York Region
Collection and Processing Optimization Study

Stewardship Ontario
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Prepared by: Shaun Spalding

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The Regional Municipality of York 17250 Yonge Street, Newmarket, ON L3Y 6Z1
Tel: (877) 464-9675 ● Fax: (905) 954-4611 ● www.york.ca

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Executive Summary

The purpose of this study was to determine the optimal level of compaction on single stream blue box recyclables; and specifically, to determine the most favourable degree of compaction that maximizes collection efficiency while maintaining efficient Material Recovery Facility (MRF) operations.

The study focused on the following:

- A survey of jurisdictions in Ontario, throughout Canada and the United States of America on the subject of collecting and processing compacted blue box recyclables;
- Analytical tests of different rates of compaction of single stream blue box recyclables through York Region's MRF; and
- Analysis and reporting of the survey and MRF processing results.

Based on the results of the survey, there is no consistent policy or procedure defining the optimal level of compaction during collection or for effective MRF operations. 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.

Of the 66 jurisdictions that completed the survey in full, only six reported having a policy in place defining a compaction limit and each of these policies were different. Of the six, five justified the policy based on factors such as legal requirements or recommendations from the vehicle manufacturer, and one justified the policy based on MRF operational requirements.

The key factor in determining the optimal level of compaction for a given blue box program is the composition of the stream.

Compaction tests of York Region's blue box recyclables were undertaken at York Region's MRF to determine the optimal level of compaction. The results of the processing test suggest that the MRF equipment manufacturer's recommendation of 2.5 to 1 compaction can be acceptable if certain processing modifications are implemented. Furthermore, an upper compaction rate of 3 to 1 is likely the maximum achievable by compaction vehicles.

The results of this project have the potential to reduce blue box system costs, contain future per tonne costs and may lead to the establishment of a compaction policy. Specifically, the results of this study are that compaction during collection is a 'better practice'. By using compaction vehicles, the amount of material collected per truck increases which could result in a decrease in collection costs in excess of $1,000,000. However, in order for a MRF to effectively process compacted blue box recyclables, process changes are required which could increase MRF operating costs. These MRF adjustments would include a reduction in conveyor speeds, an increase in the number of sorting staff and/or equipment upgrades. The cost savings to collection could offset the cost increase to MRF processing resulting in an overall reduction in system costs.

Supplementary studies are recommended to evaluate the financial impact on collection by using more compaction vehicles. The financial impact to MRF operations from increased compaction and the effect of compound compaction should also be studied.

Section 1 – Introduction and Background

1.1 Waste Management in York Region

York Region is a two-tier jurisdiction with respect to solid waste management. The Regional Municipality of York (the upper tier) is responsible for all aspects related to processing, marketing and disposal. The lower tier municipalities are responsible for collection of recyclables and waste and delivery of these materials to a Regional waste management facility. Both York Region and all of the lower tier municipalities contract with the private sector for the respective services.

In York Region, there are nine local municipalities and each is responsible for collection in their own individual area. As this pertains to blue box collection, there are nine collection contracts, each with its own specific requirements. No two local municipalities are the same in terms of the types of collection vehicles in use.

As York Region is responsible for processing, the quality of the feedstock is important to effective and efficient MRF operation. Therefore, it is in the best interest of the Region to have a policy in place that prescribes the expected quality of the inbound material. In general, feedstock quality can be impaired by the level of contamination and the degree of compaction.

In July 2005, a single stream blue box program was implemented throughout York Region. The collection method is loose (i.e. not in bags); it provided an expanded list of acceptable products and applies to the residential sector. This program change was implemented in conjunction with the opening of the Region's single stream MRF which is capable of processing in excess of 90,000 tonnes per year.

During the design of the Region's single stream MRF, it was recommended by the equipment manufacturer that the upper limit for compacting blue box recyclables be no greater than 2.5 to 1. This recommended maximum and a policy to issue violations for over-compaction has been in force since July of 2005. Violations are issued by the MRF scalehouse staff to the driver of the collection vehicle if the net weight of the load exceeds the established limit based on the methodology cited below.

Prior to establishing a policy, York Region was required to assess what 2.5 to 1 compaction means. In order to determine this ratio, the density of the loose inbound stream needed to be determined. By placing uncompacted blue box material into a container of a known volume and obtaining a net weight, the loose density is known. This loose density can be referred to as the 1 to 1 compaction rate. By multiplying this calculated density by the MRF design specification maximum compaction ratio of 2.5, the upper compaction limit is assessed. This upper compaction limit is used by the MRF staff to monitor the quality of the inbound material. By multiplying the upper compaction limit by the volumetric capacity of the collection vehicle, a maximum net weight per vehicle is established. From a MRF operation perspective, if the upper compaction rate is given as a maximum net weight per vehicle, it is easy to determine the loads that exceed the compaction limit.

As the composition of the blue box stream fluctuates seasonally, the inbound composition and density are reviewed regularly and the upper limit for compaction is adjusted as required. In York Region, the current upper compaction limit is 190 kg/m^3. This equates to a maximum net weight of 6 tonnes per collection vehicle based on a one compartment vehicle of a nominal capacity of 30.6 m^3 (i.e. top loading vehicle). This also equates to a maximum net weight of 16 tonnes per transfer trailer based on a nominal capacity of 84 m^3.

1.2 Project Overview

The purpose of this project was to determine the optimal level of compaction during collection to maximize collection efficiency while maintaining efficient MRF operations. As such, this project was undertaken to evaluate the practices used across North America and to compare them to that of York Region to ascertain if a best practice is in place or if one can be established.

The York Collection and Processing Optimization Study was conducted in two phases to examine the issue of compaction. First, a survey was, conducted to obtain information regarding compaction practices during the collection of blue box recyclables in jurisdictions outside of York Region. The second phase involved a series of tests of different degrees of compacted blue box materials and their handling through York Region's single stream MRF. These operational tests assessed the level of compaction at which the MRF could not effectively process the compacted material thereby determining the upper limit for compaction. This level of compaction was reached either when the residue or quality of the products failed to meet specifications or when the processing rate had to be decreased below the required contractual minimum to continue to meet the residue and product quality.

Section 2 – Survey on Blue Box Compaction

2.1 Background

As a municipality's waste management program evolves, challenges associated with maintaining an efficient and effective program, ranging from political and financial to technical and educational, also change.

In York Region, the implementation of the single stream blue box program meant changes to the way the program was operated. This involved the comingling of fibres and containers, the introduction of new products and changes to the collection and processing methods. A single stream program meant that the collection vehicles do not "cube out" as quickly which would allow for more efficient and cost effective collection. This change also meant that York Region needed a new, modern MRF to manage the comingled stream. While both of these aspects were advancements to the Region's blue box program, the issue of compaction was not contemplated for either. Hence, this survey focused on the impact compaction has on collection and processing for all program types: single-, dual- and multi-stream.

When York Region migrated from a multi-stream program to a single stream program in July 2005, the majority of the collection fleet was modified by removing the partitions in the top load vehicles (thereby converting them from five compartment trucks to one compartment trucks). This provided significantly greater capacity per vehicle thus reducing the number of trips to the MRF, the collection time, the number of trucks required and provided for savings on collection. Instead of using top load vehicles exclusively, the Region now also employs side load and rear load packers. These compaction vehicles allow for more material per truck, further reducing the number of trips to the MRF and theoretically producing more cost savings.

While the switch to single stream and the use of compaction vehicles have benefits related to collection efficiency, there was still no definitive link between level of compaction and its impact on a MRF operation. This project was initiated to determine the level at which compaction would negatively impact MRF operation. To this end, a survey was prepared to obtain information from other jurisdictions on their practices and experiences related to compaction.

2.2 Survey Methodology

A questionnaire was developed, a list of jurisdictions was compiled, a contact list for each jurisdiction was prepared and they were reached via telephone. To review the survey questions, the list of surveyed municipalities and complete survey results, refer to Appendix 1. The survey intended to:

- Determine the prevalence of compaction;
- Determine the level of compaction;
- Identify relationships (if any) between the use of compaction and factors such as population or travel distance; and

- Determine the extent to which compaction leads to operational issues at the MRF.

To this end, the survey questionnaire was developed to obtain information on the following:

- Capacity of collection vehicles;
- Makes and models of the collection vehicles in use;
- The type of blue box program (number of streams);
- The collection method;
- The collection frequency;
- The materials permitted in the blue box program;
- Seasonal differences;
- The mean distance from collection point to the MRF or transfer station;
- Upper limit for compaction (if using compaction); and
- Rationale for the upper limit (if using compaction).

