

**Field Testing the Proposed  
Cost Allocation Model  
And its Components**

**Project OPT–R3–01**

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**Submitted by  
AMRC**

# MWIN

## Municipal Funding Allocation Model

A draft model has been developed that provides a mechanism for allocating funds for municipal residential recycling programs according to a sliding scale based on a number of variables. In the fall of 2000, the Waste Diversion Office let a contract to a joint team of AMRC and M-WIN to field test the variables used in the model and conduct detailed model runs for a number of municipalities. To oversee the work, a “Ground Truth Steering Group” was established with representatives from AMRC, MWIN, municipalities, WDO, and industry.

The steering committee included the following:

**Russ Nicholson**

AMRC / County of Simcoe

**Rick Clow**

AMRC / Quinte Waste Solutions

**Mike Birett**

Regional Municipality of Waterloo

**Glenn Parker**

Procter & Gamble Inc.

**John Hinds**

Canadian Newspaper Association

**Art Smith**

City of Toronto

**John Rhodes**

City of Kingston

**Mark Collins**

M-WIN / City of Barrie

**Cameron Wright / Todd Pepper**

Essex-Windsor Solid Waste Authority

**Rob Sinclair**

City of Ottawa

**Don Lamont**

Ontario Community Newspaper Association

**Geoff Rathbone**

CSR: Corporations Supporting Recycling

**John Giles**

City of Kingston

The lead consultant for AMRC on this project was Bob Argue of REIC Perth. John Lackie, representing MWIN and Steve Dingman from Quinte Waste Solutions conducted many of the material density measurements.

The model was field-tested in a number of municipalities to check a number of the variables. These included the following:

- Material density
- Accuracy of information
- Sensitivity of variables
- **Simplicity:** Is the model simple to use and apply?
- **Fairness:** Does the model fairly allocate funds to municipalities and reflect the inherent differences of operating programs in different types of municipalities?
- **“Drivers”:** Does the model provide the right messages to municipalities and encourage co-operation and expansion of programs?

In many ways, the three criteria of simplicity, fairness, and appropriate drivers are mutually exclusive. For example, to be totally fair, all municipalities would be assessed individually for costs of their program and relative efficiency. This would create a model

that would be next to impossible to administer. A main objective of the model is to present these three criteria in balance.

For the purposes of this study, the model used 1999 data from the municipal data call and 1999 average costs and revenue. The base model used was a revised version that was presented at four workshops across Ontario in 2000. The following variables are contained in the model:

### Determining funding

The following data are used to determine overall funding for the program:

- *average program costs* (total reported costs/reported tonnage). For 1999 this was a gross cost of \$187/tonne.
- *average overall revenue* based on 1999 total tonnage and average revenue by material. This averaged \$88 for the provincial basket of goods.
- *WDO funding percentage* of 45% of net costs (90% of 50% of net costs directly, the remaining 10% to be provided indirectly). In 1999 funding would have been \$29,360,322 or \$44.55 per tonne on average.

	<b>Provincial total</b>	<b>\$ per tonne</b>
Gross cost	\$124,654,200	\$187
Revenue	\$58,770,800	\$88
Net cost	\$65,245,159	\$99
Funding	\$29,360,322	\$44.55

### Provincially-uniform variables

The model incorporates the following variables that are used to adjust the funding per tonne allocated for each municipality:

- *material density* by material as collected in a top-loading truck (assuming no compaction).
- *cost split by weight/volume*, based on 40% of costs allocated weight-based and 60% of costs allocated volume based.
- *glass factor*, which increases the cost impact by 50% to account for specific glass-related problems.
- *A population density factor* based on population per hectare. This factor adjusts the funding allocation for a municipality depending on its population density to account for the inherently greater efficiencies of programs with a denser population.
- *A scale factor* based on tonnage recycled. This factor adjusts the revenue assumptions, and thus the funding allocation, for each municipality to account for the inherently greater efficiencies of larger programs.

### Municipal variables

The following variables are specific to each municipality:

- *tonnage recycled* for each material by each municipality as reported in the data call.
- *population density*, the population per hectare based on 1996 census data.

## **How the Model Works**

Based on total provincial material tonnages, costs and revenue, averaged costs are modeled for each municipality, for each of the material streams and tonnage that is collected. The total pot of funding available through the program is then proportioned to each municipality and a dollar/tonne is determined for the particular basket of goods for that municipality.

In the interest of simplicity, the model does not deal with actual municipal costs other than to determine the province wide total. In the interest of fairness, the model recognizes that by the nature of size, density, and the materials handled, some programs are inherently less or more costly to operate than others. The model uses these built-in variables to account for these differences.

### **A municipality will be allocated relatively greater dollars per tonne if:**

- they have a low population density
- they are a smaller program
- they collect a wide variety of materials (especially less dense plastics)

### **A municipality will be allocated relatively lower dollars per tonne if:**

- it has a high population density
- it is a large program
- it collects relatively few and conventional materials

### **A municipality can increase its allocation if it:**

- amalgamates with a wider, less dense region
- increases its tonnage collected
- collects a wider variety of materials

### **The model does NOT do the following:**

- determine costs for any given municipal program. Costs are based on proportioned provincial average costs using the variables to account for population density and size of operation. These modeled costs, applied to each municipalities individual material tonnage, are used for the purpose of funding allocation.
- account for specific collection or processing systems. Greater or less efficient programs are the responsibility of the municipality and are not reflected in funding allocations except through provincial averages. In other words, if a municipality has a more efficient system than other programs of a similar size, population density, and material stream, it realizes the full benefit of that efficiency. On the other hand, if the program is less efficient than others, the full cost of that inefficiency is borne by the municipality.

### **The model CAN be used to simulate:**

- “what-if” scenarios to determine the effects of funding allocations through changes in recycling programs such as accepting new materials or increasing the capture rate of existing materials.

