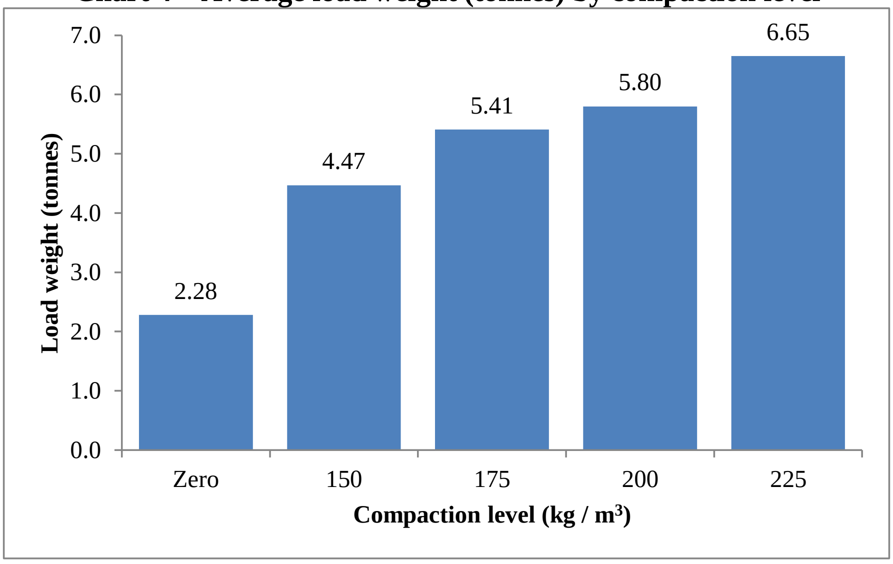


Chart 4 – Average load weight (tonnes) by compaction level



3.7 Sample processing

The project incurred a number of initial operational constraints, including collections having to occur during normal hours to fit in with the collection vehicles standard roster and council collection times. This meant that by the time the vehicle returned to the MRF the material could not be processed separately to all other recyclables received at the site. It was agreed by all parties that the collections would be held over in the collection vehicle until the next day when they would then be delivered for immediate processing at 4am.

Due to a number of operational issues, the project timeline was extended to finish in mid-July, from an initial timeframe of late June 2012. Table 7 provides a breakdown of the collection and processing schedule, with the given compaction rates and any operational issues encountered. Photos of the auditing process are shown in ***Appendix B***.

Table 7 – Collection and processing schedule

Month	**May**			
Date	**1**	**2**	**3**	**4**
Contractor	Contractor 1	MRF	Contractor 2	MRF
Activity	Collect	Process	Collect	Process
Compaction	**200 bins, 0 compaction**			
Month	**May**			
Date	**15**	**16**	**17**	**18**
Contractor	Contractor 1	MRF	Contractor 2	MRF
Activity	Collect	Process	Collect	Process
Compaction	**150 kg/m^3**			
Month	**May/ June**			
Date	**29**	**30**	**31**	**1**
Contractor	Contractor 1	MRF	Contractor 2	MRF
Activity	Collect	Process	Collect	Process
Compaction	**Collected**	**Cancelled**	**225kg/m^3**	
Month	**June**			
Date	**12**	**13**	**14**	**15**
Contractor	Contractor 1	MRF	Contractor 2	MRF
Activity	Collect	Process	Collect	Process
Compaction	**200kg/m^3**		**175 ^**	**175#**
Month	**June**			
Date	**26**	**27**	**No collection or sort due to end of month at MRF**	
Contractor	Contractor 1	MRF		
Activity	Collect	Process		
Compaction	**225kg/m^3**			
Month	**July**			
Date	**10**	**11**	**12**	**13**
Contractor	Contractor 1	MRF	Contractor 2	MRF
Activity	Collect	Process	Collect	Process
Compaction	**175kg/m^3**			
Month	**July**			
Date	**No collection or sort**		**26**	**27**
Contractor			Contractor 2	MRF
Activity			Collect	Process
Compaction			**200kg/m^3**	

^ No sign-off on compaction setting. # Poor sort, data cancelled

3.8 Residual MRF Audit

All MRFs, while undertaking the same functionality of separating individual materials from typically co-mingled kerbside collection programs, are designed and operate differently due to changes in technology. As such, newer MRFs tend to implement more advanced sorting technology. Typically, at any MRF there is a desire to separate the paper and containers as soon as possible through the use of a series of mechanical interventions, such as trommels, disc screens, bounce separators, air classifiers, magnets, eddy currents and, in some newer MRFs, optical sorters. . Due to the opportunity to recover both deposit-bearing and non-deposit-bearing commodities, South Australian MRFs typically have a greater reliance on manual separation by staff rather than by mechanisation. The MRF owner will determine the throughput for optimum recovery.

Visy Recycling own and operate three MRFs in the Greater Adelaide metropolitan area. For logistical reasons, the North Plympton MRF was deemed to be the most appropriate and is also the oldest of the plants. East Waste would typically deliver to the Wingfield MRF, however for the duration of this project East Waste transported and delivered loads to the North Plympton facility, which is co-located at the Solo Resource Recovery depot and transfer station.

The MRF agreed to slow the conveyor belt to a speed of approximately 1 tonne per hour and to manually load the belt instead of using a front-end loader as per normal operation. This approach was designed to reduce any issues and damage caused to the product during processing, in an effort to isolate issues to compaction only. The entire load was sorted through the MRF. Each processing morning the MRF operator ensured the belt was clear and the residual bin, glass fines and paper fines bins were empty. These bins were weighed and placed at the respective outlets to capture any material not recovered through the plant. Any oversize or bulky material was picked off at the beginning of the process and placed in the residual bin by MRF staff.

Once the load had been processed through the MRF, the glass and paper fines bins were re-weighed, along with the residual bin, prior to being emptied onto the sorting floor where the residual bin contents was separated into contamination and non-recoverable recyclables and the bins weighed. From these measurements the amount of glass and paper fines, contamination and non-recoverable recyclables was determined.

The APC observer undertook the following activities during the collection phase:

- Ensure the residual, glass fines and paper fines bins were empty and the tipping floor was swept clean ready for the audit.
- Record the registration number of the delivery vehicle, re-weigh the truck from the previous day to ensure the weights match.
- Record the time of delivery and ensure by visual inspection the truck is completely empty after tipping the load. Record time truck departs and tare weight.
- Record the MRF run start time and observe staff manually loading belt. Ensure no other loads or materials already in the receival areas were mixed with the delivered load.
- Monitor the sorting process.

