

# RESIDENTIAL WASTE MATERIALS DENSITY STUDY

(WDO OPT/ORG-R2-02)

**Town of Markham  
City of Guelph  
County of Northumberland**

*In Partnership with*



*Prepared By:*

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*April, 2001*

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## EXECUTIVE SUMMARY

In Ontario, there are limited reliable density data available for some of the new waste streams being tested, or even for those already in place, such as:

- source separated kitchen organics
- bagged recyclables
- bagged garbage excluding both of the previous fractions
- wet and dry waste (as collected in Northumberland and Guelph), and
- many individual curbside recyclables, such as boxboard, film plastic, polycoat and aseptic containers, etc.

Limited field density data exist for use in computer models to plan and evaluate waste management options. These models are useful tools for designing collection systems, evaluating collection vehicle and operating alternatives, projecting collection and processing needs and for estimating and allocating waste management costs. They are, however, inherently only as reliable as the assumptions they are based on. At present, the models often rely on waste density data that are based on published or theoretical data found in U.S. trade publications. In other words, density assumptions, for the most part, have not been “ground-truthed” to Ontario conditions.

The purpose of this study was to field measure Ontario-specific densities for some of these waste streams and individual recyclable materials. Markham and Guelph were originally selected as target communities for the density sampling, and as an add-on to the original contracted work, additional density data were also collected in Northumberland County, since Enviro RIS field staff were already on site at the MRF involved in another project for the County. Guelph and Northumberland already have two-stream ‘wet’ and ‘dry’ waste diversion systems operating and Markham is piloting a source separation collection system for kitchen organics and bagged recyclables.

Material densities, or weight to volume ratios, were established simply by repeatedly weighing samples of the material in a container of a known size. Densities for bagged garbage, bagged recyclables and bagged organics were established by collecting waste from the curb in Guelph, Markham and Northumberland and then repeatedly weighing samples of the wastes in large cardboard bins. Individual recyclable material densities were also calculated, where possible, by gathering and weighing materials in the three subject MRFs.

The majority of the sampled material densities approximated densities reported in trade publications. One of the densities appeared anomalous and it is recommended that further field testing be done to confirm the measured results. It is also recommended that additional field density measurements be undertaken to provide a better understanding of the materials collected across a broader range of jurisdictions.

## **1.0 Introduction**

In October 2000, The Town of Markham and the City of Guelph jointly contracted Enviros RIS (RIS) to conduct fieldwork in their communities to establish loose density data for various residential curbside recyclables and waste materials. This initiative was supported by a grant from the Ontario Waste Diversion Organization with Guelph and Markham providing workspace, equipment, and staff time to help coordinate the collection of the materials and make the measurements.

As an add-on to the original contracted work, additional density data were also collected in Northumberland County, since RIS staff were already on site at the MRF involved in another project for the County.

This report describes the field methods used to gather the necessary data to determine “loose” material densities for a number of residential curbside waste materials such as PET, boxboard, polycoat, bagged kitchen organics, ‘wet’ and ‘dry’ wastes, and residual garbage. Measured densities for various waste materials from the Guelph, Markham and Northumberland waste programs are presented.

## **2.0 Purpose of Study and Background**

In Ontario, many municipalities use computer models to evaluate waste management options. Models are useful tools for designing collection systems, evaluating collection vehicle and operating alternatives, projecting collection and processing needs and for estimating and allocating waste management costs. They are, however, inherently only as reliable as the assumptions they are based on. At present, the models often rely on waste density data that are based on published or theoretical data found in U.S. trade publications. In other words, density assumptions, for the most part, have not been “ground-truthed” to Ontario conditions.

Furthermore, with new municipal diversion activities now underway in Ontario, there are no reliable density data available for some of the new waste streams being tested (or even for those already in place), such as:

- source separated kitchen organics
- bagged recyclables
- bagged garbage excluding both of the previous fractions
- wet and dry waste (as collected in Northumberland and Guelph), and
- many individual curbside recyclables, such as boxboard, film plastic, polycoat and aseptic containers, etc.