## Model Testing

The model was tested for sensitivity to variables in the model and the potential impact these would have on funding for specific municipalities. Six municipalities were used to test the model:

- North Simcoe
- Toronto
- Ottawa
- Kingston
- Essex-Windsor
- Quinte

The base model was run for each municipality along with a number of variations based on the suggestions of the municipality. Each municipality was presented with the following information:

- Base case scenario using 1999 data for material tonnage and 1996 StatsCan data on population density.
- Summary of reported tonnage.
- Total funding that would have been available and the funding per tonne.
- Capture rate of each material stream expressed as kg/hhld.
- Comparison with typical material available expressed as kg/hhld.
- Typical total tonnage available for each material stream.
- Funding per tonne for each collected material stream.
- Total funding plus revenue available for each material stream.
- Sensitivity to the weight/volume ratio of cost allocation by material for different weight/volume ratios (30/70, 40/60, 50/50, 60/40) according to the following parameters:
  - Funding per tonne
  - Funding plus revenue per tonne
  - Gross modeled cost
  - Gross modeled cost per tonne
- Three “what-if” scenarios for each municipality that looked at funding implications of potential changes to the municipal program, including the addition of new materials, removing materials, or increasing the capture rate of currently collected materials.

*In general, municipalities found the model to be a fair way of dealing with what could too easily become an overly complex process.*

A summary of the results of these scenarios is presented in the appendix.

The following sections describe different variables and assumptions of the model, identifies concerns that have been expressed, and suggests recommendations for changes to the model.



## Recommended Changes to the Model

The following is a summary of the recommended changes to the model. The recommendations are presented beside the appropriate feature of the original model. These recommendations are for immediate implementation. A table with other considerations that should be incorporated into the model follows this table. A more detailed discussion follows.

<b><i>Original Model</i></b>	<b><i>Recommendation</i></b>
<p><b>Population density factor</b></p> <p>Population density was based on a weighted average among the municipalities involved in a given program.</p>	<p><i>Recommendation:</i></p> <p>Base population density on the average density (total population divided by total area) of any joint program.</p>
<p><b>Material mixes</b></p> <p>Material streams in the model were not always compatible with the mix in the data call.</p>	<p><i>Recommendation:</i></p> <p>Make the material streams in the model compatible with the major markets and the material streams in the data call.</p>
<p><b>IC&amp;I vs. residential</b></p> <p>There was not a rigorous distinction between material collected from the residential sector and material collected from IC&amp;I.</p>	<p><i>Recommendation:</i></p> <p>Develop guidelines for municipalities on determining the residential/IC&amp;I split. This should be combined with a built-in check in the model.</p>
<p><b>Depot vs. curbside collection</b></p> <p>These are currently funded the same, but should be changed to reflect difference in cost of operation.</p>	<p><i>Recommendation:</i></p> <p>Fund depot materials at a 50% rate if a material is only collected via depots, with no curbside component.</p>
<p><b>Scale factor</b></p> <p>There was no accounting for the inherent efficiencies of larger programs.</p>	<p><i>Recommendation:</i></p> <p>Introduce a scale factor that allows the model to adjust funding based on size of program.</p>
<p><b>Weight/volume split for cost allocation</b></p> <p>The model allocates cost of handling materials, and therefore funding, based on an adjustable split between weight and volume</p>	<p><i>Recommendation:</i></p> <p>Adopt the 40% by weight/60% by volume ratio for allocating cost for most materials.</p>
<p><b>Material density</b></p>	<p><i>Recommendation:</i></p>

Density of materials used to proportion cost based on volume used old information that required updating.	Adopt new material densities as recommended by the committee.
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The following table presents features and issues that should be considered in any future implementation of the model.

<b><i>Original Model</i></b>	<b><i>For consideration</i></b>
<p><b>Household data</b></p> <p>There was no population or household data in the model</p>	<p><i>Consideration:</i></p> <p>Incorporate population and household counts into the model for calculation of the scale factor and to provide capture rates.</p>
<p><b>Accuracy of material tonnage</b></p> <p>Some of the municipal data could be inaccurately transferred to the model.</p>	<p><i>Consideration:</i></p> <p>Provide municipalities with feedback of the tonnage breakdown that is used in the model to determine their funding allocation.</p>
<p><b>Funding fluctuation</b></p> <p>Large fluctuations in revenue from year to year make it difficult for municipalities to budget from one year to the next.</p>	<p><i>Consideration:</i></p> <p>Look at a leveling mechanism such as a 3-year rolling average for the revenue basis of the model.</p>
<p><b>Scale factor</b></p> <p>The current scale factor adjusts material revenue by up to 10% to account for different efficiencies due to size of program.</p>	<p><i>Consideration:</i></p> <p>Examine a higher factor (e.g. 20%) and assess the overall impact. This figure can be adjusted annually.</p>
<p><b>Determining revenue</b></p> <p>Current annual revenue figures are based on data compiled by CSR.</p>	<p><i>Consideration:</i></p> <p>Develop an independent revenue tracking system that is transparent and accessible to municipalities.</p>
<p><b>Material density factor</b></p> <p>A factor is used to decrease the density (and therefore increase funding) for glass to account for its difficult handling characteristics.</p>	<p><i>Consideration:</i></p> <p>Adjust density factors of other materials:</p> <ul style="list-style-type: none"> <li>• polystyrene by .67 to increase funding</li> <li>• mixed plastic by 1.5 to decrease funding</li> <li>• mixed glass by 1.5 to decrease funding</li> </ul>

<b>Kg/hhld comparison</b> There is no context for assessing capture rates and comparing programs.	<i>Consideration:</i> Add available and captured material on a kg/hhld basis to the model to allow a common measurement tool.