- Record the MRF run finish time.
- Oversee MRF staff weighing the full residual, paper fines and glass fines bins and the tare weight on the weighbridge.
- Prior to commencement of the audit of the residual bin, weigh and mark each wheelie bin with the tare weight.
- Oversee MRF staff sorting the residual bin/s into non-recovered recyclable items and contamination.
- Weigh the non-recovered recyclable and contamination sort bins.

Table 8 to 11 outline the performance at the MRF for loads from both Council 1 and Council 2. The conveyor belts were slowed to minimise breakage and maximise recovery. Therefore, these times should not be considered indicative of typical MRF sort speeds. APC did not monitor whether the belt speed was exactly the same each sort day. As expected, the higher compaction levels (and higher weights) took longer to be processed at the MRF. Council 1 shows a much clearer trend than the results for Council 2.

Table 8 – Sort time at MRF – loads from Council 1

Compaction level	Time spent at MRF (mins)	Households processed per minute	Kg processed per minute
Zero	89	2.25	26.3
150 kg /m^3	184	2.42	27.7
175 kg /m^3	257	1.94	22.8
200 kg /m^3	306	1.97	22.4
225 kg /m^3	333	1.80	21.4

Table 9 – Sort time at MRF – loads from Council 2

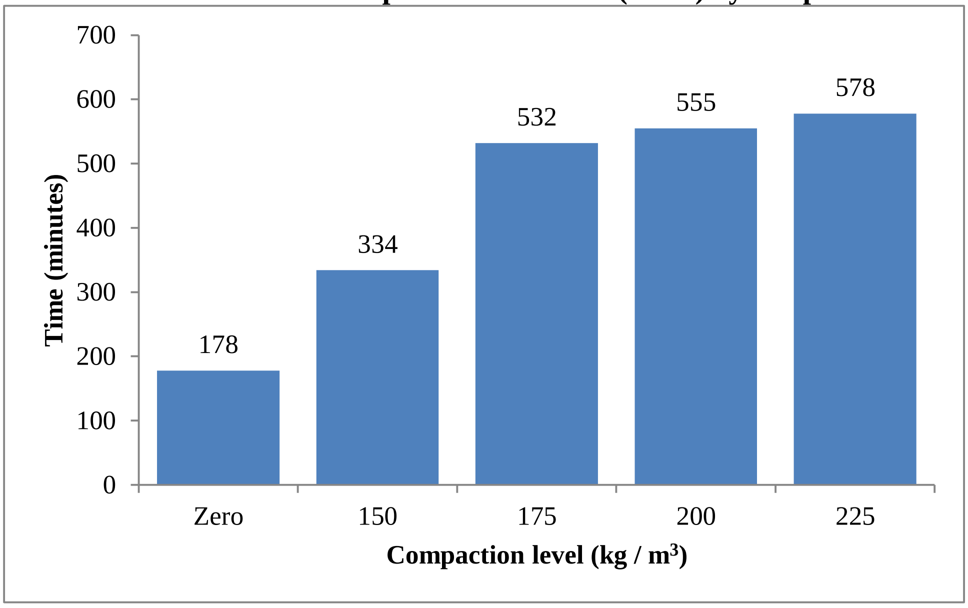
Compaction level	Time spent at MRF (mins)	Households processed per minute	Kg processed per minute
Zero	89	2.25	24.9
150kg/m^3	150	2.37	25.6
175kg/m^3	275	1.70	18.0
200kg/m^3	249	1.76	19.0
225kg/m^3	245	2.36	25.2

Table 10 – Sort time at MRF – two (2) councils combined

Compaction level	Total of two loads		
	Time spent at MRF (mins)	Households processed per minute	Kg processed per minute
Zero	178	2.25	25.6
150kg/m^3	334	2.40	26.8
175kg/m^3	532	1.82	20.3
200kg/m^3	555	1.87	20.9
225kg/m^3	578	2.04	23.0

The overall results in Table 10 show a similar trend to the individual council results. The higher compaction levels took longer to be processed at the MRF, however generally the kilograms processed per minute decreased as more waste was sorted.

Chart 5 –Total time for loads processed at MRF (mins.) by compaction level



4 RESULTS

The following section outlines the results for the audit conducted at the North Plympton MRF. The results provide the composition and quantities of the material rejected during the sort process using the following measures:

- **Contamination** – materials not accepted in recycling as a percentage of total load
- **Non-recovered recyclables** – recyclable materials not recovered in MRF process as a percentage of total load
- **Paper fines** – paper fines as a percentage of total load
- **Glass fines** – glass fines as a percentage of total load
- **Total recyclables** – total amount of recyclable material including non-recovered recyclables, glass fines and paper fines not recovered by the MRF process (minus contamination) as a percentage of total load.

There was one atypical result from Council 2 at the 150kg/m^3 compaction level. This result has affected some parts of the analysis. It is not clear what caused this load composition to be atypical.

4.1 Load composition

Table 11 presents the results for both councils combined. The average percentage of contamination between loads did not vary with any pattern related to compaction levels. This is most likely due to contamination being primarily influenced by household behaviour, not waste collection. The average percentage of non-recovered recyclables did not increase significantly as compaction increased. There was a weak correlation of increased percentage of total rejected material by compaction level, however this result was confounded by the atypical high value in the 150kg/m^3 compaction category.