The purpose of this study was to field measure Ontario-specific densities for communities (Guelph and Northumberland) which already have two-stream 'wet' and 'dry' waste diversion systems operating and for another (Markham) that is piloting a source separation collection system for kitchen organics and bagged recyclables.

Bob Graham was the lead RIS consultant on this project, with field work conducted by John Dixie and supervised by Gord Day. RIS would like to thank staff from the City of Guelph, The Town of Markham, Northumberland County, Canadian Waste Systems and Miller Waste Systems for their cooperation in conducting the field tests.

## **3.0 Methodology**

### **3.1 Overview**

Material densities, or weight to volume ratios, were established simply by repeatedly weighing samples of the material in a container of a known size. Densities for bagged garbage, bagged recyclables and bagged organics were established by collecting waste from the curb in Guelph, Markham and Northumberland and then repeatedly weighing samples of the wastes in large cardboard bins.

Density measurements for individual recyclables can practically only be measured after recyclables are collected and delivered to the processing facility. In this project, densities

were identified by repeatedly weighing samples of individual materials after they were sorted in the Guelph Dry MRF, York Region's MRF (where Markham's recyclables are processed by Miller Waste Systems) and Northumberland County's MRF.

Because the MRF's were operating at the time the measurements were made, not all of the same materials were sampled at each location. Samples were gathered for those materials that were available and accessible on the sampling day. The sampled material was collected in a variety of ways:

- Setting a bin in a bunker below the sorting line and allowing it to fill
- Hand loading material from a bunker into a bin (for safety reasons the bunkers below the sorting line were entered only when the line was down for a staff break or when sorters had been directed not to use the bunker's feed chute)
- Using a front-end loader to load material from a bunker into a bin
- Replacing the regular bin at the end of a conveyor with a bin
- Using stockpiled materials that were already stored in bins.

In some situations, the field crew could not safely access material because the manner in which it was stored (e.g. in sunken bunkers or where channeled through a closed system directly into a compactor).

Collected sample material was weighed in large cardboard bins commonly known as 'gaylords'. Care was taken to ensure that sample material was leveled flush with the top of the bin before the bins were weighed. The bins were then moved by hand or forklift, depending on the weight of the material, to a 4' x4' floor scale. If a forklift was used, the bins were set on wooden pallets to accommodate the forks of the truck. The procedure was repeated until the supply of sampled material was exhausted. The number of measurements per material ranged from one to seven depending on the quantity of material available at the time the sampling was done.

The density of each material sampled was calculated by adding the net weights of the samples together and dividing by the total volume the material occupied. An example of a density calculation is shown below.

**Density Calculation for 4 Full Bins of Loose Commingled Container Material**

$$\text{Density} = \frac{\text{Total Gross Weight of Material}}{\text{Total Volume Material Occupies}}$$

$$\text{Total Gross Weight} = 103.5 \text{ kg} + 82.5 \text{ kg} + 102.5 \text{ kg} + 87.5 \text{ kg} = 376 \text{ kg}$$

$$\text{Total Tare Weight} = 19 \text{ kg (bin)} + 19 \text{ kg (bin)} + 21 \text{ kg (bin)} + 19 \text{ kg (bin)} + (4 \times 9 \text{ kg (skid)}) = 114 \text{ kg}$$

$$\text{Total Net Weight} = 376 \text{ kg} - 114 \text{ kg} = 262 \text{ kg}$$

$$\text{Total Volume} = 4 \times (32" \times 53" \times 23") = 156,032 \text{ cubic inches} = 3.34 \text{ cubic yards} = 2.56 \text{ cubic metres}$$

$$\text{Density of commingled containers} = 262 \text{ kg} \div 2.56 \text{ cubic metres} = 102.3 \text{ kg/cubic metre}$$

What follows is a detailed description of how sample materials were collected and weighed in Guelph, Markham and Northumberland.