<b><i>Original Model (cont'd)</i></b>	<b><i>For consideration</i></b>
<p><b>Population density factor</b></p> <p>A slope of 1.5 is used to allocate revenue between the most dense population and least dense municipalities.</p>	<p><i>Consideration:</i></p> <p>Use a slope of 2.0 to put more funding to the less dense municipalities and adjust as required.</p>
<p><b>Accuracy of census data</b></p> <p>1996 census data may not accurately describe a municipality's current circumstance.</p>	<p><i>Consideration:</i></p> <p>Put in place a review system that would allow municipal input on any significant change in circumstances that affects population or density.</p>
<p><b>Distribution of funding</b></p> <p>Distributing funding within a multi-tier or joint program can be difficult to do fairly.</p>	<p><i>Consideration:</i></p> <p>Release a breakdown of how the funding allocation was determined in each circumstance to allow more transparent disbursement of funds.</p>
<p><b>Presenting the model</b></p> <p>There needs to be a clear and simple explanation and background description of the model for politicians and staff.</p>	<p><i>Consideration:</i></p> <p>Prepare a simple presentation suitable for delivery to councils on the funding allocation process and make available someone to present it.</p>
<p><b>Municipal version of the model</b></p> <p>There is a need for a version of the model that could be used by municipalities as a planning tool.</p>	<p><i>Consideration:</i></p> <p>Prepare a municipal version that allows for comparisons and feedback and provides opportunity to examine alternative program scenarios and their effect on funding.</p>
<p><b>Regular updating of the model</b></p> <p>Many of the variables in the model are constantly changing.</p>	<p><i>Consideration:</i></p> <p>Provide ongoing review of the model with annual updates.</p>

**The following points provide more detail on the changes suggested for immediate implementation to the model:**

- **Population density factor:** the model currently applies a weighted density factor for joint programs. Political amalgamations are factored by the average density. When Ottawa-Carleton became the City of Ottawa, its weighted density of 16.67 people/ha was reduced to an average density of 2.97 people/ha. This had the effect of increasing the funding allocation for 1999 by \$450,000. The use of weighted density, while more accurately reflecting costs of administering programs, also tends to discourage joint programs and cooperation. When combined with the scale factor, it is generally in the interest of programs to go it alone. Given that many of the larger municipalities have already politically amalgamated (Ottawa, Hamilton, Toronto) the average density could be used for all programs. *Recommendation:* use the average density to simplify number of programs reporting and encourage joint programs and cooperation.
- **Material mixes:** the current material streams in the model are not fully compatible with the streams in the data call. *Recommendation:* make the material streams in the model compatible with the major markets and the material streams in the data call.
- **IC&I vs. residential:** There is currently not a rigorous distinction between material collected from the residential sector and material collected from IC&I, whether through depots, curbside collection, or brought to the MRF. This can have a significant impact (both positive and negative) on funding allocation and is likely to be exploited by municipalities. *Recommendation:* develop guidelines for municipalities on determining the residential/IC&I split. This should be combined with a built-in check in the model (e.g. capture rate per household) that can be used to “red-flag” potential problem areas.
- **Depot vs. curbside collection:** depots are currently funded the same rate as curbside programs, which does not reflect the difference in cost. *Recommendation:* fund depot materials at a 50% rate. If a material is only collected via depots, with no curbside component, it would be funded at 50% of the curbside rate.
- **Scale factor:** this is the factor that recognizes that smaller populations are inherently less efficient due to economies of scale for processing and marketing. It is currently based on tonnage, which penalizes more efficient programs of equivalent size. *Recommendation:* establish a Scale factor and base it on population or households.
- **Weight/volume split for cost allocation (30/70, 40/60, 50/50, 60/40).** The current ratio used is 40% by weight and 60% by volume. Each tested municipality was provided with material costs (as determined by the model), as well as funding splits for different weight/volume ratios. Municipalities found it difficult to determine actual cost allocations, but all seemed satisfied that the 40/60 split was a reasonable representation. There was some concern expressed that the 40/60 split did not work across the board for all materials. *Recommendation:* adopt the 40% by weight/60% by volume for most materials.
- **Material density:** The chart below summarizes the density measurements of different materials in different municipalities. The “Suggested” row is the recommended density for input into the model. The row labeled “New Factored” is the density the

model would use in its calculations after applying an adjustment factor. The methodology for arriving at the density measurements and the results of the measurements are described later in this report.

Recommended Material Density Measurements										
Material	ONP carts	ONP trucks	Mixed Paper	OCC	OBB	Clear Glass	Coloured Glass	Mixed Glass	Aluminum Cans	Steel Cans
New Factored Kg/Cu m		250	135	45	62	200	200	300	30	91
Factor		1.000	1.000	1.000	1.000	0.667	0.667	1.000	1.000	1.000
<b>Suggested</b>		<b>250</b>	<b>135</b>	<b>45</b>	<b>62</b>	<b>300</b>	<b>300</b>	<b>300</b>	<b>30</b>	<b>91</b>

Material	OBB/OCC	PETE	HDPE Coloured	HDPE Natural	Plastic Tubs	Plastic Film	Poly-styrene	Aseptic	Poly-Coat	Mixed Plastic
New Factored Kg/Cu m	56	25	25	25	33	28	8	45	33	51
Factor	1.000	1.000	1.000	1.000	1.000	1.000	0.667	1.000	1.000	1.500
<b>Suggested</b>	<b>56</b>	<b>25</b>	<b>25</b>	<b>25</b>	<b>33</b>	<b>28</b>	<b>12</b>	<b>45</b>	<b>33</b>	<b>34</b>

**The following provides more detail on the considerations suggested for future implementation of the model:**

- Household data:** there is currently no population or household data built into the model. These data would be useful for determining the scale. This information could also be used for determining available tonnage and capture rates of individual material streams. There are potential problems with dealing with population (census data is standard but problems can arise regarding seasonal and student populations). Household data has no StatsCan base but could be computed. *Recommendation:* incorporate population and households into the model.
- Accuracy of material tonnage:** there is concern with the accuracy of the reported tonnage in the data call and its transfer to the model. *Recommendation:* provide municipalities with feedback of the tonnage breakdown that is used in the model to determine their funding allocation.
- Funding fluctuation:** the current model bases the funding formula on the costs, tonnage, and revenue from the preceding year. Thus a good revenue year followed by a poor year would see a sharp decline in funding, just when it is needed most. There will also be good years following poor years. This wild fluctuation makes it difficult for municipalities to budget from one year to the next. Although municipalities could establish a contingency fund, this is not always a politically easy thing to do. Industry would also face a wildly fluctuating funding program. *Recommendation:* look at a leveling mechanism such as a 3-year rolling average for the revenue basis of the model.