Table 11 – Average of load composition of rejected material

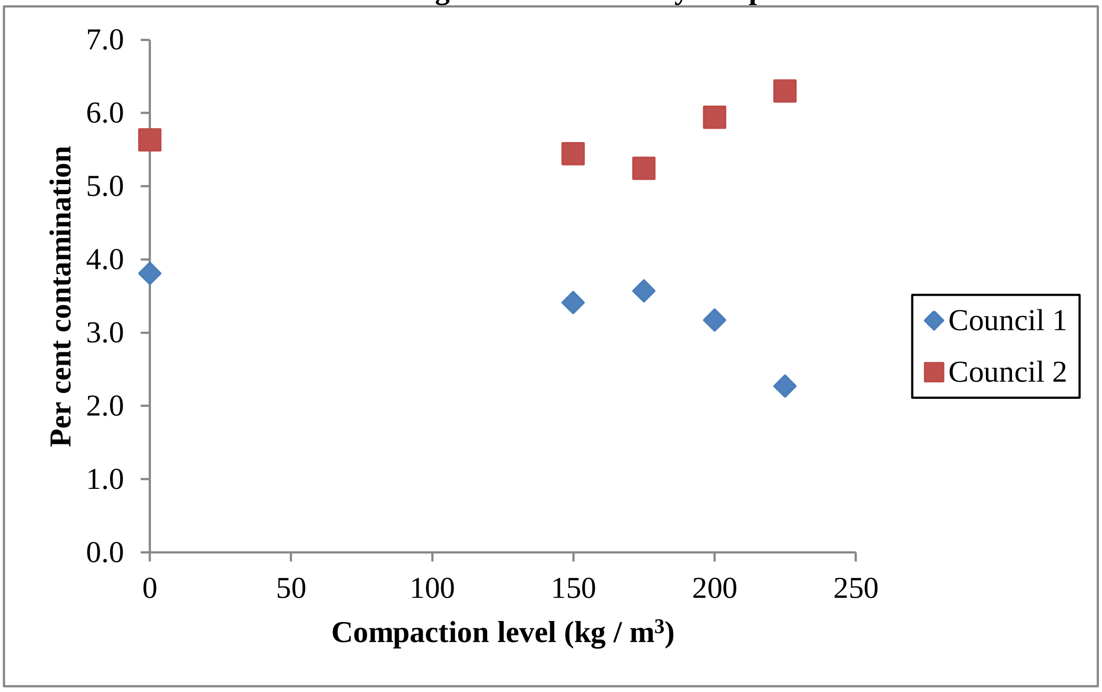
Compaction level	Average of two councils					
		Recyclables				
	% contamination	% non-recovered recyclables	% paper fines	% glass fines	% total recyclables	% total rejected material
Zero	4.7	1.3	1.7	5.2	8.3	**11.7**
150kg m^3	4.4	1.1	6.9	7.9	15.9	**19.2**
175kg/m^3	4.4	0.8	3.5	6.4	10.8	**14.3**
200kg/m^3	4.6	1.2	4.1	5.1	10.3	**13.8**
225kg/m^3	4.3	1.4	3.6	6.9	11.8	**14.7**
Average	**4.5**	**1.2**	**4.0**	**6.3**	**11.4**	**14.7**

Note: '% total recyclables' is the addition of '% non-recovered recyclables', '% paper fines' and '% glass fines'. Note that individual percentages do not always add across to the total as these measures are averaged over the two observations (trucks).

4.2 Contamination

There is no apparent relationship between compaction levels and percentage contamination. Contamination levels were consistently higher in Council 2 collections than in Council 1.

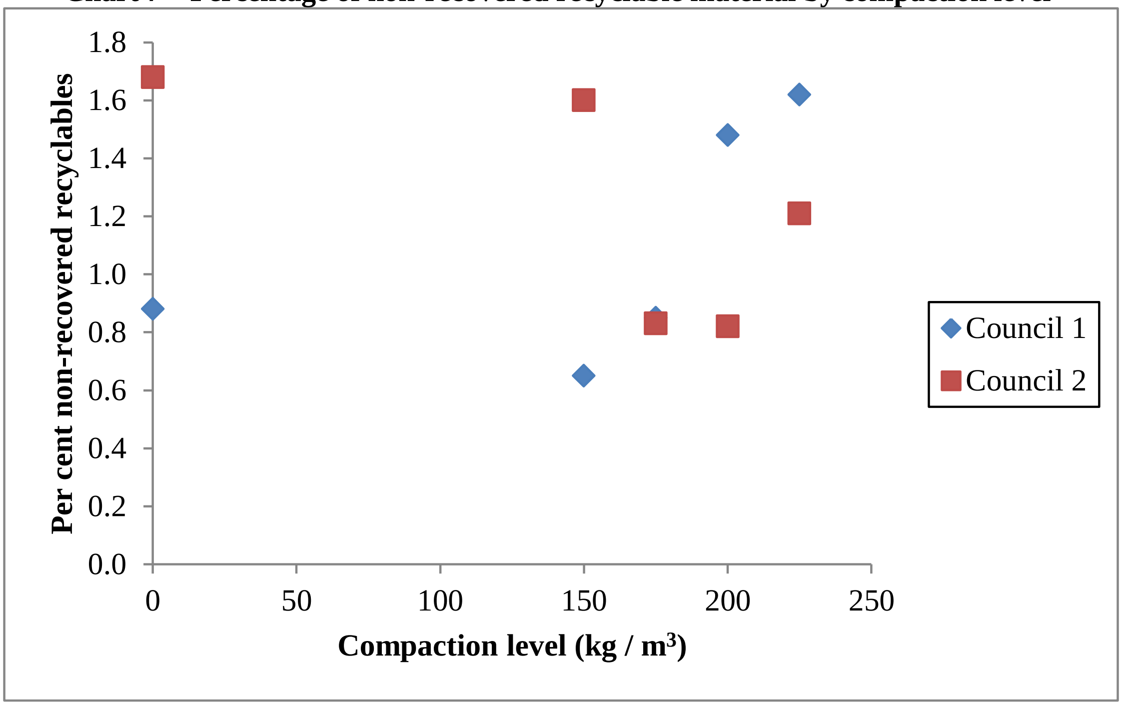
Chart 6 – Percentage contamination by compaction level



4.3 Non recovered recyclables

There is no apparent relationship between compaction levels and percentage of non-recovered recyclables, as is shown in the scatter graph below.

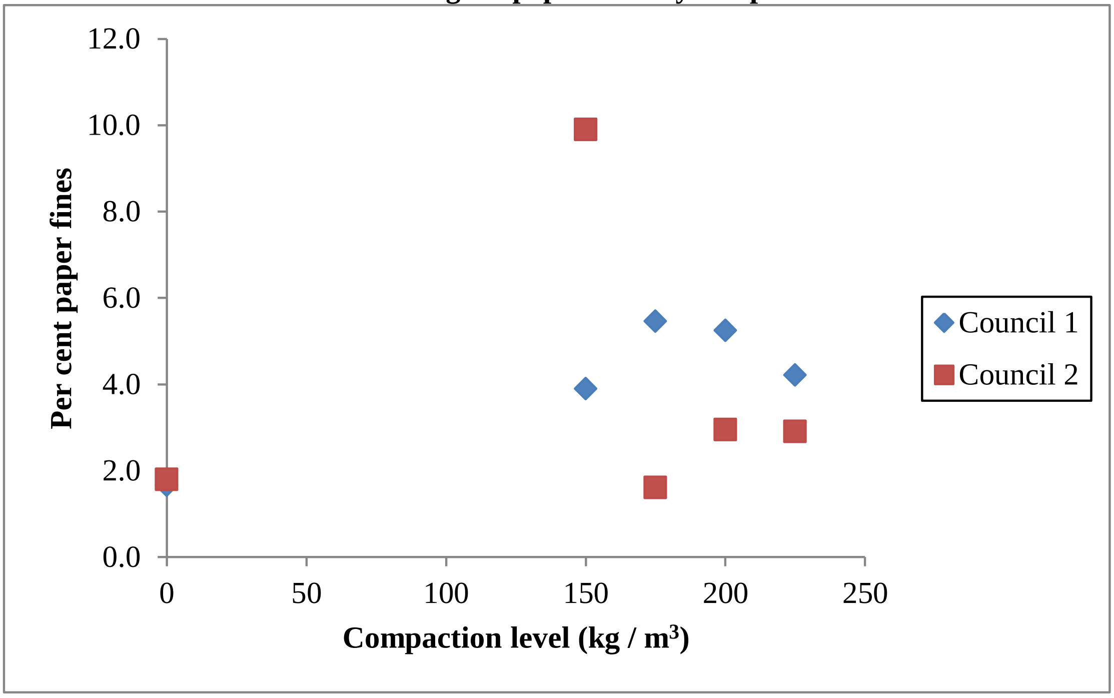
Chart 7 – Percentage of non-recovered recyclable material by compaction level