The survey population chosen was from across North America, with a focus on Ontario municipalities. The survey was inclusive of all blue box programs including single stream, dual stream and multi-stream and was intended for only those that had a curbside program. A list of municipalities and contacts were collected from their respective Web sites. The contacts were asked whether or not they were responsible for collection or MRF processing and if they were not, they were asked for referrals. Once the appropriate contact was reached, the questions were asked and recorded.

Most of the respondents were individual municipalities. However, some programs were cooperatives involving several municipalities. As such, for the purposes of this report, the cooperatives were treated as a single jurisdiction. Examples of such cooperatives were: Bluewater Recycling Association which collects in 23 municipalities in South-western Ontario, Quinte Waste Solutions which services 9 municipalities in South-eastern Ontario and Hawkesbury Joint Recycling which services the Town of Hawkesbury and the Townships of East Hawkesbury and Champlain in Eastern Ontario.

For statistical purposes, the most recent available populations used were obtained from Statistics Canada (2001) and the United States Census Bureau (2000).

2.3 Survey Analysis

To sort and analyze the results, the collected data was grouped into categories including:

- Geographical location;
- Population (above or below 100,000);
- The use of compaction; and
- Mean travel distance between collection point and MRF or transfer station.

For the purposes of this report, the compaction rate of blue box recyclables is expressed as kilograms per cubic meter (kg/m^3). If a respondent could not provide a compaction rate in kg/m^3, a compaction rate was calculated from the weights and capacity of the vehicles provided.

2.4 Survey Participation

In total, 140 jurisdictions were contacted. This included 114 in Ontario, 13 across Canada and 13 in the United States of America. Of the 140, 66 jurisdictions completed the entire survey, 36 jurisdictions were not included as the appropriate contact could not be reached, 11 jurisdictions did not answer all of the questions, 10 jurisdictions were disqualified as they did not have curbside programs, 5 jurisdictions declined to participate. Only those jurisdictions that were able to answer all of the survey questions were included in the analysis but all responses are included in Appendix 2.

Table 1 – Survey Participation

Survey Status	Ontario	Across Canada	Across USA	Total
Complete	55	6	5	***66***
Incomplete	7	0	4	***11***
Disqualified	7	3	0	***10***
Declined	4	1	0	***5***
Unreachable	29	2	5	***36***
Total	***114***	***13***	***13***	***140***

2.5 Prevalence of Compaction

Of the 66 jurisdictions that completed the survey in full, 34 (51.5%) used compaction during collection. Of this, 25 were from Ontario (45.5% of the Ontario survey population), 4 were from across Canada (66.7% of the Canada survey population) and all 5 in the USA (100% of the USA survey population).

In considering population as a factor in using compaction during collection, a benchmark population of 100,000 was used. Of the 66 jurisdictions that completed the survey, 27 had populations over 100,000 and 63.0% of these jurisdictions used compaction vehicles to collect blue box recyclables. Of the 39 jurisdictions under 100,000, only 43.6% used compaction vehicles. Based on this, there is a loose relationship between population size and the use of compaction but the results are not decisive.

In comparing the mean travel distance to the use of compaction, the survey results revealed that the mean travel distance from collection location to MRF or transfer station was 20 km. In the jurisdictions with a mean travel distance of greater than 20 km, 56.7% of the respondents reported using compaction. In jurisdictions where the mean travel distance was less than 20 km, the use of compaction was 45.9%. As such, there does not appear to be a clear relationship between distance travelled and the use of compaction for collecting blue box recyclables.

Of the 34 jurisdictions that use compaction vehicles, 16 (47.1%) have a dual stream program, 14 (41.2%) have a single stream program, 3 (8.8%) have a multi stream program and 1 (2.9%) uses a combination of single stream and dual stream program. Based on this, the use of compaction vehicles to collect blue box recyclables is not influenced by the type of program in place.

Overall, the survey results indicate that the prevalence of compaction is not driven by population, travel distance or program type. In fact, the results of the survey suggest that the type of vehicle used is not based on any consistent or common set of operational or logistical criteria. Instead, other undeniable factor(s) or reason(s) are motivating whether or not compaction vehicles are used.

2.6 Compaction and Collection

Of the 66 jurisdictions that completed the survey, 34 used compaction vehicles for collection. The mean upper limit for compaction among these jurisdictions was 320.0 kg/m^3 and the average compaction value was 217.0 kg/m^3. These values are presented in Table 2. By comparison, York Region (inclusive of all nine local municipalities), has upper limit is 190 kg/m^3 and average compaction value is 133.9 kg/m^3. Due to the large distance between the southern collection area and the MRF, 33% of York Region's curbside collected blue box material is transfer-hauled to the MRF. When the transfer-hauled material is included, the average compaction rate for blue box materials delivered to York's MRF increases to 137.3 kg/m^3.

Table 2 – Summary of Compaction Rates

Jurisdiction	Upper Comp. Rate (kg/m^3)	Ave. Comp. Rate (kg/m^3)
Brockville, ON	655.0	425.8
Chicago, IL	594.8	423.8
Clarence-Rockland, ON	523.6	235.6
New York City, NY	497.5	335.1
Orlando, FL	494.5	409.0
Kawartha Lakes, ON	424.0	265.0
Ottawa, ON	418.8	301.0
Toronto, ON	418.8	288.0
Edmonton, AB	405.5	217.4
Alfred & Plantagenet Twp, ON	393.0	142.9
Fredericton, NB	369.3	236.4
Capital Regional District, BC	350.5	260.1
Shelburne, ON	326.8	163.4
Northumberland, ON	314.1	189.6
Peel Region, ON	314.1	269.2
Quinte Waste Solutions, ON	304.3	173.9
Red Deer, AB	304.3	304.3
San Diego, CA	288.6	204.5
Guelph, ON	282.7	176.5
Essex/Windsor, ON	265.0	194.3
Fort Frances, ON	261.0	195.8
Sault Ste. Marie, ON	257.7	189.0
Bluewater Recycling, ON	251.0	117.4
Barrie, ON	250.0	171.1
Portland, OR	207.5	173.0
Blind River, ON	196.1	147.1
York Region, ON *	***190.0***	***137.3***
Niagara Region, ON	186.9	167.9
Mono, ON	186.6	111.9
North Stormont, ON	186.6	143.3
Wellington County, ON	178.6	160.7
Casselman, ON	131.0	114.6
Greater Sudbury, ON	130.7	114.4
Average	***320.0***	***217.0***

Note: York Region's upper compaction rate is per the policy at the MRF and the average compaction rate is the aggregate of the nine York Region local municipalities.

In comparing the compaction rate to population size, the jurisdictions with a population greater than 100,000 using compaction vehicles, the upper compaction limit is 325.1 kg/m^3 and the average compaction rate is 229.7 kg/m^3. For the jurisdictions with a population under 100,000 using compaction, the upper compaction limit is 313.8 kg/m^3 and the average compaction limit is 201.7 kg/m^3. As can be seen from the results in Tables 3 and 4, the overlap in compaction rate suggests that population does not appear to be a factor in deciding to use compaction vehicles to collect blue box recyclables.

Table 3 – Summary of Compaction Rates for populations over 100,000

Jurisdiction	***Population***	***Upper Comp. Rate (kg/m^3)***	***Ave. Comp. Rate (kg/m^3)***
Chicago, IL	2,896,016	594.8	423.8
New York City, NY	8,008,278	497.5	335.1
Orlando, FL	185,951	494.5	409.0
Ottawa, ON	774,072	418.8	301.0
Toronto, ON	2,481,494	418.8	288.0
Edmonton, AB	666,104	405.5	217.4
Capital Reg. District, BC	325,754	350.5	260.1
Peel Region, ON	988,948	314.1	269.2
Quinte, ON	136,819	304.3	173.9
San Diego, CA	1,223,400	288.6	204.5
Guelph, ON	106,170	282.7	176.5
Essex/Windsor, ON	374,975	265.0	194.3
Bluewater Recycling,ON	165,237	251.0	117.4
Barrie, ON	103,710	250.0	171.1
Portland, OR	529,121	207.5	173.0
York Region, ON	779,063	190.0	137.3
Niagara Region, ON	410,574	186.9	167.9
Greater Sudbury, ON	155,219	130.7	114.4
Average	***1,128,384***	***325.1***	***229.7***