- **Revenue factor of 10%:** the current revenue (scale) factor is 10%. This may not adequately address the issue of scale. *Recommendation:* examine a higher factor (e.g. 20%) and assess the overall impact. This figure can be adjusted annually.
- **Determining revenue:** the model is very sensitive to revenue factors. There is concern from municipalities that the tracking of the revenue factors used in the model be independent and transparent. *Recommendation:* develop an independent revenue tracking system that is transparent and accessible to municipalities.
- **Material density factor:** a factor that adjusts material density to more accurately reflect the ease or difficulty in handling a given material is built into the model. Currently this is only applied to glass to recognize the difficulty in dealing with the material (separate compartment or wear and tear on equipment). It was agreed that the glass factor was appropriate, but that other materials could also be adjusted. *Recommendation:* consider the following suggestions/options:
  - a similar factor be applied to polystyrene which is a difficult material to work with
  - a factor increasing density (say 1.5) of mixed plastic to encourage resin separation (as the program is currently designed, funding is higher for mixed plastic (i.e. \$218/t) compared to resin streams such as PET (\$145/t) or tubs (\$187/t).
  - a factor increasing density (say 1.5) of mixed glass to encourage colour separation (currently funding is higher for mixed glass compared to clear or coloured glass)
- **Kg/hhld comparison:** the model could include a line showing the available material and the capture rate for that specific municipality. This can be compared to provincial norms and best practices. There are many benefits of this:
  - It is easy to spot major discrepancies such as accounting for IC&I material included in the residential stream.
  - It provides a check on program effectiveness.
  - It allows for municipalities to compare themselves with others to help explain why funding levels may be lower or higher than other areas.
  - It allows for easy “what-if” scenarios.*Recommendation:* add available and captured material on a kg/hhld basis.
- **Population density factor Slope of 1.5:** the model adjusts the ratio of funding for the densest and the least dense municipalities using a slope of 1.5. Using a greater slope puts more funding to the less dense municipalities. *Recommendation:* use a slope of 2.0 and adjust as required.
- **Accuracy of Municipal information:** it has been identified that there is no mechanism in place if a municipality’s data of population or area differs from the census data. *Recommendation:* put in place a review system that would allow municipal input on any significant change in circumstances.
- **Distribution of funding:** concern has been expressed over what tier of municipal government reports and gets the funding and how the funds are distributed in multi-municipal programs. The agreements amongst municipalities vary considerably, as does the way municipal programs distribute funding. *Recommendation:* release a

breakdown of how the funding allocation was determined in each circumstance to allow more transparent disbursement of funds.

- **Presenting the model:** there needs to be a clear and simple explanation and background description of the model for politicians. A third party rather than staff may best present this because of their understanding of the model and ability to clearly identify why funding is as it is. *Recommendation:* prepare a simple PowerPoint or similar presentation suitable for delivery to councils on the funding allocation process. Make available someone to make a presentation where this is appropriate.

- **Municipal version of the model**

It is agreed that there should be a municipal version of the model that:

- Provides feedback to the municipality on the tonnage figures and population density used (to check for accuracy).
- Indicates what the funding level will be.
- Compares this with provincial norms.

There is also a strong interest to see this as a working tool for municipalities to assess their program and to use as a planning tool to create “what-if” scenarios. This would include the following:

- Presenting tonnage by material for current recyclables.
- Presenting the capture rate (kg/hhld) by individual materials and comparing this with provincial available or norms.
- Providing a working area in the model to develop new scenarios for program changes such as adding new material, removing material, or changing the capture rate.
- Providing an additional working area to determine the net cost of any changes. This would include all gross savings (change in revenue, change in funding, landfill diversion credit) and all gross costs (costs for collecting and processing incremental material, costs for promotion). Impacts on collection using the density factors could also be included.
- Itemizing other recycling benefits such as greenhouse gas reduction.

It has also been suggested that the data call and the model could be easily modified to offer a total waste diversion picture for the municipality, addressing diversion of organics, household special waste, and waste to landfill. This information could be presented as a simplified kg/hhld or kg/capita and compared to provincial norms and best practices.

- **Regular updating of the model**

There was general agreement that the model should be reviewed on a regular basis and updated annually. Among other issues, this would allow the following functions to be evaluated or updated:

- Use of the model as a planning tool should be checked periodically to determine how the model drives programs.

- Material density should be reviewed and updated to track changes from changing material streams or collection practices.
- The key variables need to be checked to ensure that the fairness principal is being maintained.

## Material density measurements

The funding allocation is very sensitive to material density since 60% of the modeled costs are allocated based on the volume of material collected and processed. An important component of this study was to determine the typical density, as collected, of various recyclable material streams. The focus is on uncompacted material in streams as marketed.

While it may first appear that material density is a relatively straightforward calculation, there were variations in different programs. For example, the density of PET stream depends on what types of packaging are targeted and the capture rate. Collecting predominately 2-litre pop containers would yield a density of around 15 kg/m<sup>3</sup>. If other containers are added, including single serving containers, the density could go up to 20 to 23 kg/m<sup>3</sup>. If the public has been encouraged to crush the containers prior to setting them in the blue box, the density could increase to 29 kg/m<sup>3</sup>.

To account for these kinds of variations, density measurements were conducted in a number of municipalities. This allowed for a variety of circumstances. The Steering Committee, on review of the data, made recommendations on the density to be used in the model. This data should be updated periodically to account for changes in material streams, market mixes and packaging techniques.

The following is a list of basic material streams:

### Fibre

ONP mix	old newspaper, including inserts, flyers and magazines, typically also includes some household paper
Fine paper	a household version of an office paper mix, including residential fine paper, junk mail
OCC	old corrugated cardboard, flattened (broken down) but not compacted
OBB	old boxboard cartons, flattened
Aseptic	aseptic containers (tetrapak) as collected
Polycoat	gable-end cartons as collected

### Metals

Aluminum cans	aluminum cans (mainly beverage containers) as collected (may include foil and plates)
Steel cans	ferrous mix, may or may not include empty paint and aerosol containers

### Plastic

PETE	#1 small-mouth containers, often includes other PET containers
HDPE	#2 coloured or mixed

Plastic tubs	mixed tubs (mainly PP) and lids (#2, #3, #4, #5)
Plastic film	#4 low-density polyethylene film (grocery bags, wrap)
Polystyrene	#6 mix of rigid and foam polystyrene
Mixed plastics	a varied mix (i.e. #2 to #7 containers, #1 to #7 containers, less PET soft drink, etc.)