4.4 Paper fines

Paper fines as a percentage of the total load appeared to increase with compaction. However, the pattern is obscured by one very high observation. It should be noted that the paper fines bin contains some non-paper materials. It is unlikely that paper itself would be affected by increased compaction.

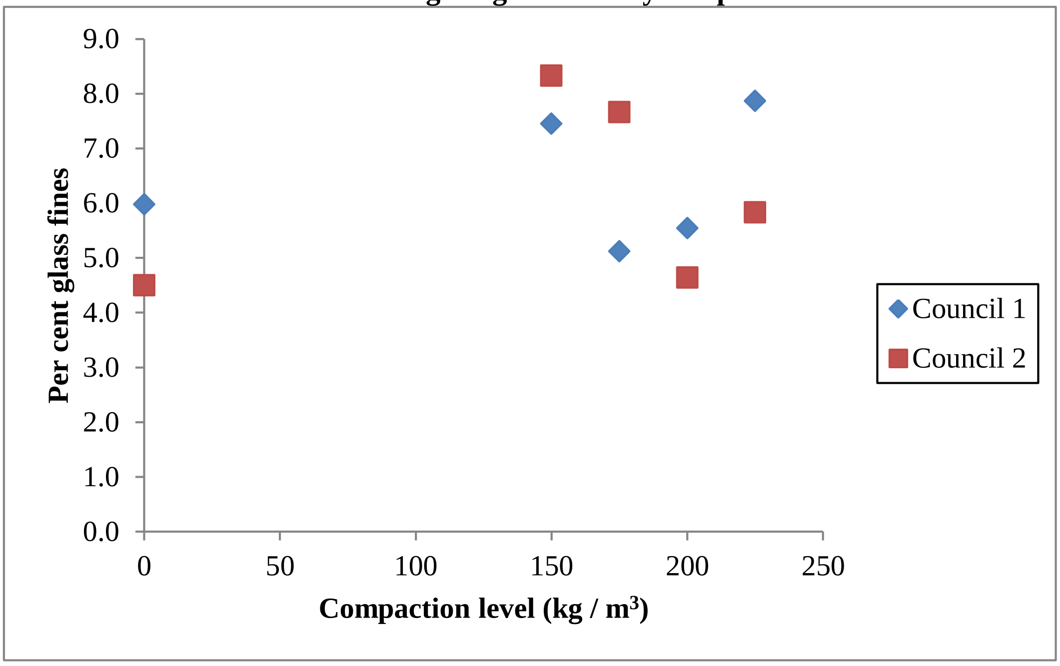
Chart 8 – Percentage of paper fines by compaction level



4.5 Glass fines

There is no clear trend of increased glass fines in the incremental compaction level increases.

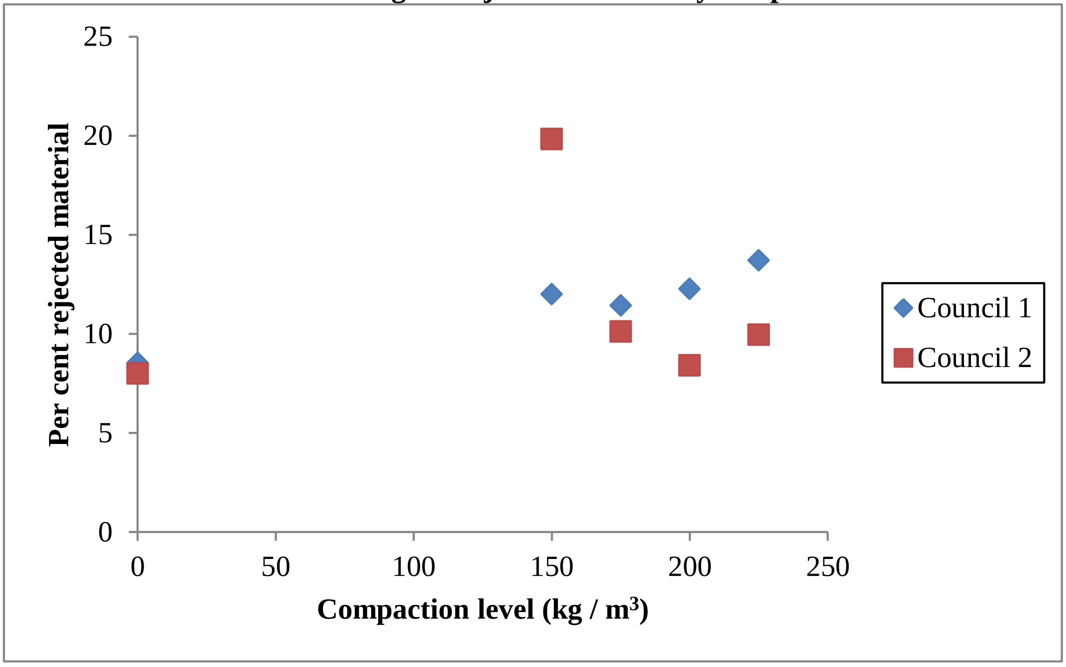
Chart 9 – Percentage of glass fines by compaction level