**3.2 Guelph**

The fieldwork for Guelph was conducted on November 23, 2000, with assistance from City staff and a private hauler. Density measurements were made for the materials listed in Table 3.1.

**Table 3.1  
Guelph Waste and Recyclable Materials Sampled**

Bagged Materials Sampled from Curb	Recyclables Sampled at Guelph Wet/Dry Recycling Facility
<ul style="list-style-type: none"> <li>• 'wet' waste (kitchen organics and other compostables)</li> <li>• 'dry' waste (recyclable containers and fibres plus other waste)</li> </ul>	<ul style="list-style-type: none"> <li>• Newsprint / Mixed Paper</li> <li>• Corrugated Cardboard / Boxboard</li> <li>• Ferrous Cans</li> <li>• Aluminium Cans &amp; Foil</li> <li>• PET</li> <li>• HDPE Bottles</li> <li>• Wide Mouth Tubs &amp; Lids</li> <li>• Plastic Film</li> </ul>

City staff arranged for a private hauler to collect 'wet' and 'dry' waste from the curb and to deliver it to Guelph's Wet/Dry Recycling Centre. The hauler collected 'wet' waste (set out in green bags) from 82 homes and 'dry' waste (set out in blue bags) from 102 homes on five streets (see Table 3.2).

**Table 3.2  
Guelph Streets and Households Sampled**

Street Name	'Wet' Set Outs (# of households sampled)	'Dry' Set Outs (# of households sampled)
Waverley	19	26
Balmoral	6	9
Algonquin	12	16
Author	13	20
Westgate	21	19
Burns	11	12
<b>Total</b>	<b>82</b>	<b>102</b>

At the Wet/Dry Recycling Centre, RIS's two-person fieldwork team unloaded the bags from a 20 yd<sup>3</sup> roll off bin and separated the material into two piles, 'wet' and 'dry'. The bags of 'wet' waste were then hand loaded into large, cardboard bins, leveled off flush with the top of the bin, then transported by forklift to a rental 4' x 4' floor scale and weighed. The procedure was repeated until the supply of sample material was exhausted. The bags of 'dry' waste were weighed in the same manner.

The sample material was weighed in two sizes of bins. Guelph provided bins measuring 39" x 39" x 45" (1.47 square yards or 1.12 square metres) and RIS supplied bins measuring 32" x 53" x 23" (0.84 square yards or 0.64 square metres).

RIS selected these bins for the study because of their low cost, because they could be folded flat for easy transport and because they were relatively easy to handle and weigh at the MRF. Processed recyclables from the MRF were loaded into the bins either by hand or by front-end loader, depending on the availability of the loader and the weight of the material being measured.

### 3.3 Markham

Density measurements for Markham were made on December 4, 2000 and January 12, 2001, at the Miller Waste MRF on Woodbine Avenue. Miller assisted with the collection and weighing of the materials. The materials sampled are listed in Table 3.3.

**Table 3.3**  
**Markham Waste and Recyclable Materials Sampled**

Bagged Recyclables & Waste Sampled from Curb	Recyclables Sampled at Miller MRF
<ul style="list-style-type: none"><li>• Kitchen organics from pilot area</li><li>• Garbage from pilot area</li><li>• Fibre 'A' and Fibre 'B' from pilot area</li><li>• Container material from pilot area</li><li>• Regular garbage (outside pilot area)</li></ul>	<ul style="list-style-type: none"><li>• Blue Box Fibre 'A' (newspapers, magazines, glossy paper, fine paper)</li><li>• Blue Box Fibre 'B' (corrugated cardboard, boxboard, polycoat)</li><li>• Commingled Containers (ferrous cans, aluminium cans, PET, HDPE )</li></ul>

On December 4th, 2000 RIS's two-person field crew weighed samples of unprocessed Blue Box Fibre 'A' (newspapers, magazines, glossy paper, and fine paper), Fibre 'B' (corrugated cardboard, boxboard, polycoat) and commingled containers (ferrous cans, aluminium cans, PET, and HDPE) from the tip floor at the Miller MRF.