Table 4 – Summary of Compaction Rates for populations under 100,000

Jurisdiction	***Population***	***Upper Comp. Rate (kg/m^3)***	***Ave. Comp. Rate (kg/m^3)***
Brockville, ON	21,375	655.0	425.8
Clarence-Rockland, ON	19,612	523.6	235.6
Kawartha Lakes, ON	69,179	424.0	265.0
Alfred & Plantagenet,ON	8,593	393.0	142.9
Fredericton, NB	47,560	369.3	236.4
Shelburne, ON	4,122	326.8	163.4
Northumberland, ON	77,497	314.1	189.6
Red Deer, AB	67,707	304.3	304.3
Fort Frances, ON	8,315	261.0	195.8
Sault Ste. Marie, ON	74,566	257.7	189.0
Blind River, ON	3,969	196.1	147.1
Mono, ON	6,822	186.6	111.9
North Stormont, ON	6,855	186.6	143.3
Wellington County, ON	81,143	178.6	160.7
Casselman, ON	2,910	131.0	114.6
Average	***33,348***	***313.8***	***201.7***

When comparing the compaction rate results of jurisdictions with a mean travel distance of either greater or less than 20 km, the result is unexpected. The mean upper compaction limit for those with a mean travel distance of greater than 20 km is 293.0 kg/m^3 (data range: 130.7 to 523.6 kg/m^3). The mean upper compaction limit of those with a travel distance of less than 20 km is 374.6 kg/m^3 (data range: 186.6 to 782.6 kg/m^3). The variation between the upper and lower compaction values is considerable and therefore a correlation cannot be concluded.

When the average compaction rate is used instead of the upper compaction rate (a more representative value), the end result remains the same. The mean compaction rate for jurisdictions with a travel distance of greater than 20 km is 192.7 kg/m^3 (data range: 114.4 to 409.0 kg/m^3). The mean compaction rate for those with a travel distance of less than 20 km is 254.8 kg/m^3 (data range: 111.9 to 425.8 kg/m^3). Since the data range and overlap is so large, the values cannot be considered statistically significant. Therefore, there is no clear relationship between the distance travelled and the degree of compaction.

When the type of blue box stream is analyzed for the use of compaction during collection, 45.5% have a single stream program, 45.5% have a dual stream program and 9.0% use a multi-stream program. From this, the decision to collect blue box recyclables is not linked to the number of streams. Tables 5, 6 and 7, present the mean upper and average compaction rates of the different streams.

Table 5 – Compaction Rates of single stream programs

Jurisdiction	***Upper Comp. Rate (kg/m^3)***	***Ave. Comp. Rate (kg/m^3)***
Toronto, ON	418.8	288.0
Edmonton, AB	405.5	217.4
Alfred & Plantagenet Twp, ON	393.0	142.9
Fredericton, NB	369.3	236.4
Northumberland, ON	314.1	189.6
Peel Region, ON	314.1	269.2
Red Deer, AB	304.3	304.3
San Diego, CA	288.6	204.5
Guelph, ON	282.7	176.5
Fort Frances, ON	261.0	195.8
York Region, ON	190.0	137.3
Niagara Region, ON	186.9	167.9
North Stormont, ON	186.6	143.3
Casselman, ON	131.0	114.6
Greater Sudbury, ON	130.7	114.4
Average	***278.4***	***193.5***

Table 6 – Compaction Rates of dual stream programs

Jurisdiction	***Upper Comp. Rate (kg/m^3)***	***Ave. Comp. Rate (kg/m^3)***
Chicago, IL	594.8	423.8
Clarence-Rockland, ON	523.6	235.6
New York City, NY	497.5	335.1
Orlando, FL	494.5	409.0
Kawartha Lakes, ON	424.0	265.0
Ottawa, ON	418.8	301.0
Capital Regional District, BC	350.5	260.1
Shelburne, ON	326.8	163.4
Essex/Windsor, ON	265.0	194.3
Sault Ste. Marie, ON	257.7	189.0
Bluewater Recycling, ON	251.0	117.4
Barrie, ON	250.0	171.1
Portland, OR	207.5	173.0
Mono, ON	186.6	111.9
Wellington County, ON	178.6	160.7
Average	***348.5***	***234.0***

Table 7 – Compaction Rates of multi stream programs

Jurisdiction	*Upper Comp. Rate (kg/m^3)*	*Ave. Comp. Rate (kg/m^3)*
Brockville, ON	655.0	425.8
Quinte Waste Solutions, ON	304.3	173.9
Blind River, ON	196.1	147.1
Average	***385.1***	***248.9***

2.7 Compaction and MRF Processing

As part of the survey, MRF operators were contacted to gather information on the impact compaction has on blue box processing. Of the 34 jurisdictions that reported using compaction during collection, 18 reported negative impacts for MRF processing while 21 respondents report no operational impacts.

From the 18 respondents that reported MRF processing issues or problems associated with compaction during collection included, the feedback is as follows:

- 20.6% reported glass breakage (7 of 34 respondents);
- 11.8% reported contamination (4 of 34 respondents);
- 8.8% reported sorting problems (3 of 34 respondents);
- 5.9% reported congealing of fibre when the feedstock is wet (2 of 34 respondents);
- 2.9% reported infraction notices due to heavy loads (1 of 34 respondents); and
- 2.9% reported problems unloading due to jamming in the vehicle (1 of 34 respondents).

From the 16 that did not report any MRF operational issues, the issues were avoided by:

- 4.8% reported that a state-of-the-art MRF was in use(1 of 16 respondents);
- 4.8% reported that compaction limit policy worked effectively (1 of 16 respondents);
- 9.5% reported that curbside separation was adequate at avoiding compaction (2 of 16 respondents);
- 9.5% reported that compaction vehicles were newly introduced and MRF problems not been identified to date (2 of 16 respondents); and
- 18.5%did not report a specific reason(s) (10 of 16 respondents).

When relating the compaction rates to the reported MRF problems, the results are questionable. The mean upper compaction limit for those reporting issues at the MRF is 328.1 kg/m^3 (data range: 186.6 to 594.8 kg/m^3). The mean upper compaction limit for those not reporting issues is 314.6 kg/m^3 (data range: 130.7 to 655.0 kg/m^3). As the overlap between the mean upper compaction limit for those reporting issues and those not reporting issues is so large, there is no apparent relationship between compaction rate and MRF operational issues. The average compaction rate for those reporting issues at the MRF is 234.5 kg/m^3 (data range: 143.3 to 423.8 kg/m^3) and the average compaction rate for those not reporting issues is 205.5 kg/m^3 (data range: 114.4 to 425.8 kg/m^3). Again, since the overlap is large, no clear conclusions can be made.

There were six single stream programs using compaction that reported issues or problems at the MRF. They had a mean upper compaction rate of 266.8 kg/m^3, an average compaction rate of 205.1 kg/m^3 and an average residue rate of 11.8%. There were ten single stream programs that used compaction that did not report issues / problems at the MRF. They had a mean upper compaction rate of 286.2 kg/m^3, an average compaction rate of 185.7 kg/m^3 and an average residue rate of 10.5%.

Regarding the dual stream programs, there were only six that used compaction that reported issues or problems at the MRF. They had a mean upper compaction rate of 393.8 kg/m^3, an average compaction rate of 274.1 kg/m^3 and an average residue rate of 14.7%. There were nine dual stream programs using compaction that did not report any operation issues or problems at the MRF. The mean upper compaction limit for these jurisdictions was 318.2 kg/m^3, and average compaction rate of 207.3 kg/m^3 and a 9.0% average residue rate. It should be noted that only 3 of the dual stream programs reported a residue rate, which impacts the average residue rate for the dual stream programs.

The least common blue box program found in the survey was a multi-stream program. There was one multi-stream program using compaction that reported operational issues at the MRF. It had an upper compaction limit of 304.3 kg/m^3, an average compaction rate of 173.9 kg/m^3 and a residue rate of 5.0%. There were two multi-stream programs that used compaction but reported no operational issues at the MRF. The mean upper compaction limit was 425.6 kg/m3, the average compaction rate was 286.5 kg/m3 and neither of the two reported a residue rate.

From the comparisons of stream type to the reports of operational issues at the MRF from those using compaction, there is no clear relationship between compaction rate and MRF operational issues.

When comparing the residue rates for jurisdictions using compaction to those not using compaction, those not using compaction have a lower residue rate. Of the jurisdictions not using compaction, 55.6% are multi-stream programs, 33.3% are dual stream and 11.1% are single stream. Since the jurisdictions that do not use compaction are primarily multi-stream where sorting is done at the curb, there is less contamination entering the MRF. As MRF residue is comprised of both contamination (unsolicited materials) and MRF process loss, the use of compaction alone cannot be entirely responsible for the differences in residue rates.