4.6 Total rejected materials

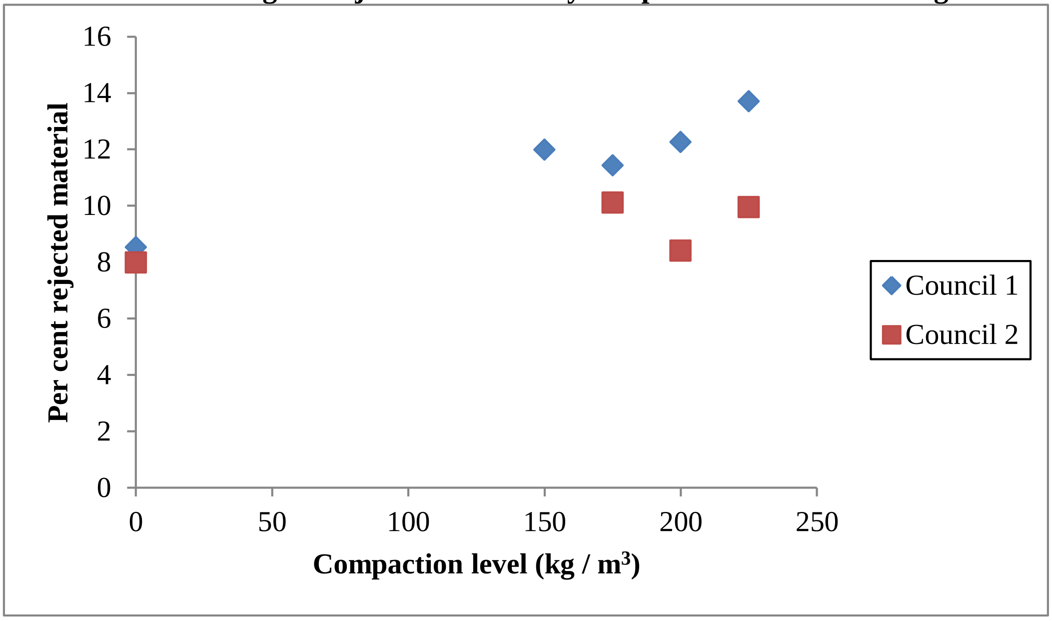
The percentage of total rejected material not recovered by the MRF process (non-recovered recyclables, glass fines and paper fines, excluding contamination) appears to increase slightly with higher compaction levels.

Chart 10 – Percentage of rejected material by compaction level



When the high observation is removed, there is a weak pattern of higher percentages of rejected materials with higher compaction levels.

Chart 11 - Percentage of rejected material by compaction level – excluding outlier



4.7 Multiple linear regressions

The relationship between compaction levels and percentages of materials not recovered at the MRF can be tested using multiple linear regressions.

Several regressions were run using the measures previously listed, however no significant results were obtained. The load from Council 2 at 150kg/m^3, which showed atypically high values, was removed and the regressions were re-run with nine observations instead of ten. Since the main aim of this study is to determine a trend rather than specific council results, it is appropriate to take the average difference between the two councils. With the reduced data set, two notable results were obtained for paper fines and rejected materials. The percentage of non-recovered recyclables (alone) and percentage of glass fines were not significantly associated with compaction levels.

4.7.1 Paper fines – regression analysis

The regression analysis for the percentage of paper fines in the waste showed that it was significantly associated with the individual council studied and the compaction level.

The average difference between the two councils' results for paper fines (0.889) was used to construct a third trend line, which represents the average effect of compaction levels on the percentage of paper fines. Table 12 shows the assumptions used in the linear regression analysis for paper.

Table 12 – Assumptions used in linear regression for percentage of paper fines

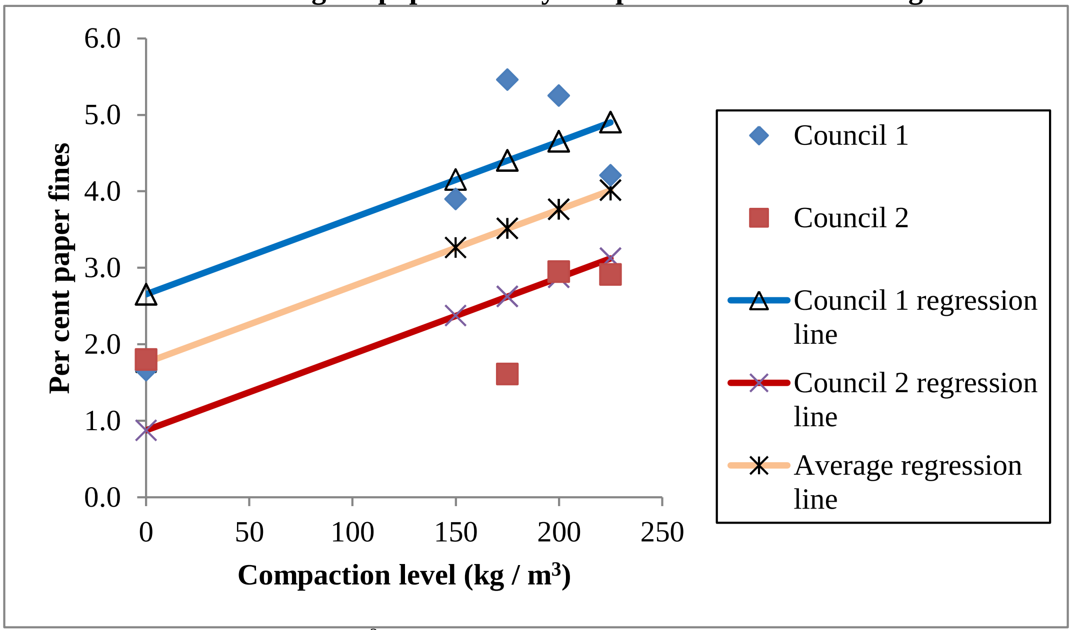
Independent variable	Coefficient	P-value
Constant	2.652	0.008
Mid-point	0.889	0.03
Compaction level	0.010	0.04

This result indicates that the percentage of paper fines in a load can be predicted by the following equation:

Per cent paper fines = (2.652 – 0.889) + (0.010 x compaction level)

This result can be represented by the following graph, which shows an increase in paper fines as compaction levels increase, when using a line of best fit.

Chart 12 – Percentage of paper fines by compaction level – excluding outlier



Note: the atypical observation (150kg/m^3) for Council 2 has been removed from the analysis.

4.7.2 Rejected materials – regression analysis

In a similar way to the previous analysis, the average difference between the two councils was used to represent the effect of compaction levels on the rejected materials (excluding contamination). The assumptions used in the regression calculation are shown in Table 13.

Table 13 – Assumptions used in linear regression for rejected materials

Independent variable	Coefficient	P-value
Constant	9.499	<0.001
Midpoint	1.233	0.01
Compaction level	0.014	0.01

This result indicates that the percentage of rejected materials in a load can be predicted by the following equation:

Per cent rejected materials = (9.499 – 1.233) + (0.014 x compaction level).