The field crew also weighed Blue Bag Fibre 'A' and Fibre 'B' which Miller had gathered from the Markham Pilot Area. Miller Waste provided a forklift and driver to help load and weigh the materials. The samples were weighed in RIS's portable cardboard bins (0.64 square metres).

Part of the reason Markham was selected for this project was the opportunity to obtain density data for a variety of waste streams currently collected in the community. Markham has operated a bagged organic collection trial, whereby bagged kitchen organics, bagged recyclables and the remaining waste (also bagged) are collected weekly from about 500 households. In addition, Markham has a conventional "blue box" curbside recyclables program with the remaining waste collected in garbage bags.

On January 12th, 2001, RIS's field crew collected bagged curbside waste and recyclables from fifty-five consecutive households on Oak Lea in the Markham Organics Pilot area

using a rented cube van. Bagged organic kitchen waste (set out in kitchen-catcher sized green bags) was collected from all homes with setouts in the Pilot area (approximately 150 homes) in order to obtain a sufficient sample size. Regular, non-pilot garbage was collected from 19 homes on Sir Garrett, 16 homes on Woodside, and 4 homes on Sir Kay.

The material was delivered to the Miller MRF and was unloaded from the truck into the weigh bins. These materials were weighed in Miller 'Fiber Bins', wooden bins on wheels measuring 58.5" x 28 x 29.5 (1.04 cubic yards or 0.79 cubic metres). The fieldwork team found that these bins were ideal for weighing purposes because they could be moved onto the floor scale by hand even when loaded with heavy organic waste (see Figure 3.1).

**Figure 3.1**  
**Weighing Bags of Organic Kitchen Waste at the Miller MRF in Markham**



### 3.4 Northumberland

The fieldwork for Northumberland was conducted on February 15 and 16, 2001 with assistance from City staff and Canadian Waste Services. The materials sampled are listed in Table 3.4.

Curbside samples of bagged 'wet' and 'dry' waste were collected on February 16, 2001 in Cobourg, from 20 detached homes on Mackechnine Crescent and 18 homes on Westwood Drive. RIS and CWS staff made two trips in a CWS pick-up truck to pick up all the materials.

**Table 3.4**  
**Waste and Recyclable Materials Sampled in Northumberland**

Bagged Materials Sampled from Curb in Cobourg	Recyclables Sampled at Grafton MRF
<ul style="list-style-type: none"><li>• 'wet' waste (kitchen organics &amp; garbage)</li><li>• 'dry' waste (recyclables)</li></ul>	<ul style="list-style-type: none"><li>• Newsprint / Mixed Paper</li><li>• Corrugated Cardboard / Boxboard</li><li>• PET Containers</li><li>• HDPE Bottles</li><li>• Polystyrene</li><li>• Plastic Film</li><li>• Aluminium Cans</li><li>• Aluminium Foil and Trays</li><li>• Ferrous Cans</li><li>• Wide Mouth Tubs and Lids</li><li>• Textiles</li></ul>

The bags of 'wet' and 'dry' waste were transported to Northumberland's MRF in Grafton and were unloaded into RIS cardboard bins by hand. Once the material was leveled flush with the top of the bin, the bins were moved by forklift to a 4' x 4' floor scale and weighed.

Additional individual recyclables from bunkers were also sampled where they were accessible and where time permitted.

## 4.0 RESULTS AND DISCUSSION

Table 4.1 summarizes results of the field sampling. The top portion of the table shows densities for the Guelph and Northumberland wet/dry programs, organics, recyclables and garbage from Markham's organic bag collection pilot and garbage from Markham's regular collection system. One glaring anomaly is the large variation in calculated density between Northumberland's "wet" waste (187.8 kg/m<sup>3</sup>) and Guelph's "wet" waste (418.3 kg/m<sup>3</sup>).