2.8 Other Results Related to Compaction

The composition of blue box stream is fundamental to determining the optimal compaction rate for both collection and MRF processing. In addition, since not all jurisdictions report composition in the same categories, a direct comparison of compositions was not available. Of the jurisdictions that completed the survey in full, some only provided the composition as fibres and containers. As such, the general categories of fibres and containers were presented.

The results of the survey indicate that, based on the general categories of fibres and containers, the blue box composition between jurisdictions are consistent. The percentage of fibre in compacting jurisdictions was 71.3% and in those not using compaction, the percentage was 72.4%. Containers made up 27.9% of the composition for those using compaction and 26.7% for those not using compaction. As such, the composition does not appear to be a factor in determining whether or not to use compaction.

On the average, jurisdictions using compaction during collection use smaller capacity vehicles (by volume). The mean truck volume was 22.5 m^3 for those using compaction and 29.7 m^3 for those not using compaction.

As almost every result from the survey was inconclusive, the overall result of the survey is that there is no clear ‘best practice’ regarding the optimal compaction rate during collection or for MRF processing.

Section 3 – Compaction Tests through York Region’s MRF

3.1 Introduction and Background

As a complement to the survey portion of this project, a series of compaction tests of York Region’s single stream blue box recyclable material were conducted to determine the optimal level of compaction during collection that maintained MRF processing efficiency.

The processing tests involved compacting York Region's single stream blue box material to different compaction rates to determine the level of compaction at which the MRF could not effectively produce products that met end market specifications or if the MRF residue or the processing rate failed to meet the contractual (operational) requirements.

Based on the historical performance of the MRF and the contractual requirements for the operation of the MRF, the baseline conditions were established against which the various tests would be compared.

Of the nine local municipalities in York Region, the Town of Newmarket was selected to supply material for these compaction tests. This source was selected due to their proximity to the MRF and the fact that they use compaction vehicles. In addition, this local municipality uses a different collection contractor than the one the Region uses for MRF operations. This was required to ensure as much objectivity of the test as possible. Furthermore, to ensure a blind test (MRF operators unaware of the compaction rate), the collection contractor was instructed to weigh each load at an independent, third-party weigh scale.

An auditing protocol was developed. This procedure ensured the feedstock for the tests was consistent with York Region's average composition and to assess the quality of the residue, newspaper, mixed paper, and all glass streams. All percentage values in the tables below are based on weight.

3.2 Study Methodology

The compaction rates expected for the tests were 2.5, 3 and 4 to 1 based on York Region's blue box composition.

The MRF operator was permitted to make minor adjustments to the processing system during the tests. However, these adjustments were strictly limited to only those that would normally occur during day-to-day operation. These changes included replacement of damaged discs on screens and adjustments to the angles of the screens (to achieve effective separation).

End product audits were based on Stewardship Ontario's Guide to Waste Audits September 2005 and modified where required. The end products selected for analysis to determine the performance of the MRF were: MRF residue, newspaper (#8), mixed paper (#6), mixed broken glass (MBG), clear and coloured glass. The reason for selecting these materials was due to the "cause and effect relationship" inherent with compacting blue box recyclables.

The physical act of compacting blue box recyclables means that container products will deform and either flatten or break and if wet, fibre products will congeal. In single stream MRFs, the majority of the processing is done mechanically and is based on the size and shape of the materials. If the amount of container deformation is considerable, the mechanical screens will not effectively separate the products resulting in containers either ending up on the fibre lines, in the MBG or in the residue. Compaction typically has little effect on the fibre products unless they are wet. Since compaction affects the containers more readily than fibres, auditing the identified end products for quality was expected to verify the optimal limit for compaction during collection that maintains MRF efficiency.

Prior to each of the processing tests, a series of tasks were performed to ensure only the compacted feedstock material was processed and analyzed. These tasks were: clearing all belts of blue box recyclables from the prior shift, emptying the newspaper and mixed paper holding bunkers, emptying the MBG, clear and coloured glass holding bunkers and placing an empty collection container under the residue conveyor to collect all MRF residue from each process test.

For analysis, 400 kg of feedstock, MRF residue, newspaper and mixed paper were collected. A sample of larger than 400 kg of each was initially collected and from this larger sample, sub-samples were taken to obtain a representative sample. To obtain a sample of MBG, the bucket from a front-end loader was used and sub-samples were taken for analysis. For clear and coloured glass, as the respective holding bunkers were emptied prior to the test, all of the material that entered the bunker was collected for analysis.

Each of the products was audited for quality against the end market specifications and the baseline data. The amount of time required to collect the MBG, clear and coloured glass was recorded to determine the production rates. The production rate of the various glass products was done to assess the amount of glass breakage that occurs as a result of compaction. For further information on the methodology and audit categories, refer to Appendix 3.

3.3 York MRF Operation

York Region's single stream MRF opened in July 2005 and is capable of processing in excess of 90,000 tonne per year. The MRF has an average throughput of 25 tonne per hour; operates 16 hours per day on 2 shifts and employees 45 staff per shift.

The process flow (Appendix 2) is along two parallel conveyors running from the tipping floor through three sets of mechanical screens and two staffed sorting rooms for manual sorting. In the first step of the process, recyclables pass through a manual sorting room to remove any unsolicited materials, de-bag any recyclables mistakenly collected in bags, and un-bundle any product that was tied-up at the curb. The unsolicited materials become part of the MRF residue and are directed to the waste transfer station for disposal.

From this sorting room, the recyclables pass over three sets of mechanical screens, each successively smaller than the previous screen. The objective of the mechanical screens is to separate the recyclables by size then by shape. First, cardboard is removed then newspaper, then mixed paper and finally containers are sorted from any remaining paper and MBG. The mechanically sorted cardboard is quality checked prior to baling. The mechanically separated newspaper, mixed paper and containers are transferred into the final sorting room for further sorting. Newspaper and mixed paper are manually sorted to remove any containers and unsolicited materials prior to shipment to the end market.

The containers are transferred to the container line and are sorted by type both manually and magnetically. Any item that is not sorted from of the container line becomes part of the MRF residue and is directed to the waste transfer station for disposal.

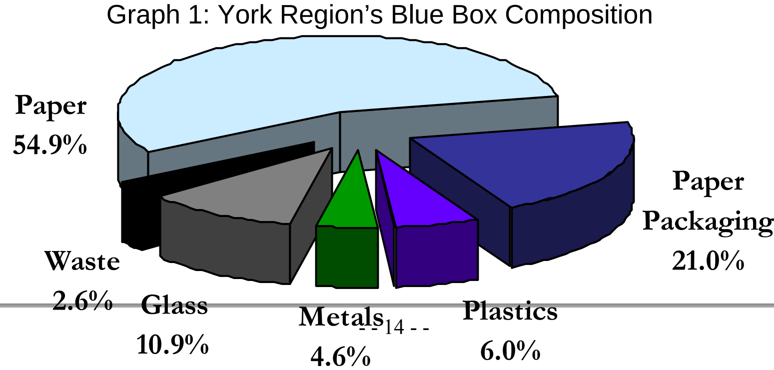
3.4 York Region's Historical Data

Historic operational data in York Region is provided for comparison to the compaction tests. The historical data is from the period July 2005 to July 2006.

- Collection fleet: 42.2% top load, 20.7% side packer, 4.6% rear packer, 32.5% trailers
- Baseline compaction rate of inbound recyclables into MRF: 1.6 to 1
- MRF processing rate: 25 tonne / hour
- MRF total residue rate: 7.3%

The broad categories of York Region's single stream inbound composition are as follows:

Graph 1: York Region's Blue Box Composition



York Region's baseline compaction rates based on inbound deliveries into the MRF are as summarised in Table 8. This compaction study was done in August 2006 and for clarity, the baseline compaction rates are from the period July 2005 to July 2006.

Table 8 – York Region Baseline Compaction Rates

Collection Vehicle Types	***% of Loads into the MRF***	***Average Net Weight (kg)***	***Capacity (m^3)***	***Compaction Rate (x : 1)***	***Average Compaction (x : 1)***
Top Load	42.2%	2,610	32	1.1	1.6
Side Load	20.7%	4,170	26	2.1	
Rear Load	4.6%	3,900	24	2.1	
Transfer Trailer	32.5%	12,400	84	1.9	

3.5 Feedstock Results

To ensure the tests were conducted using a common feedstock, a comparison of the inbound material for all compaction tests was done. Other than the total recyclable paper and paper packaging categories, the standard deviation between the tests was low indicating the composition was comparable. For clarity, the baseline compaction rate is 1.6 to 1 and the compaction rates were 2.4, 2.8 and 3.0 to 1 respectively for Tests 1 through 3.