### **Glass**

Clear glass	flint glass
Coloured glass	green and amber glass

### **The following categories are more rare:**

Aluminum foil	aluminum foil and plates
HDPE natural	#2 natural (uncolored) containers
PVC	#3 PVC containers
OCC + OBB	a mix of corrugated cardboard and old boxboard
ONP + mixed	old newspaper plus mixed household paper
OTB	old phone books
Mixed paper	variable mix and ratios

### **Methodology for Determining Material Density**

Where possible, volumes were measured in carts or cages of several different sizes. The largest containers were 11 m<sup>3</sup> cages that were filled directly off the sort line. These large cages were weighed full on a truck scale just prior to baling the contents, then weighed again following the removal of the contents into the baler. Measurements were taken of the cages to determine the volume of each individual cage. A measurement from the top of the cage to the top of the material in the cage was taken just prior to baling the material to determine the complete volume of material in the cage. The large cages were used for lighter material such as polystyrene and containers.

A smaller cage with a volume of 4.92 cubic metres was also used. This smaller cage was filled from the larger cages before baling. Material was leveled in the cage and the cage and contents weighed on a floor scale that had an accuracy of 0.5 kg. This size of cage was used for containers, boxboard and OCC. Three samples of each material were weighed in this size cage.

Other samples were done using a 0.36 cubic metre cart. Heavy material such as newspaper and office paper could be handled in a cart, with the full cart weighed on a floor scale or a portable scale that has a capacity of 150 kg in 0.05-kg increments. Most other materials, with the exception of OCC and polystyrene, could be measured in these carts. Where possible, material was packed in the carts to try and replicate how the material would settle in a truck compartment. This meant OBB was put in as flattened boxes and film plastic was stuffed into the cart.

Material was either collected off the floor or sampled from larger cages. When sampled from cages, three samples were taken — from the bottom, middle, and top of the cage.

Where cart and cage measurements were taken of the same material, there was no significant difference in material density weighed in different sizes of cages or carts, with the exception of ONP.

Glass was weighed as hand-packed in carts in an unbroken state.

Newspaper mix (ONP mix) was the main material that measured significantly different depending on the type of container. Initial measurements in carts yielded a density that averaged around 200 kg/m<sup>3</sup>. If the density was measured in shipping loads of loose material, the density went up to around 280 kg/m<sup>3</sup>. It was decided to measure the density as collected in a truck compartment. 20 different samples were taken in North Simcoe, York Region, and Lanark County. The results varied considerably, with height of material being the most important variable. The fuller the compartment, the more dense the material. The Steering Committee determined that a compartment height of 1.5 m and a density of 250 kg/m<sup>3</sup> would be used as the standard density for newspaper.

### **Density Measurement Variables**

Whenever conducting a density measurement of a material, the specific circumstances or conditions around the measuring should be noted. Some of the variables that can influence the results include the following:

- *weather conditions*: rain, snow, or ice can effect the weight and increase density.
- *municipality*: a given municipality can have a different mix in the material stream compared to another municipality and this can affect density. For example, the ratio of newspaper to magazines or flyers can differ from one municipality to another.
- *materials targeted*: the material being measured may represent only a portion of that potential material stream. PET stream might be mainly 2-litre soft drink bottles or HDPE may be mainly water or milk jugs. Generally, the broader the targeted stream, the greater the density.
- *materials captured*: programs with a high participation and capture rate can have denser materials. User pay, bag limits, or a good promotion campaign can cause an increase capture of smaller and less conventional materials. This will tend to increase the material density.
- *material condition*: the public may assist in creating a denser material stream through flattening of plastic bottles and jugs, crushing aluminum beverage containers, flattening boxboard, etc.
- *handling and processing technique*: how the material is handled in the truck, dumped, sorted and stored will effect the density. In general, the more handling, the greater the “fluff” and the less the density.
- *measuring technique*: loading a cart to measure density as it would approximate collection in a truck can be as much an art as a science. Shaking the cart to aid settling and pressing material down will all affect the density.
- *time of year*: material streams can change depending on the season and the source of material. A summer measurement can vary from a winter measurement because of different makeup in the material stream. For example, there may be more single-serving PET containers during the summer months.

- *changes in production:* industry is always changing the type of packaging for products. Some of this tends to increase density (i.e. more single-serving containers), others may decrease density (i.e. thin-walling), while other changes could go either way (i.e. material substitution).

## Data from municipal material density studies

The charts on this page provide the results of material density measurements in different municipalities. A summary of this information follows.

Quinte Material Density Study													
	kg/m3												
	Average	Cages (4.92m3)						Carts (.35m3)					
		1	2	3	4	5	average	1	2	3	4	5	average
<b>Fibre</b>													
ONP	194.5						-	198.1	185.7	201.4	193.8	193.3	194.5
OCC	36.5	31.5	32.5	28.6	46.8	43.2	36.5						-
OBB	56.1	56.2	57.1	56.8			56.7	53.3	57.1	56.1			55.5
fine paper	122.9						-	89.0	134.8	117.1	122.9	150.5	122.9
polycoat	38.8	38.8					38.8						-
<b>Metal</b>													
aluminum	37.8	38.3	36.5	37.4			37.4	39.1					39.1
steel cans	99.1	105.7	98.6	100.7	97.4		100.6	96.2	96.2				96.2
<b>Plastic</b>													
PETE	27.9	27.5	28.5	28.2	28.9		28.3	25.0	28.1	28.6	28.6		27.6
HDPE	30.5	30.2	29.7	30.5	31.6		30.5						-
film	24.4						-	22.6	24.7	25.9			24.4
tubs	35.1	33.6	34.6	34.3	38.1		35.1						-
polystyrene	13.4	14.3	12.2	13.7			13.4						-
<b>Glass</b>													
clear	238.2						-	225.0	229.2	260.6	237.9		238.2
coloured	250.1						-	243.1	254.3	252.9			250.1

Note: each cart sample is an average of 3 samples done in a 90 gallon (0.35m3) cart