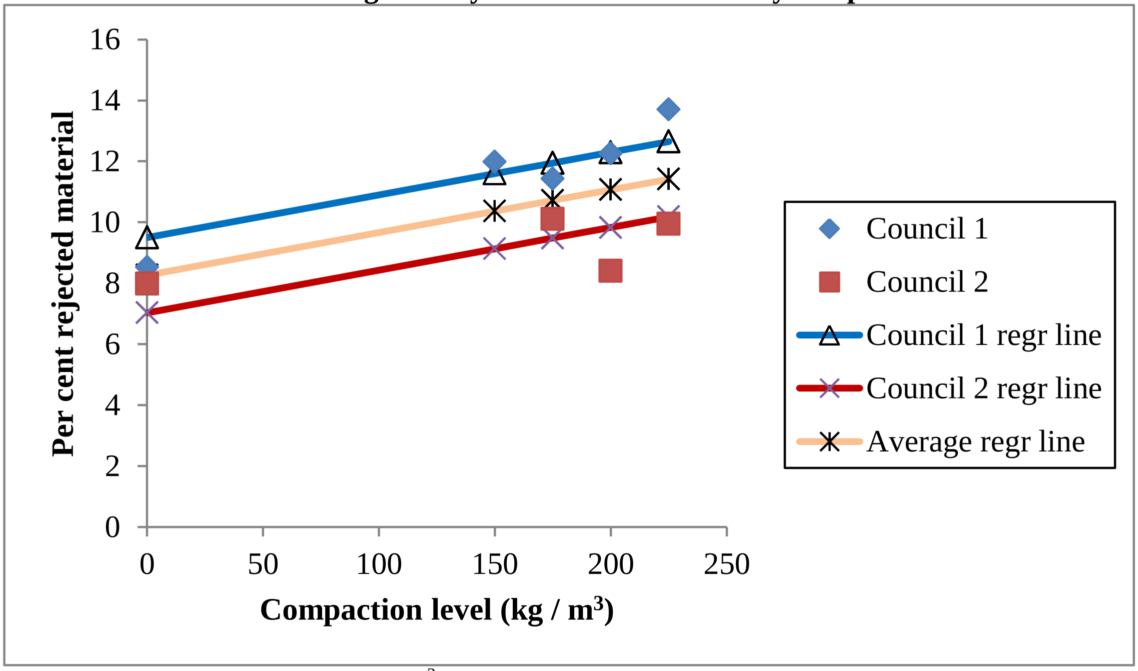
Thus, the equation predicts that the percentage of rejected materials will increase by 0.014% for each unit increase in the compaction level. Using this formula and the mid-point between Council 1 and Council 2 (1.233), the following material loss can be predicted at each compaction setting for a typical council.

Table 14 – Average rejected materials

Compaction setting	% rejected materials
150	10.366
175	10.716
200	11.066
225	11.416

This result can be represented by the following graph. Results indicate that increasing compaction levels are associated with a small increase in the rejected materials.

Chart 13 – Percentage of recyclables not recovered by compaction level



Note the atypical observation (150kg/m^3) for Council 2 has been removed from the analysis

4.8 Verification of contamination rates

The contamination rates found by sorting at the MRF were compared with contamination rates found in recent kerbside domestic waste audits. The contamination level for this study was an average contamination across the five (5) compaction levels, excluding the data anomaly in Council 2.

Table 15 – Contamination rate comparison with kerbside audits

Council	Source	Contamination level
Council 1	Contamination from this study 2012(includes contamination, glass fines and paper fines)	14.8%
	Contamination measured from kerbside audit 2012	14.0%
Council 2	Contamination from this study 2012 (includes contamination, glass fines and paper fines)	14.9%
	Contamination measured from kerbside audit 2009	12.2%

The MRF contamination level was slightly higher than the kerbside contamination, as reflected by the findings of this study.

5 COST–BENEFIT ANALYSIS

A cost–benefit analysis can be run on the savings to be made by increasing compaction incrementally from 150kg/m^3 to 225kg/m^3. There are a number of assumptions and variables that affect any cost–benefit analysis, so individual councils and contractors would need to re-run the analysis based on assumptions specific to their service area.

Based on the audit results, the difference in non-recovered recyclables between the highest and lowest compaction levels is 1.5%, with no clear trend related to compaction. Therefore, this has not been factored into the cost–benefit analysis.

Assumptions used in the following calculations were determined using ABS data and audit results as well as information from ZWSA, Visy, Solo, East Waste and desktop research. As many of these factors are variable, and stakeholders provided a number of values, a middle-range value was used.

The cost–benefit analysis has been run for two scenarios – 50,000 households representing a large council and 20,000 households representing a medium-size council. The following assumptions were made for both scenarios:

- 150kg/m^3 is the minimum compaction setting that would be used
- 85% participation rate in recycling
- Fortnightly recycling collection
- 29m^3 side-loader, single-operator vehicle
- Fuel costs of $0.55/km
- Trucks will do two (2) runs per day, working five (5) days per week
- Average density traffic and roads to influence collection time
- Average run distances of 50–80km; the longer runs have more bins in the load
- Bin numbers per vehicle and average run time based on the audit findings
- Driver salary, including overheads, based on 40-hour week, 52-week year is $62,400/year.
- Vehicle costs (based on a $300,000 purchase cost, seven (7)-year life, with no residual value at end of life, interest of 7% and annual maintenance costs of 6%) is $48,620/year.

Table 16 shows the assumptions for the 50,000 household scenarios.

Table 16 – Assumptions for 50,000 households recycling collection

Total no. of hhlds collected/wek	Compaction setting kg/m^3	Average number of bins per load	Collect time (min)	No. of runs/wk	No. of km/ run	Distance to MRF	Total km
21,250	150	400	176	53	65	15	4,250
21,250	175	480	199	44	70	15	3,763
21,250	200	520	211	41	75	15	3,678
21,250	225	590	239	36	80	15	3,422

There is a large number of variables, including fuel use, the way in which the trucks are driven, the distances of the runs, the fuel price, the ages and maintenance of the vehicle, etc.

Table 17 considers potential fuel savings for this scenario. The annual savings are not enough on their own to justify the increased compaction settings.

Table 17 – Potential fuel savings for 50,000 households

Total km	Fuel costs/km	Fuel costs/week	Fuel costs/year	Incremental fuel savings/year
4,250	$0.55	$2,338	$121,550	
3,763	$0.55	$2,070	$107,622	$13,928
3,678	$0.55	$2,023	$105,188	$16,363
3,422	$0.55	$1,882	$97,858	$23,692

Table 18 shows the impact of compaction settings reducing the number of vehicles and staff as a result of increasing compaction. Note that the number of trucks used will depend on the size of the truck, the number of households, how many runs the drivers do per day, etc. As these variables change for each council, there may be a slightly different compaction level that affects the cut-off for removing a truck/staff from the fleet. In this scenario, there is no difference between 200kg/m^3 and 225 kg/m^3. It is assumed that there will be the same management costs regardless of the number of staff, therefore only the driver's wages costs are included.