There is no apparent explanation for this variation. Previous waste audits of both streams have shown them to be very similar in composition and both were sampled and weighed in the same way by the same field crew. The Guelph density (418.3 kg/m<sup>3</sup>) is closer to that expected of a waste stream with high organic content (compare to Markham's source separated kitchen organic density of 487.5 kg/m<sup>3</sup>). It is recommended that further field testing of Northumberland's wet waste be done to confirm the measured density.

Individual material densities are shown in the bottom half of the table. Most of these approximate published densities. Some variations are noted for individual materials, (particularly fibres) as a result of how the material is sorted in the MRF (i.e. how much it is "fluffed up") and how the material is loaded into the container for weighing. Previous experience also shows that density variations will occur if fibre is weighed in containers of various sizes. In larger containers, consolidation typically takes place, and a higher density will likely result. This is another reason why all of the field testing for this project used containers of approximately the same size.

Density measurements for this project concentrated on only three communities. Manufacturers and retailers continue to change the mix of recyclables available to consumers and over time, the density of individual materials will continue to change. Furthermore, as Ontario's waste diversion efforts intensify and municipalities continue to test various separation and collection techniques, it will important that additional field density measurements be undertaken to provide a better understanding of the materials collected across a broader range of jurisdictions.

**Table 4.1**  
**Materials Density Study - Summary of Results**

<b>Material</b>	<b>Description</b>	<b>Number of Samples</b>	<b>Total Volume (m<sup>3</sup>)</b>	<b>Total Net Weight (kg)</b>	<b>Density (lb/yd<sup>3</sup>)</b>	<b>Density (kg/m<sup>3</sup>)</b>
Wet Bags (Cobourg curbside)****	bags of "wet" waste from the curb, noncompacted	3	3.41	640.0	316.6	187.8
Dry Bags (Cobourg curbside)****	bags of "dry" waste from the curb, noncompacted, recyclable paper fibre, plastics, metals, glass and textiles	4	3.56	244.0	115.5	68.5
Wet Waste (Guelph curbside)***	noncompacted bagged kitchen organics and other compostables such as diapers, tissue/towelings, animal feces and litter (packed, by hand, into weighing container)	2	1.25	524.50	705.2	418.3
Dry Waste (Guelph curbside)**	noncompacted, bagged recyclables fibre and container material (ONP, OBB, OCC, textiles, ferrous, PET, HDPE, LDPE, PP, glass etc. ) and non-compostable residual waste (packed, by hand, into weighing container)	6	3.76	324.50	145.4	86.3
Organics (from Markham pilot area)**	bagged kitchen organics (packed, by hand, into weighing container)	4	3.18	1550.5	821.8	487.5
Garbage (from Markham pilot area)**	garbage in garbage bags and grocery bags (packed, by hand, into weighing container)	7	5.57	571.5	173.1	102.7
Fibre (from Markham pilot area)*	bagged fibre (ONP, OBB, OCC, fine paper, polycoat, magazines, glossy, junk mail) (packed, by hand, into weighing container)	5	3.14	891.0	478.9	284.1
Containers (from Markham pilot area)*	bagged ferrous cans, aluminium cans, PET, glass, HDPE bottles (packed, by hand, into weighing container)	5	3.14	181.0	97.3	57.7
Garbage (regular Markham garbage)**	garbage in garbage bags and grocery bags (packed, by hand, into weighing container)	5	3.98	328.0	139.1	82.5
ONP (from Miller MRF)*	stacked newspapers and magazines and other inserts (packed tightly by hand)	4	1.44	365.5	427.9	253.8
ONP (from Guelph MRF)***	newspaper, magazines, glossy paper, fine paper, junk mail, books (bobcat loaded)	3	3.37	412.50	206.3	122.3
ONP / Paper Mix (Northumberland MRF)****	newspapers and magazines, inserts, office paper, books (loaded by bobcat)	2	2.40	298.0	209.6	124.3
ONP / Paper Mix (Northumberland MRF)****	newspapers and magazines, inserts, office paper, books (packed flat by hand)	1	1.20	204.0	286.9	170.2
Fibre A (from Miller MRF)*	newspapers, magazines, glossy paper, fine paper, junk mail (Bobcat loaded)	5	3.14	1315.5	707.1	419.4
Fibre B (from Miller MRF)*	corrugated cardboard, boxboard, polycoat (Bobcat loaded)	3	1.88	170.5	152.7	90.6
OCC / OBB mix (Northumberland MRF)****	corrugated cardboard, boxboard, rolls, moulded pulp trays, kraft paper (Bobcat loaded)	2	2.40	110.0	77.4	45.9
OCC / OBB (Guelph MRF)***	corrugated cardboard and boxboard mix with some newspaper (bobcate loaded, approx. 3% newspaper)	3	3.37	145.50	72.8	43.2