N Simcoe & MCS Density Study										Kingston Material Density Study							
	kg/m3										kg/m3						
	Average	1	2	3	4	5	6	average	1		2	3	4	5	6	average	
<b>Fibre</b>																	
ONP cart NS	198.2	169.4	216.4	225.8	190.6	194.2	192.8	198.2	198.2	ONP cart	193.9	190.3	228.9				204.3
ONP truck NS	204.2	232.9	195.1	201.6	127.3	264.4		204.2	204.2	ONP truck							-
ONP trailer NS	224.5	183.7	263.5	172.8	210.9	235.9	280.1	224.5	224.5	ONP trailer							-
OCC NS	286.1	301.1	282.1	275.1				286.1	286.1	OCC							-
OBB	54.4	43.5	50.2	40.2	71.0	67.0		54.4	54.4	OBB	69.1	66.4	69.7				68.4
fine paper								-	-	fine paper							-
polycoat MCS	30.6	27.9	32.1	31.8				30.6	30.6	polycoat							-
aseptic MCS	36.8	36.8						36.8	36.8	aseptic							-
<b>Metal</b>																	
aluminum NS	28.3	27.6	28.6	28.8				28.3	28.3	aluminum	24.4	24.6	25.0	25.1	25.6		25.1
steel cans NS	93.6	98.5	88.7					93.6	93.6	steel cans	73.9	79.4	86.6	84.1			81.0
<b>Plastic</b>																	
PETE NS	25.4	23.5	27.4					25.4	25.4	PETE	21.6	22.9	24.6				23.0
HDPE NS	27.1	29.8	24.4					27.1	27.1	HDPE	18.6	17.0					17.8
film								-	-	film	35.6	33.3	28.0				32.3
tubs								-	-	tubs							-
polystyrene								-	-	polystyrene							-
Comingled containers	41.1	38.9	33.7	52.1	39.3	41.5		41.1	41.1	mixed plastic	29.9	29.3	29.0				29.4
mixed plastic 3-7 MC	33.4	31.5	35.3					33.4	33.4	coloured							-
<b>Glass</b>																	
clear NS	389.0	364.7	260.5	541.8				389.0	389.0	clear							-
coloured NS	332.3	439.0	321.9	235.9				332.3	332.3	coloured							-

Toronto & Niagara Density Study								Lanark							
	kg/m3								kg/m3						
	Average	1	2	3	4	5	6		average	1	2	3	4	5	6
<b>Fibre</b>															
ONP cart TO	200.8	193.1	195.0	214.4				200.8	ONP truck	227.6	182.8	282.1	234.2	211.5	
ONP truck								-	OBB/OCC	56.2	51.2	63.6	54.7	55.4	
ONP trailer Niag	276.5	252.9	278.9	288.2	273.7	289.0		276.5							
OCC TO	30.9	25.6	26.8	40.2				30.9							
OBB TO	26.7	26.7						26.7							
fine paper TO	146.9	146.9						146.9							
polycoat NR	28.4	27.5	28.6	29.0				28.4							
aseptic NR	45.3	45.0	45.6					45.3							
<b>Metal</b>															
aluminum								-							
steel cans								-							
<b>Plastic</b>															
PETE NR	25.3	24.9	25.8					25.3							
HDPE TO	25.0	25.0						25.0							
HDPE NR	22.5	20.6	23.2	23.8				22.5							
film NR	14.8	14.9	12.1	17.4				14.8							
tubs NR	30.4	33.2	27.6					30.4							
polystyrene NR	10.2	10.6	10.6	9.3	10.3			10.2							
Comingled containers								-							
narrow neck 1-7 NR	37.8	36.7	38.9					37.8							
<b>Glass</b>															
clear								-							
coloured								-							

Quinte Truck compartment densities					
	Bancroft	Belleville	depot*	depot	average
fibres	97	100		91	96
containers	55	30	39	48	43
flint	384	312	268	323	322
coloured		235	333	303	290

\* no ONP, only boxboard @ 72.35

Summary of Material Density Measurements										
Material	ONP carts	ONP trucks	Mixed Paper	OCC	OBB	Clear Glass	Coloured Glass	Mixed Glass	Aluminum Cans	Steel Cans
New Factored Kg/Cu m		<b>250</b>	<b>135</b>	<b>45</b>	<b>62</b>	<b>200</b>	<b>200</b>	<b>300</b>	<b>30</b>	<b>91</b>
Factor		1.000	1.000	1.000	1.000	0.667	0.667	1.000	1.000	1.000
Kingston	204				68				25	81
Niagara										
Toronto	201		147	31	27					
North Simcoe	201	204		54		389	332		28	94
Muskoka										
Quinte	194		123	37	56	238	250		38	99
North Simcoe		224								
York (Markham)		291								
Lanark County		228								
Average	200	237	135	41	62	314	291		30	91
<b>Suggested</b>		<b>250</b>	<b>135</b>	<b>45</b>	<b>62</b>	<b>300</b>	<b>300</b>	<b>300</b>	<b>30</b>	<b>91</b>