Table 9 – Feedstock Composition by Recyclable Category

Category	***Baseline***	***1st Test***	***2nd Test***	***3rd Test***	***STDEV***
Recyclable Paper	54.9%	33.8%	33.4%	38.9%	10.1%
Non Recyclable Paper	0.2%	0.1%	0.2%	0.3%	0.1%
Recyclable Packaging	21.0%	37.8%	41.4%	34.7%	8.9%
Non Recyclable Packaging	0.2%	0.3%	0.3%	0.4%	0.1%
Recyclable Plastics	6.0%	11.6%	8.9%	9.5%	2.3%
Non Recyclable Plastics	0.9%	1.4%	1.3%	1.2%	0.2%
Recyclable Metals	4.6%	5.1%	3.9%	3.7%	0.6%
Non Recyclable Metals	0.3%	0.0%	0.3%	0.1%	0.1%
Recyclable Glass	10.9%	9.8%	9.7%	11.2%	0.8%
Non Recyclable Glass	0.1%	0.0%	0.0%	0.0%	0.0%
HSW	0.1%	0.0%	0.4%	0.0%	0.2%
Organics	0.4%	0.2%	0.1%	0.0%	0.2%
Other Wastes	0.7%	0.0%	0.1%	0.0%	0.3%
Total Recyclables	97.4%	98.0%	97.3%	98.0%	0.4%
Total Non Recyclables	2.6%	2.0%	2.7%	2.0%	0.4%
All Materials	100%	100%	100%	100%	

Note: STDEV refers to the Standard Deviation
Note: If a category description is "non recyclable", it means the item is not part of York Region's blue box program

The average composition of fibres and containers from the baseline, compaction tests and survey results (as mentioned in Section 2.8), are comparable as presented in Table 10.

Table 10 – Feedstock Comparison

Category	***Baseline***	***Jurisdictions using Compaction***	***Jurisdictions not using Compaction***
Fibres	74.5%	71.3%	72.4%
Containers	25.5%	27.9%	26.7%

As mentioned in Section 3.2, the compaction rates for this study were expected to be 2.5, 3 and 4 to 1. These compaction rates were requested of the collection contractor but the compaction rates actually achieved for the tests were 2.4 (test 1), 2.8 (test 2) and 3.0 to 1 (test 3). The proposed level of 4 to 1 was not achieved for the third test due to the collection contractor's concerns that compacting beyond the recommended limit of the vehicle manufacturer may damage the equipment and compromise the health and safety of the collection crew.

The Ontario Ministry of Labour's *Mobile Compacting Equipment Safety Guideline, May 2004*[1] provides general assistance on potential hazards associated with operating mobile compacting equipment. Specifically, this guideline addresses the operating control requirements to ensure worker safety. There is a requirement within this guideline that, "the number of ram compaction cycles initiated by a single activation of the controls shall not exceed three (3)"[2]. This requirement is to prevent a continuous cycle in the event the operator becomes entangled after starting the ram. However, once the cycle has completed, there is nothing to prevent the operator from activating the control again to initiate another cycle. As this study investigated the optimal compaction rate for blue box recyclables, this requirement is not applicable because it does not specify how much a load can be compacted.

Compaction during collection has the greatest impact on container products. By analyzing the feedstock prior to each compaction test, the amount of deformation as a result of compaction can be determined. As can be seen in Table 11, as the compaction rate increases, the amount of container deformation also increases. The amount of deformation was measured by adding additional categories to the waste audits. Rather than simply categorizing the materials by type, the physical shape was taken into account in addition to the material type. In this way, the quantity of compacted and uncompacted materials was determined. As discussed elsewhere, as compaction is increased, the deformation of containers also decreases which impacts processing on the MRF equipment.

3.6 MRF Performance Results

3.6.1 Processing

While considerable effort was made to ensure that the compaction tests were as unbiased as possible, the MRF staff was aware that the tests were being done and it is conceivable that behaviours were adjusted. Specifically, there is the potential that the belt speeds, mechanical screens or manual sorting efforts were influenced to skew the outcome of the tests. To mitigate this possibility, these variables were compared to historical processing parameters.

It is recognized that processing adjustments are required on a regular basis and these adjustments are done based on the quality of the feedstock. During this compaction study, the weather conditions were dry which meant that any adjustments to MRF operation were in response to feedstock quality (as feedstock quality is affected by compaction) not due to moisture content. During the tests, adjustments made were to the finishing screen which controls the separation of mixed paper from containers and from MBG. The nature of the adjustments included fine-tuning of the pitch-and-roll to adequately separate the mixed paper from the containers and the replacement of a worn disc on the screen. If the worn disc was not replaced, a higher than normal quantity of paper and containers would end up in the MBG, as York Region's MRF does not have a MBG clean-up system.

During each processing test, the number of sorters (including their location) and the various belt speeds were recorded for comparison to the baseline conditions.

The baseline MRF operating staff complement is 45. They are located throughout the MRF in the two manual sorting rooms, tipping floor and for baling operations. This number does not include supervisors, managers or others onsite that have roles and responsibilities that are not directly related to processing material through the MRF. The number of sorters and their locations was the same during the compaction tests as during the baseline.

- Tip Floor: 2, 1 front end loader operator and 1 spotter
- Sort Room #1: 4 manual sorters to remove the unsolicited materials
- Sort Room #3: 35 manual sorters for fibres and containers
    - 3 for mixed paper and 16 for newspaper
    - 14 for containers
    - 2 extra for sorting but the primary function is housekeeping
- Bailing: 2 are for quality control prior to baling, 2 for baling

The baseline processing rate through York Region's MRF is 25 tonne per hour.

In comparing the results of the processing rates to the baseline, the throughput was higher during the tests than the baseline. Since the belt speeds during the tests ran inline with the baseline conditions, but the throughput was higher than the baseline conditions, the effect of compaction on the density of the feedstock is apparent. Table 11 outlines the throughput (expressed in tonne per hour) and the belt speeds (expressed in metres per minute). In comparing to Table 10, the baseline compaction rate is 1.6 to 1, the first compaction test was at 2.4 to 1, the second compaction test was 2.8 to 1 and the third compaction test was at 3.0 to 1.

Table 11 – Processing Rates (Conveyors m / minute)

Category	***Baseline***	***1st Test***	***2nd Test***	***3rd Test***
Throughput (tonne / hr)	25.0	27.2	27.9	32.2
In Feed Conveyors	8.2	8.2	8.2	8.5
Mixed Paper Conveyor	115.9	111.3	111.3	115.9
Newspaper Conveyors	115.9	114.3	114.3	114.3
Container Conveyor	69.5	68.6	68.6	69.5

As can be seen in Table 11, during each compaction test, the throughput increased but the belt speeds remained constant. This is because as compaction increases the density of the material increases and if the belt speeds remain constant, a higher throughput is achieved. However, as can be seen in the following sections, the quality of some products decreased as the compaction rate increased while the operating parameters remained the same. This implies that if the feedstock is compacted to a known amount, the MRF could adjust the conveyor speeds to reduce the throughput which could allow for effective mechanical and manual separation which could produce materials that meet the end market specifications. This may require additional sorters and/or other equipment.

3.6.2 Newspaper

In order to determine the effectiveness of the MRF at meeting the end market specifications for material quality, the end market specifications contained in the MRF operating contract were used. For the complete composition of the newspaper stream and end market specifications, refer to Appendix 3.