Table 18 – Potential vehicle costs savings by increasing compaction – 50,000 hhlds

Compaction setting (kg/m^3)	No. of runs/ week	No. of runs/ day	No. of trucks/ day	Annual staff cost	Annual vehicle costs	Total	Savings/ yr
150	53	11	6	$374,400	$291,717	$666,117	
175	44	9	5	$312,000	$243,097	$555,097	$111,019
200	41	8	4	$249,600	$194,478	$444,078	$222,039
225	36	7	4	$249,600	$194,478	$444,078	$222,039

Table 19 shows the cumulative savings by increasing the compaction settings, factoring in fuel, staff and vehicle costs. There are minimal savings between 200kg/m^3 and 225 kg/m^3 in this scenario.

Table 19 – Cumulative savings per year – 50,000 hhlds

Compaction setting (kg/m$^{3)}$	Cumulative savings per year
150	Minimum compaction
175	$124,947
200	$238,401
225	$245,731

For a council with 20,000 households, there is no vehicle cost saving using this model because a minimum of two trucks is required each day regardless of the compaction setting. Therefore, the only potential cost saving is fuel, and possibly restructuring the runs to save a few staff hours.

Table 20 – Potential fuel saving for 20,000 hhlds

Total no. hhlds collected/wk	Compaction setting	No. of runs/ wk	No. of km/ run	Total km	Fuel costs/wk	Fuel costs/yr	Savings/ yr
8,500	150	21	65	1700	$935	$48,620	
8,500	175	18	70	1505	$828	$43,049	$5,571
8,500	200	16	75	1471	$809	$42,075	$6,545
8,500	225	14	80	1369	$753	$39,143	$9,477

Table 21 – Potential vehicle costs savings by increasing compaction – 20,000 hhlds

Compaction setting (kg/m^3)	No. of runs/wk	No. of runs/ day	No. of trucks/ day	Annual staff cost	Annual vehicle costs	Total	Savings/ yr
150	21	4	2	$124,800	$97,239	$222,039	
175	18	4	2	$124,800	$97,239	$222,039	$0
200	16	3	2	$124,800	$97,239	$222,039	$0
225	14	3	2	$124,800	$97,239	$222,039	$0

6 FINDINGS

The average percentage of contamination in loads did not vary with any pattern related to compaction levels. This is very probably due to contamination being primarily influenced by household behaviour, not waste collection. The average percentage of non-recovered recyclables did not increase significantly as compaction increased. There seemed to be a pattern of increased percentage total recyclables not recovered by compaction level but this was confounded by a high value in the 150kg/m^3 compaction category.

The results from the regression analysis (with the high value in the 150 kg/m^3 removed) indicate that increasing compaction levels are associated with a small increase in the percentages of paper fines and total non-recovered recyclable material minus contamination at the MRF. The percentage of non-recovered recyclables (alone) and percentage of glass fines were not significantly associated with compaction levels.

The MRF contamination level was slightly higher than the kerbside contamination levels.

For all material streams audited there was minimal difference – only 1% between the 150kg/m^3 and 225kg/m^3 compaction settings. This implies that for the product mix presented by South Australian councils, with a lower proportion of glass containers, the contamination, glass fines, paper fines and non-recovered recyclables, is not significantly affected by compaction. Any significant material loss occurs at other stages of the collection and processing cycle.

On this basis, co-mingled recyclables collection in South Australia could be conducted using compaction levels of up to 225kg/m^3. This would maximise collection efficiencies with minimal additional materials loss from compaction. However, this study has not considered the implications of glass being embedded in paper or plastic at any compaction level, or compaction levels above 225kg/m^3. The study also did not consider the impact of paper clumping as a result of increased compaction.

There are potential cost benefits for councils that can decrease their fleet and staffing costs by increasing compaction rates. However, the potential savings for each council would need to be determined based on the costs for that area. For the two scenarios run in this model, a council with 50,000 households could save $125,000/year by increasing compaction from 150kg/m^3 to 175 kg/m^3 or $245,000/year by compacting up to 225kg/m^3. These savings result from reducing the vehicle fleet and staff. However, a council with 20,000 households would not make any significant savings using the assumptions in this scenario because they would still require the same number of vehicles and staff regardless of the compaction levels.

All councils increasing compaction could adjust their runs and staffing to make some savings. Significant savings are only seen, however, where there is a significant enough reduction in runs to remove a vehicle or staff from the fleet.

7 CONCLUSION

This study found that the average percentage of rejected materials, which included contamination, non-recoverable recyclables, glass fines and paper fines, did not increase significantly as compaction rates of kerbside collected materials increased.

When one atypical observation was removed, compaction rates had a small but significant positive effect on the proportion of paper fines and total rejected materials in the waste processed (minus contamination). The study indicates that the increase in the proportion of rejected materials between the 150kg/m^3 and 225kg/m^3 compaction rates is 1% (from a predicted 10.4% to a predicted 11.4%).

This result is markedly different to the results obtained by APC in 2004 and 2005 in the NSW Glass Compaction Study, where it was found that the proportion of broken glass could be expected in the most ideal conditions (that is, fully co-mingled with load density of 120kg/m^3) to be 26.5%. In containers-only collections (no paper present) with the same load density, an additional 19.7% of broken glass was generated. The study found that for every increase of 10kg/m^3 in load density above 120kg/m^3, the proportion of broken glass increased by 1.9%.

The key reason for the two very different results is due to the significant difference in the recycling stream composition between South Australia, where a deposit–refund scheme operates, and other states. While glass containers account for 12% to 19% of the recycling stream in South Australia, in other states they account for as much as 26% of the recycling mix – in some cases double that found in SA.

In addition, the glass mix is very different in SA compared with other states. Beer bottles, which have been light-weighted over the years in the quest to use fewer raw materials, are part of the deposit system in SA and therefore only present in very small quantities in the kerbside recycling bins. Most glass containers tend to be heavier beverage containers such as wine and champagne (which are excluded from the deposit scheme) and condiment, sauce and coffee containers, while in other states the beer stubby is the major glass item found in recycling bins. Due to its light-weighted nature, it rarely makes its way through the collection and processing cycle intact.

We understand some collection contractors are currently using up to 225kg/m^3 compaction setting on vehicles as a standard operating mode. Discussions with the two collection contractors who participated in this project indicated an unwillingness to exceed compaction settings above 225kg/m^3 due to issues associated with payload of the collection vehicles.

While it appears loads using this compaction setting have and are being routinely used, we are not aware of any issues reported by the MRF operator in connection with adverse impacts of glass being impregnated into paper and plastic or decreases in the quality of the paper product delivered to the mills for reprocessing. The issue of glass impregnation or 'clumping' of paper in loads with higher compaction was not considered as part of this scope of works.