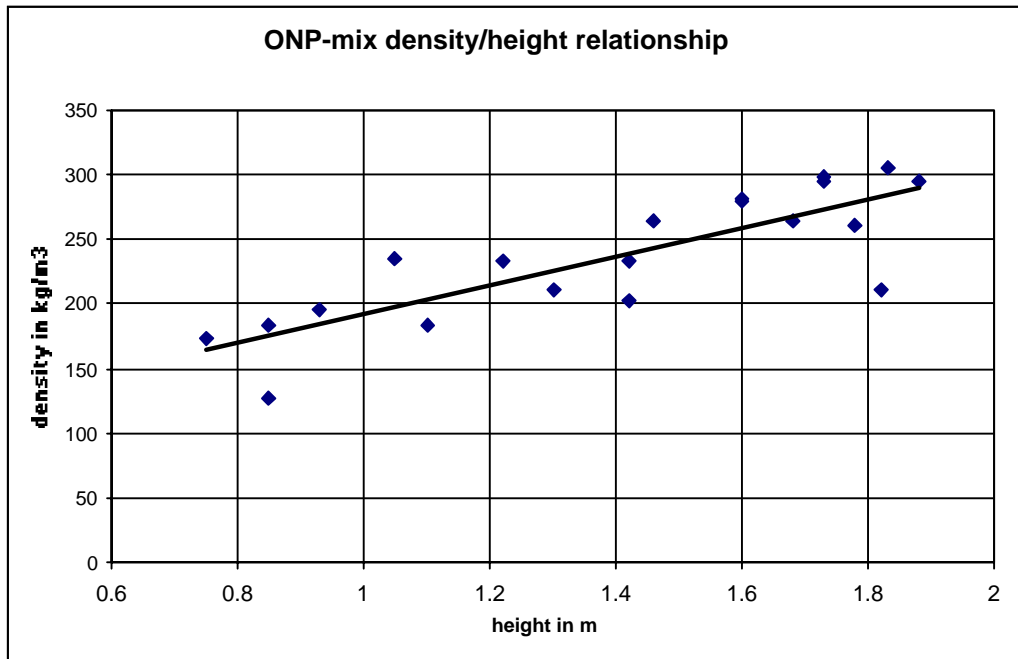
Material	OBB/OCC	PETE	HDPE Coloured	HDPE Natural	Plastic Tubs	Plastic Film	Poly-styrene	Aseptic	Poly-Coat	Mixed Plastic
New Factored Kg/Cu m	<b>56</b>	<b>25</b>	<b>25</b>	<b>25</b>	<b>33</b>	<b>28</b>	<b>8</b>	<b>45</b>	<b>33</b>	<b>51</b>
Factor	1.000	1.000	1.000	1.000	1.000	1.000	0.667	1.000	1.000	1.500
Kingston		23	18			32				29
Niagara		25	23		30	15	10	45	28	38
Toronto			25							
North Simcoe		25	27							
Muskoka								37	31	33
Lanark County	56									
Quinte		28	30		35	24	13		39	
Average	56	25	25		33	28	12	41	33	34
<b>Suggested</b>	<b>56</b>	<b>25</b>	<b>25</b>	<b>25</b>	<b>33</b>	<b>28</b>	<b>12</b>	<b>45</b>	<b>33</b>	<b>34</b>

Note: numbers in italic are not part of the average due to anomalies in measurement.

## Summary of ONP-mix density studies

The chart below summarizes ONP-mix (ONP, inserts, flyers, magazines and household paper) density measurements in 360 litre carts, truck compartments as collected, and trailer loads shipped loose to market. The graph shows the relationship between height in the truck compartment with density of material.

	kg/m <sup>3</sup>	ONP-mix Densities					
	Average	1	2	3	4	5	6
<b>Cart</b>							
Toronto	200.8	193.1	195.0	214.4			
N. Simcoe	198.2	169.4	216.4	225.8	190.6	194.2	192.8
Kingston	204.3	193.9	190.3	228.9			
AVERAGE	<b>201.1</b>						
<b>Truck</b>							
N. Simcoe	204.2	232.9	195.1	201.6	127.3	264.4	
N. Simcoe	224.5	183.7	263.5	172.8	210.9	235.9	280.1
York w hhd paper	291.2	295.7	305.9	260.9	299.1	294.3	
Lanark w hp	227.6	182.8	282.1	234.2	211.5		
AVERAGE	<b>236.9</b>						
program average	<b>244.4</b>						
truck average	<b>236.7</b>						
<b>Trailer</b>							
Niagara	276.5	252.9	278.9	288.2	273.7	289.0	
N. Simcoe	286.1	301.1	282.1	275.1			
AVERAGE	<b>281.3</b>						
<b>Mixed</b>							
Quinte fibre	96.0	97.0	100.0	91.0			
Lanark OBB/OCC	56.2	51.2	63.6	54.7	55.4		



## Summary of Results of Program Runs

The following are the results of program runs for the six municipalities. All runs are based on 1999 data.

### Quinte examples

Quinte Waste Solutions operates an expanded curbside recycling program in the Centre & South Hastings area and collects from a number of municipalities. The program collects the maximum number of materials and has high participation and capture rates since most of the households are in a user-pay garbage program. The model allocates a relatively high funding rate due to the large rural area and because there is a high capture rate of all materials.

- Quinte recycled 11,204 tonnes and would have been eligible for \$67.89 a tonne for a total of \$762,442.
- Increasing the capture rate of film plastics and polystyrene by 50% would have resulted in an increase in funding to \$70.82 a tonne for a total of \$805,628, a \$48,692 increase.
- Adding aseptic containers (assuming a 50% capture rate of 26.5 tonnes/yr) would increase funding by \$5,506.
- Reporting half of the tonnage of aluminum as IC&I material would have increased funding by \$43,397.
- Reporting half of the tonnage of OCC as IC&I material would have decreased funding by \$114,753.
- Reporting half of the tonnage of mixed paper as boxboard material increases funding by \$45,634.

### Kingston examples

Kingston collects a wide variety of materials, although the capture rate is not as high as that of Quinte. Some of the less dense materials such as film plastic and polystyrene have a very low capture rate which would account for the relatively lower funding compared with Quinte.

- Kingston recycled 10,176 tonnes and would have been eligible for \$58.09 a tonne for a total of \$591,073.
- Increasing the capture rate of steel containers and adding paint and aerosols would increase tonnage by 183 tonnes and increase WDO funding by \$12,705. There would be a breakeven point at a contractor cost of \$150 a tonne for the new material. If the direct cost to collect and process the new material exceeds \$150 per tonne for that extra material, the city would have to pay the difference. If costs are less than \$150 per tonne, the city benefits.
- Removing film plastics, tubs and polystyrene from collection would have resulted in a decrease in funding to \$52.74 a tonne for a total of \$522,684, a \$68,389 decrease. There would be a breakeven point at a contractor credit of \$370 a tonne for the new material.

- Alternatively, increasing the capture rate of film plastics, tubs and polystyrene by 100% would have resulted in an increase in funding to \$63.13 a tonne for a total of \$659,197, a \$68,123 increase. There would be a breakeven point at a contractor cost of \$305 a tonne for the new material.
- Reporting half of the tonnage of aluminum as IC&I material increases funding by \$34,261.
- Reporting half of the tonnage of OCC as IC&I material decreases funding by \$87,711.