Table 12 – ONP Quality Data

Category	***Specs.***	***Baseline***	***1st Test***	***2nd Test***	***3rd Test***
ONP	70.25%	71.6%	73.8%	74.6%	69.2%
Coated Paper & Magazines	18%	5.7%	6.4%	6.7%	9.9%
Other Paper	9%	10.1%	8.5%	6.8%	8.6%
Out Throws	2%	9.4%	8.5%	10.4%	10.9%
Prohibitives	0.75%	3.2%	2.9%	1.5%	1.4%

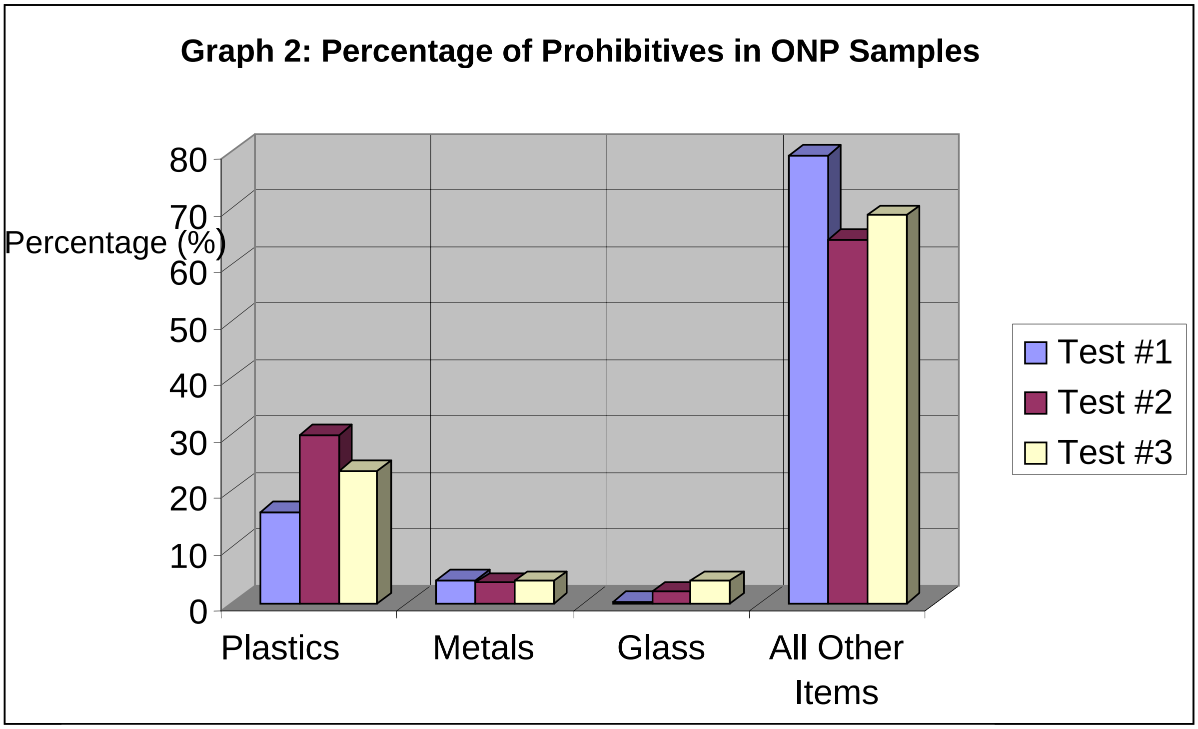
The objective of the compaction tests was to determine the level of compaction at which the MRF could not effectively process the blue box material and produce marketable products. By comparing the percent composition of the newspaper to the end market specifications, a pass/fail grade would be issued. If the result was a pass, the MRF could effectively process the compacted recyclables. If the

result was a fail, the MRF could not meet the performance expectations and therefore establish the compaction limit.
As stated in Table 12, the contractual end market specification for newspaper is: no greater than 18% coated paper, 9% other paper, 2% out throws and 0.75% prohibitives. In comparing the results of Table 13 to these specifications, the result is that the MRF failed to meet the ONP quality requirements for all categories.

Table 13 – ONP Quality Pass/Fail

Category	***Baseline***	***1st Test***	***2nd Test***	***3rd Test***
Coated Paper & Magazines	Pass	Pass	Pass	Pass
Other Paper	Fail	Pass	Pass	Pass
Out Throws	Fail	Fail	Fail	Fail
Prohibitives	Fail	Fail	Fail	Fail

It should be noted that the "prohibitives" category is comprised of non-paper products where the remaining three categories are all paper products. The major prohibitive items found in the newspaper stream during the three compaction tests are listed in Graph 2.



The results of the composition audits after the processing test indicated that the quality is negatively affected by compaction. While the ONP content remained consistent, the quality decreased as compaction increased due to increasing amounts of out throws and coated papers & magazines. As presented in Table 13, the newspaper failed to meet the quality specifications for three of the four categories during each test where the number of manual sorters and belt speeds remained the same during each test. However, corrective action could be used to mitigate the impact compaction has on the quality of the newspaper. As a result, the number for sorters could be increased or the belt speeds could be decreased which could produce a newspaper product that met the end market specifications while maintaining MRF design throughput.

3.6.3 Mixed Paper

The end market specifications for mixed paper, as contained in the MRF operating contract was used to assess the effectiveness of the MRF at meeting the quality criteria. Appendix 3 contains the complete composition of the mixed paper stream and the end market specifications.

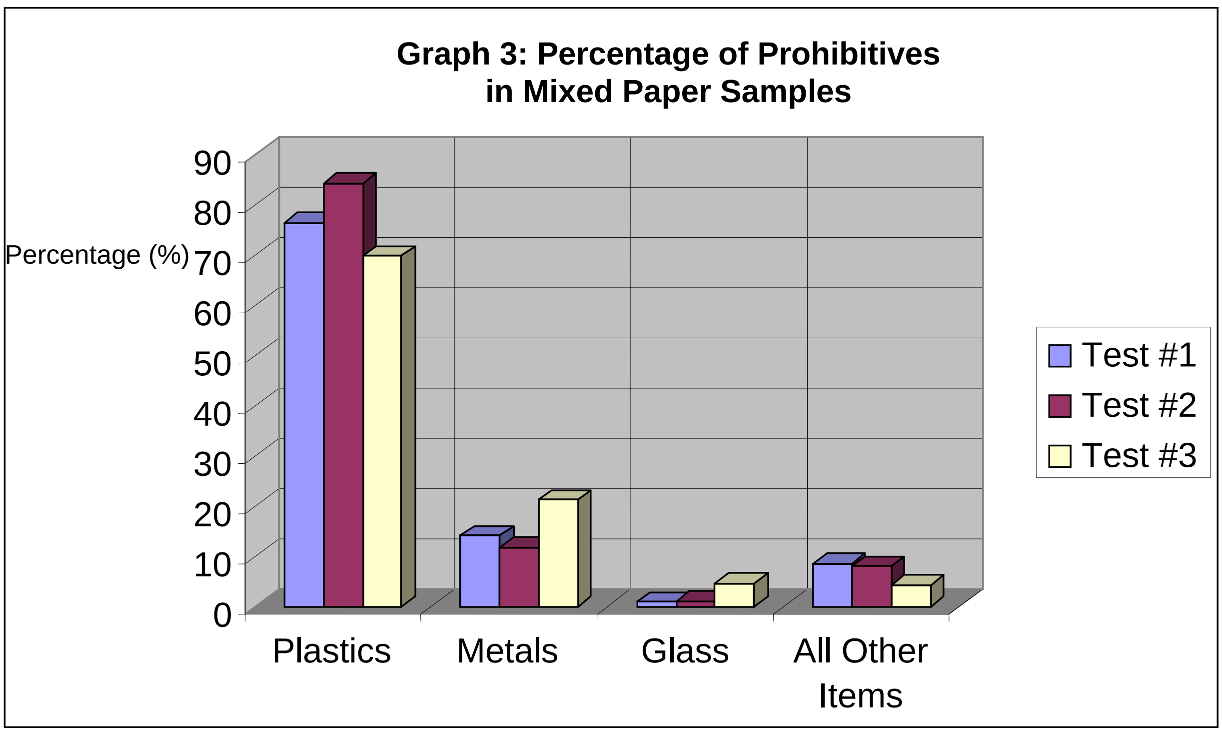
Table 14 – Mixed Paper Quality Data

Category	***Specs.***	***Baseline***	***1st Test***	***2nd Test***	***3rd Test***
Total Mixed Paper	89.0%	95.2%	96.8%	96.4%	95.5%
Out Throws	10.0%	0.2%	0.4%	0.3%	0.2%
Prohibitives	1.0%	4.7%	2.8%	3.3%	4.3%

In comparing the results of Table 14 to these specifications, the result is that the MRF failed to produce a mixed paper product that met the quality requirements for each category.

Table 15 – Mixed Paper Quality Pass/Fail

Category	***Baseline***	***1st Test***	***2nd Test***	***3rd Test***
Out Throws	Pass	Pass	Pass	Pass
Prohibitives	Fail	Fail	Fail	Fail



The composition audits of the mixed paper after the processing tests indicate that the quality is negatively affected by compaction when the operating conditions remain the same. As with the newspaper, the number of sorters and belt speeds remained constant during each test and quality result did not change. Therefore, adjusting the belt speeds or the number of sorters could produce a product that met the end market specifications.