8 RECOMMENDATION

While the higher compaction setting is suitable for council and contractors in SA, it is not considered suitable for other states where deposit schemes for beverage containers do not exist. It is not recommended that the results from this study be adopted by other states owing to the differences in composition of the recycling stream.

In our opinion, on the basis of these findings, recycling collection contracts in South Australia, or where a deposit–refund scheme for beverage containers operates, could specify a standard compaction setting of $200kg/m^3$ with an upper limit of $225kg/m^3$ without compromising resource-recovery efforts.

APC recommend that the LGA SA *Model Waste and Recycling Collection Contract* be modified to specify that *'the standard compaction settings of* $200kg/m^3$ *be nominated with an upper limit of* $225kg/m^3$*'*.

APPENDIX A LITERATURE REVIEW

Earth Tech Canada Inc. In association with Enviros RIS: *Review of the containers collection and processing operations in the regional municipality of Ottawa-Carleton*, January 12, 2001 http://www.wdo.ca/files/domain4116/OPT%20R1-06.pdf

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Department of Energy and Environmental Protection – Environment Protection, *Recycling Collection Systems*, State of Connecticut, June 2012
http://www.ct.gov/dep/cwp/view.asp?a=2714&q=435386&depNav_GID=1645
info on studies and research for State of Connecticut

Glass recycling UK: *How we recycle – Glass Recycling UK process thousands-of-tonnes of glass per day through an organised process; from Collection through to Quality Control*, http://www.glassrecycle.co.uk/prod1.asp?ID=274

Glass Packaging Institute: *Tips for high quality cullet*, copyright 2010
http://www.gpi.org/recycle-glass/collection/tips-for-highquality-cullet.html#2

Local Government Association of South Australia: *Model Waste and Recycling Collection Contract*, Section D Specification Part 3: Recyclables Specification Version 2 (November 2011), http://www.lga.sa.gov.au/site/page.cfm?u=267

NSW EPA: *Model Waste and Recycling Collection Contract*, 26 July 2012
http://www.environment.nsw.gov.au/warr/WasteContract.htm

Ministerial Media Statements: *$73,000 grant to help with glass recycling*, Government of Western Australia, Cheryl Edwardes, Fri 05 January, 2001
http://www.mediastatements.wa.gov.au/ArchivedStatements/Pages/CourtCoalitionGovernmentSearch.aspx?ItemId=114456&minister=Edwardes&admin=Court

Shoalhaven City Council: *Two Bin Recycling Collection Trial* March – July 2009, http://doc.shoalhaven.nsw.gov.au/Displaydoc.aspx?Record=d11/288148,

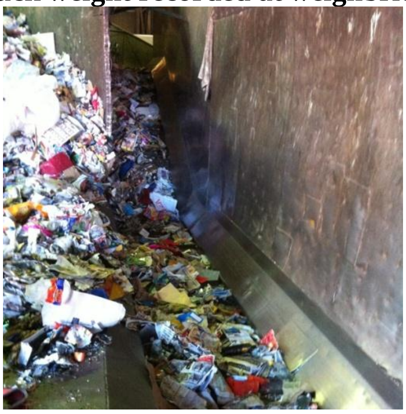
Stewardship Ontario, 2006: *York Region Collection and Processing Optimization Study*, Effectiveness & Efficiency Fund Project #207 Prepared by: Shaun Spalding

APPENDIX B PHOTOS

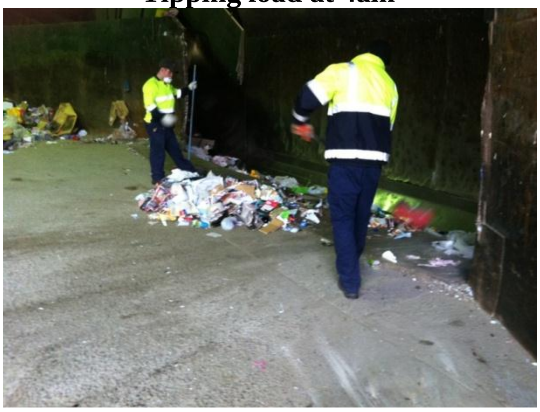
Preparing truck unloading site

Truck weight recorded at weighbridge

Tipping load at 4am

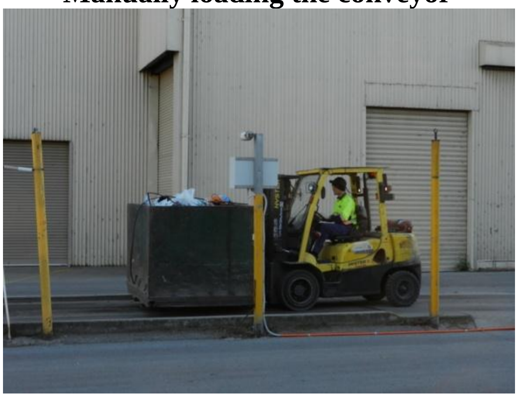


In-feed conveyor



Manually loading the conveyor

MRF sort line

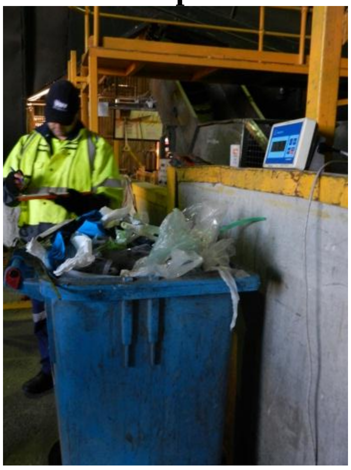


Weighing residual waste bucket

Residual waste sort site


Residual waste prior to sorting


Visy staff sorting residual


Weighing bin of contamination


Glass fines bin


Paper fines bin

APPENDIX C SAMPLE DATA RECORDING SHEET

COLLECTION PHASE					
Date:		Day:		Rego:	
Council name:		Service provider:		Driver name:	
Compaction setting:		Empty weight:		Time left depot:	
Start street/suburb:		Bin count:		End street:	
Time back to depot		Full weight:			
Collection comments:					
MRF PROCESSING PHASE					
Date:		Day:		Rego:	
MRF time in:		MRF time out:		Check full weight:	
Check empty weight:		Residual bin empty?:		Concrete tipping floor clean?:	
MRF run start time:		MRF run finish time:		Residual bin weight	
Glass fines bin weight:		Paper fines bin weight			
MRF comments:					
SORT PHASE					
Acceptable material			Contamination		
Empty MGB bin weight:			Empty MGB bin weight:		
Bin contents weight:			Bin contents weight:		
Sort comments:					