### **Toronto examples**

The Toronto program is the largest in the province. Currently Toronto collects few of the less dense plastics and has a relatively low capture rate of the materials it does collect. This, in part, accounts for the relatively low rate of funding, although the funding level exceeded 50% of their net costs.

- Toronto recycled 136,360 tonnes and would have been eligible for \$34.76 a tonne for a total of \$4,740,508.
- Adding film plastic (at a 25% capture rate) would increase tonnage by 3,538 tonnes and increase WDO funding by \$625,281. There would be a breakeven point at a contractor cost of \$200 a tonne for the new material.
- Adding polystyrene (at a 25% capture rate) would increase tonnage by 944 tonnes and increase WDO funding by \$256,473. There would be a breakeven point at a contractor cost of \$420 a tonne for the new material.
- Adding tubs (at a 25% capture rate) would increase tonnage by 708 tonnes and increase WDO funding by \$94,159. There would be a breakeven point at a contractor cost of \$150 a tonne for the new material.

### **Simcoe examples**

Simcoe has a large rural component that brings their funding to a relatively high level despite not collecting many of the plastics.

- The County of Simcoe recycled 16,987 tonnes and would have been eligible for \$55.38 a tonne for a total of \$949,259.
- Adding film plastic, tubs, and polystyrene would increase tonnage by 1,279 tonnes and increase WDO funding by \$333,872. There would be a breakeven point at a contractor cost of \$360 a tonne for the new material.
- Adding aseptics and polycoat would increase tonnage by 271 tonnes and increase WDO funding by \$45,144. There would be a breakeven point at a contractor cost of \$260 a tonne for the new material.
- Going to a comprehensive program that targets all materials would increase tonnage by 10,844 tonnes and increase WDO funding by \$954,304. There would be a breakeven point at a contractor cost of \$250 a tonne for the new material.

### **Ottawa examples**

The new City of Ottawa increased its funding due to political amalgamation of the former region of Ottawa-Carleton. The funding is relatively high, in part due to a relatively high capture rate of a broad mix of materials.

- Ottawa recycled 56,407 tonnes and would have been eligible for \$51.14 a tonne for a total of \$2,884,702.
- Removing glass from collection would have resulted in a decrease in funding to \$49.20 a tonne for a decrease of \$478,092. There would be a breakeven point at a contractor credit of \$122 a tonne for the material not collected.

- Increasing the capture rate of boxboard and mixed household paper would increase tonnage by 8,437 tonnes and increase WDO funding by \$967,395. There would be a breakeven point at a contractor cost of \$195 a tonne for the new material.
- Increasing the capture rate of HDPE by 500 tonnes would increase WDO funding by \$63,801. There would be a breakeven point at a contractor cost of \$350 a tonne for the new material.

### Essex-Windsor examples

Essex-Windsor, although it includes a large rural component, has relatively low funding, mainly due to a small mix of materials collected. The only plastic collected is PET.

- Essex-Windsor recycled 19,667 tonnes and would have been eligible for \$37.17 a tonne for a total of \$731,001.
- Adding HDPE would increase tonnage by 583 tonnes and increase WDO funding by \$70,284. There would be a breakeven point at a contractor cost of \$360 a tonne for the new material.
- Removing coloured glass from collection would have resulted in a decrease in funding to \$36.15 a tonne for a decrease of \$54,238. There would be a breakeven point at a contractor credit of \$125 a tonne for the material not collected and processed.
- Adding film plastic and polycoat would increase tonnage by 1,312 tonnes and increase WDO funding by \$273,500. There would be a breakeven point at a contractor cost of \$250 a tonne for the new material.

### Comparing Funding Variables

The charts below compare municipal funding allocations under different scenarios.

The first chart uses the average population density and examines variations in the slope (2.0) and scale variables (20%) to see how funding would change for selected municipalities.

The second chart examines funding allocations and the effects of joint programs. The example of Kingston and Loyalist Township shows that under the weighted average system, the funding would be higher if they were separate programs rather than joining together. If the average population was used, the funding is higher if the programs are tied together. Because of this, the use of weighted population density rather than weighted averages, will encourage program cooperation.

		Average Density Variations					
45% of reported cost	1999 reported cost/tonne		base scenario (slope 1.5, scale 10%)	slope 2.0	scale 20%	slope 2.0 scale 20%	% difference from base
		<b>simcoe</b>	\$ 56.40	\$ 62.06	\$ 56.76	\$ 62.14	10%
\$ 27.20	\$ 60.45	<b>toronto</b>	\$ 33.14	\$ 26.02	\$ 31.60	\$ 24.99	-25%
\$ 52.33	\$ 116.28	<b>quinte</b>	\$ 67.31	\$ 73.28	\$ 67.08	\$ 72.85	8%
		<b>kingston</b>	\$ 55.74	\$ 58.64	\$ 56.08	\$ 58.81	6%
		<b>essex</b>	\$ 42.18	\$ 44.98	\$ 42.95	\$ 45.53	8%
		<b>ottawa</b>	\$ 48.17	\$ 48.81	\$ 47.34	\$ 48.08	0%
\$ 134.55	\$ 299.00	<b>nora</b>	\$ 62.56	\$ 67.80	\$ 62.22	\$ 67.30	8%

<b>Effects of a Joint Program</b>				
	<b>population density</b>	<b>tonnes recycled</b>	<b>WDO funding /tonne</b>	<b>total 1999 funding</b>
Kingston + Loyalist (weighted average)	2.28	10,176	\$ 58.09	\$ 591,073
Kingston + Loyalist (average density)	1.61	10,176	\$ 59.52	\$ 605,705
Kingston alone	2.52	9,012	\$ 57.66	\$ 519,591
Loyalist alone	0.43	1,164	\$ 63.68	\$ 74,133
Total		10,176	\$ 58.35	\$ 593,724

This chart is a sample from a summary sheet that examines program options and funding implications for the City of Kingston. The numbers used for the costs and savings are for illustrative purposes only.



These charts examine funding and revenue streams by material using different weight/volume allocations for the City of Kingston.