Containers (Miller MRF)*	ferrous cans, aluminium cans, mixed PET, mixed glass, HDPE bottles (packed, by hand, into weighing container)	4	2.51	262.0	176.0	104.4
Ferrous Cans (Guelph MRF)***	ferrous food and beverage cans (gaylords directly off the sort line)	1	1.12	114.00	171.0	101.4
Ferrous Cans (Northumberland MRF)****	food and beverage cans (no compaction at MRF)	1	0.80	78.0	163.7	97.1
Alum. Cans & Foil (Guelph MRF)***	aluminum food and beverage containers and aluminium foil and trays (packed, by hand, into weighing container)	2	2.25	101.00	75.8	44.9
Aluminium Cans (Northumberland MRF)****	aluminium beverage cans (hand loaded with no compaction at MRF)	2	1.77	74.0	70.6	41.9
Aluminium Foil and Trays (Northumberland MRF)****	aluminium foil and trays (hand loaded with no compaction at MRF)	2	1.95	58.0	50.1	29.7
PET (Guelph MRF)***	non perforated food, beverage and other PET containers (all sizes - packed, by hand, into weighing container)	5	5.62	184.50	55.4	32.8
PET - perforated (Guelph MRF)***	perforated food, beverage and other PET containers (all sizes - packed, by hand, into weighing container)	3	1.93	109.50	95.8	56.8
PET (from Northumberland MRF)****	non perforated, all sizes with no compaction at MRF	1	2.23	68.0	51.5	30.5
HDPE Bottles (Guelph MRF)***	HDPE food & beverage bottles and other HDPE bottles (packed, by hand, into weighing container)	4	4.50	125.50	47.1	27.9
HDPE (Northumberland MRF)****	mixed HDPE bottles and jugs (hand loaded into gaylord)	2	1.96	74.0	63.5	37.7
PS (Northumberland MRF)****	mixed white trays, cups, insulation board	2	2.35	22.0	15.8	9.4
Wide Mouth Tubs/Lids (Guelph MRF)***	food and beverage tubs and lids, other tubs and lids, HDPE, PP, LDPE (packed, by hand, into weighing container)	1	1.12	36.50	54.8	32.5
Wide Mouth Tubs and Lids (Northumberland MRF)****	#2, #4 and #5 wide mouth tubs and lids with some #5 bottles	2	1.95	61.0	52.8	31.3
Film Plastic (Guelph MRF)***	compressed recyclable LDPE bags and wraps, grocery bags, garbage bags, etc. (packed tight by hand)	3	1.88	124.00	111.1	65.9
Recyclable Film (Northumberland MRF)****	clean plastic bags, all sorts (not compressed much - hand loaded)	2	2.40	40.0	28.1	16.7
Textiles (Northumberland MRF)****	clothes	2	1.93	206.0	179.5	106.5

\* fieldwork conducted on Dec 4, 2000

\*\* fieldwork conducted on Jan 12, 2001

\*\*\* fieldwork conducted on Nov 23, 2000

\*\*\*\* fieldwork conducted on Feb 15 and 16, 2001