3.6.4 Glass

Unlike newsprint and mixed paper, the MBG composition audit categories were simplified from Stewardship Ontario's Guide to Waste Audits, September 2005. The purpose of including an assessment of the MBG in this study was to evaluate the quality and quantity of MBG produced from each compaction test. Unlike other products in the blue box stream, the amount of MBG produced is greater than the amount in the feedstock. Glass breakage is the major contributor to this, but MBG is also comprised of non-MBG items which are contaminants. The MBG evaluation also involved a size distribution.

In contrast to the newspaper and mixed paper audit results, the quality of the MBG improved with compaction. During each processing test, the capture rate of MBG trended upwards and the contamination trended downwards. Table 17 outlines the composition of the MBG during the compaction tests.

Table 16 – MBG Composition by Recyclable Category

Category	***Baseline***	***1st Test***	***2nd Test***	***3rd Test***
Paper	4.8%	5.3%	4.6%	3.6%
Paper Packaging	1.7%	0.7%	0.8%	0.6%
Compacted Plastics	0.3%	0.8%	0.7%	0.6%
Uncompacted Plastics	0.1%	0.1%	0.2%	0.1%
Other Plastics	2.8%	1.8%	1.8%	1.4%
Compacted Metals	3.1%	2.3%	3.2%	3.1%
Uncompacted Metals	0.1%	0.0%	0.0%	0.0%
Other Metals	0.3%	0.0%	0.0%	0.1%
Glass	84.7%	89.0%	88.3%	90.1%
HSW	0.1%	0.0%	0.0%	0.0%
Organics	0.5%	0.0%	0.0%	0.1%
Other Wastes	1.5%	0.0%	0.5%	0.3%
Total Glass	84.7%	89.0%	88.3%	90.1%
Total Non Glass	15.3%	11.0%	11.7%	9.9%

It should be noted that of the plastics and metals found in the MBG, the majority were compacted. The final set of screens in York Region's MRF is to separate the small fibres products from containers products and MBG. If there are any fibre or container products that are smaller than the screen size, they end up in the MBG stream. Typically, containers would not pass through this screen (only the lids would) but as compaction increases, the container's shape and size is altered. This deformation allows these non-glass items to pass through the screen and enter the MBG stream. Currently, York Region does not have a MBG clean up system to capture these non-glass items.

Table 16 shows that there is a decrease in the amount of total non-glass in the MBG during each of the compaction tests. This may have been the result of the adjustments made by the MRF staff as mentioned in Section 3.5.1. However, a more likely explanation is that as compaction increases, so does glass breakage which results in more MBG produced.

While a deceasing amount of total non-glass in the MBG stream may appear to be an end product that has an improved quality as compaction increases, in fact, the quality remains the same. While the amount of paper and paper packaging decreased during the compaction tests (as compared to the baseline), the amount of plastics and metals did not decrease during the compaction tests. In fact, the percentage of plastics increased and metals remained the same.

The inference is that the final screen cannot effectively separate compacted containers which results in contamination of the MBG stream. As MBG has a negative market value, contamination from easily marketable materials should be prevented. A corrective measure for this would be to install a MBG clean up system to remove the fibre and containers and re-direct them back into the MRF.

As compaction increases, so does the output rate of MBG whereas the production rate of clear and coloured (whole glass bottles) decreases. By understanding the production rate of each, the impact on glass breakage by compaction would be assessed.

Table 17 – Production Rates of Glass (kg/hr)

Category	Baseline	1st Test	2nd Test	3rd Test
MBG	3,480	3,527	3,455	6,168
Clear Glass	69	83	83	91
Coloured Glass	150	166	103	100
Total Glass	3,398	3,777	3,340	6,359

3.6.5 MRF Residue

MRF residue, while not an end product, is an important element in determining the effectiveness of the MRF. The loss of recyclables products to disposal means a loss in diversion rate and revenue. As these losses impact the overall blue box system, minimizing MRF residue is important.

York Region's MRF operating contact specifies a minimum processing efficiency for which regular performance tests are required. The minimum efficiency prescribes that the MRF is to capture 93% of the recyclable content in the blue box stream. This means that if the inbound material contains 2.6% unsolicited material, the minimum processing efficiency is 90.6% (100% - 2.6% * 93%). This means that the total residue rate can be up to but cannot exceed 9.4%. As the feedstock quality varies, the minimum processing efficiency and maximum residue rate are adjusted when the percentage of unsolicited materials increases or decreases.

The historical total residue rate of the York Region MRF is 7.3% (July 2005 to July 2006) (see Table 19). As MRF residue is comprised of both unsolicited and solicited materials an evaluation of the residue to determine its recyclable content will yield the actual MRF residue rate. The actual MRF residue rate, also called MRF process loss, is the difference between the total residue percentage and the unsolicited materials percentage. If the MRF does not meet the minimum processing requirement, the MRF will fail the test. For the purposes of this test, the MRF also fails if the percentage of recyclables in the residue reaches an unacceptable level.

Table 18 – MRF Residue Composition

Category	Dec 2005	June 2006	Average
ONP	5.6%	4.5%	5.0%
OCC	1.7%	4.4%	3.1%
Mixed Paper	12.2%	33.7%	23.0%
PET	1.0%	3.7%	2.4%
HDPE	0.6%	0.3%	0.4%
Mixed Plastics	2.8%	12.9%	1.2%
Aluminum	0.9%	1.5%	0.7%
Steel Cans	1.4%	0.1%	1.4%
Polycoat (Aseptic & Gable Top)	0.9%	1.9%	7.8%
Large Glass	2.9%	0.1%	3.0%
MBG	14.6%	3.2%	7.4%
Total Recyclables	44.7%	68.2%	55.4%
Total Non Recyclables	55.3%	33.8%	44.6%

As compaction increases, the degree of congealing increases. Congealing refers to different materials (product types) being compacted together and once merged, they are no longer considered a recyclable product. Congealed material is removed from the MRF in the first manual sorting room.

As the amount of compaction increases, so does the amount of recyclables in the residue. The reason behind this is due to the increase in congealing and ineffective separation by the mechanical screens. As mentioned in Section 3.5.1, the final set of mechanical screens separates the fine paper from the containers and from the MBG. In order to achieve effective separation, the screens are adjusted based on the quality of the material being processed. As compaction affects quality, the MRF staff had to adjust the screens during the tests in the attempt to achieve acceptable separation of fibres and containers. As demonstrated in the compaction tests, as compaction increased, the effectiveness of the final screens at separating the fine paper and containers decreased. This resulted in an increase in fibre on the container line. This fibre adds to the burden depth which reduces the ability of the sorters to recover container products. In this regard, by increasing the amount of fibre on the container line, the result was more fibre and containers ending up in the residue. The residue composition is outlined in Table 20.

Table 19 – Change in MRF Residue Composition

Category	*Historical*	*Baseline*	*1st Test*	*2nd Test*	*3rd Test*
ONP	5.0%	14.7%	17.0%	18.9%	17.9%
OCC	3.1%	4.3%	10.7%	13.8%	6.0%
Mixed Paper	23.0%	20.7%	32.0%	26.8%	33.8%
PET	2.4%	9.5%	3.8%	5.5%	8.5%
HDPE	0.4%	4.2%	0.7%	1.4%	2.5%
Mixed Plastics	1.2%	2.8%	1.7%	1.8%	1.9%
Aluminum	0.7%	1.3%	1.5%	1.8%	2.4%
Steel Cans	1.4%	1.0%	1.2%	0.7%	0.6%
Polycoat	7.8%	3.3%	2.6%	1.7%	3.5%
Large Glass	3.0%	5.1%	4.1%	2.7%	5.8%
MBG	7.4%	1.2%	2.4%	4.6%	5.0%
Total Recyclables	55.4%	67.9%	77.7%	79.7%	87.9%
Total Non Recyclables	44.6%	32.1%	22.3%	20.3%	12.1%

It is evident that as compaction increases, so does the percentage of recyclables in the residue. As mentioned in Section 3.5.2, the unsolicited material in the feedstock was consistent between baseline and compaction tests and therefore does not account for the decrease in the residue. The percentage of non recyclables in the residue is a function of its weight relative to the entire sample.

Table 20 compares the amount of total residue produced per 100 tonne of feedstock. For clarity, each test had a slightly different amount of feedstock and none of the tests had exactly 100 tonne. The table provides a total residue rate for a theoretical 100 tonne feedstock test and the residue rates presented are calculated from the actual total residue amount (tonnes) and actual feedstock amount (tonnes). The formula is 100 * total residue tonnes / feedstock tonnes.

Table 20 – MRF Residue Production per 100 tonne

Category	*Historical*	*Baseline*	*1st Test*	*2nd Test*	*3rd Test*
Total Residue %	6.8%	5.5%	6.0%	4.8%	5.0%

In order to give a pass/fail rating to the compaction tests for MRF residue quality, the contract requirement for minimum processing efficiency was used in combination to the results of Table 20. The contractual minimum processing efficiency is 93% of the recyclable content in the feedstock. Table 21 presents the results of the processing efficiency during the compaction tests.

Table 21 – MRF Processing Efficiency Assessment

Category	Historical	Baseline	1st Test	2nd Test	3rd Test
Total Residue %	7.3%	6.0%	6.0%	4.8%	5.0%
Process Loss %	3.6%	4.0%	4.0%	2.1%	3.0%
Minimum Processing %	89.6%	90.6%	91.2%	90.5%	91.2%
Achieved Processing %	96.3%	96.0%	96.0%	97.9%	97.0%
Pass / Fail	Pass	Pass	Pass	Pass	Pass

As can be seen in Table 21, the total residue percentage decreased with each compaction test indicating that as compaction increases, the total amount of residue decreases. While an improved processing efficiency is a good result, the percentage of residue that is recyclables is a cause for concern. This could be remedied by adjusting the belt speeds and or increasing the number of sorters in the MRF.

3.7 Summary of Compaction Tests

The compaction tests showed that as the compaction rate increases, the quality of the end products decreases. This is because compaction causes deformation of the blue box materials which leads to ineffective mechanical and manual sorting.

The compaction tests showed that the MRF could not produce newspaper or mixed paper that met the end market specifications at the tested compaction rates. As the operating procedure was the same for each test (i.e. belt speeds and number of sorters) but the throughput increased as a result of compaction, a decrease in the belt speed(s) and/or adding manual sorters could improve the quality of the end products.

While the quality of the MBG improved during the compaction tests (on a percentage of MBG present in the stream), as the compaction rate increased, the relative percentage of individual non-glass items increased as well. This increase in non-glass items in the MBG stream represents a significant increase in costs and decrease in revenue. In order to mitigate this contamination, a better practice would be to install a MBG clean up system and re-direct the non-glass items back into the MRF.

The processing efficiency of the MRF improved with each compaction test but MRF residue quality decreased as the compaction rate increased. During each compaction test, the percentage of recyclables in the residue increased dramatically. Even though the processing efficiency increased, the quantity of recyclables in the residue was considerably high. To decrease the amount of recyclables in the residue, a decrease in throughput and/or an increase in sorting staff would be a 'better practice'.

The results of the compaction tests are that York Region's MRF equipment supplier's recommendation of 2.5 to 1 compaction could be acceptable if the MRF processing operations are modified to accommodate the compacted feedstock. Processing compacted blue box material without process modifications results in products that either fail to meet end market specifications or result in increased costs or decreased revenue. If the appropriate adjustments cannot be implemented, a lower compaction rate, such as 2 to 1, could be used. However, a further study would be needed to determine the actual adjustments (i.e. exact reduction in belt speed and how many additional sorting staff) required to meet the end product specifications while maintaining an effective processing rate for processing compacted materials.

Since York Region's average compaction rate is 1.6 to 1, if the compaction rate of 2.5 to 1 is used, the collection and transfer systems can be improved by 36%. In theory, this would reduce the collection costs by 36%. There are approximately 80 top loading vehicles in York Region's collection fleet and by converting 36% of these to compaction vehicles, a reduction of 29 vehicles is possible. However, this may not be practical. If each top load vehicle cost $100,000, by removing 10 of these 29, $1,000,000 could be saved in capital costs. This calculation is an educated guess and a further detailed costing study is required.

If 2 to 1 compaction is used in York Region, the inbound density of blue box recyclables would be adjusted to 152 kg/m^3 (from 190 kg/m^3). This change would translate into an operationally efficient net weight of 4.8 tonne (from 6 tonne) for single compartment collection vehicles of nominal capacity of 30.6 m^3. In addition, transfer trailers with a nominal capacity of 84 m^3 would have an operationally efficient net weight of 12.8 tonne (from 16 tonne).

Section 4 – Conclusions

4.1 Survey

The objective of the survey was to gather information to learn from the experiences and practices on the issue of compacting blue box recyclables. The goal was to ascertain justifications for compacting blue box recyclables during collection and the impacts compaction has on blue box processing at MRFs.

- The overall finding of the survey was that across North America, and in particular Ontario, there is no standard policy regarding compaction during collection nor is there a standard for MRF processing operations.
- The survey found that there is no correlation between population size, distance travelled between collection point and MRF / transfer station or program type that justifies the use of compaction.
- Of the jurisdictions that use compaction to collect blue box recyclables, there is no clear relationship between the compaction rate in use and the incidence of operational problems during processing even if the residue rates are high.

While the survey did provide 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.

4.2 Compaction Processing Tests

The objective of the compaction tests was to determine the compaction rate that maximized collection efficiency while maintaining an effective MRF operation. Key findings of the compaction tests are:

- There needs to be MRF operational changes when processing compacted blue box recyclables, such as a decrease in belt speed and/or increase in sorting staff.
- Without process changes, end market quality specifications are not achieved.
- Supplementary equipment is needed to decrease contamination in end products such as the MBG stream.
- The MRF residue quality decreased as the compaction rate increased.
- The MRF equipment supplier's recommendation of 2.5 to 1 can be considered valid if adjustments are made to the MRF operations. If operational adjustments cannot be made, a lower compaction rate, such as 2 to 1 could be used as a 'better practice'.

This study showed that the end products did not meet the specifications when processing compacted blue box recyclables under standard operating conditions. In order to effectively process compacted blue box recyclables, MRF processing changes are required. An additional study should be undertaken to determine the exact extent of savings to collection versus the increase in cost to MRF operations for processing compacted blue box recyclables.

This report did not evaluate the potential of compounding compaction. Compounding compaction is a result of multiple handling of blue box materials prior to processing. This occurs when blue box material is collected using a compaction vehicle, delivered to a transfer station, further compacted onto a transfer trailer destined for a MRF. If this happens, the compaction rate has the potential to be greater than the recommended upper compaction rate for MRF processing. Therefore, a supplementary study is suggested to evaluate the impact compounding compaction has on the overall blue box system.

Next Steps

The first step will be to review the results of the compaction tests with York Region's MRF operator. As the results from the baseline test identified areas for improvement, by implementing the some or all of the recommendations, the MRF operations can be enhanced. This would demonstrate continual improvement to York Region's blue box system.

The second step will involve discussions with the local municipalities that recently issued a collection tender. It should be noted that the collection tender closed prior to the completion of this compaction study. However, the tender included a provision that blue box recyclables not be compacted to greater than 2.5 to 1. In this regard, the consultation will include a review of the results of the compaction tests and how to incorporate the findings into the upcoming contract.

The results of both the survey and MRF operational tests identified several key areas for supplementary studies and further research is recommended to investigate:

- The potential financial impact to York Region's blue box program by using more compaction vehicles to collection blue box recyclables. This should examine both the potential cost savings to collection and probable cost increases to MRF processing to determine an overall reduction in the blue box system costs.
- The motivating factors that influence the decision to use or not use compaction. As this study discovered, the use of compaction to collect blue box recyclables is not universal or consistent. Notwithstanding the potential overall system cost reduction, by assessing geographical, financial, technical or other criteria underlying principals may be established which could form the basis for a policy decision to use compaction or not.
- The impact that compounding compaction has on the blue box system and in particular, MRF processing operations.

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Definitions

"Cube out" …... If using multiple compartments to sort blue box material at the curb, when one compartment becomes full, the vehicle cannot collect any more material and travels to the MRF or transfer station

Kg …………….. Kilogram; equal to 2.2 pounds

Km ……………. Kilometer; equal to 1.61 miles

M ……………… meter, equal to 3.28 feet

m^3 …………….. Cubic meter; equal to 1.31 cubic yards

MBG ………..… Mixed Broken Glass

References

1. www.labour.gov.on.ca/english/hs/guidelines/compacting
2. Mobile Compacting Equipment Safety Guideline, May 2004, page 8 (c)

Appendices

Appendix 1 – York Region MRF Location Map
Appendix 2 – York Region MRF Process Flow Diagram
Appendix 3 – Compaction Survey Report
Appendix 4 – Compaction Processing Report