Disposal-based Commercial and Industrial Waste Characterisation Survey

Sydney Metropolitan Area

May - July 2003

waste

Department of
Environment and Conservation (NSW)

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Acknowledgements

The data collection for this project was conducted by

- Waste Audit and Consultancy Services
- GHD Pty Ltd
- APrince Consulting
- Nolan ITU

The Department of the Environment and Conservation would like to thank the participating waste facilities for their participation and co-operation.

Disclaimer

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EXECUTIVE SUMMARY

Between May and July 2003, the Department of Environment and Conservation (NSW) (formerly Resource NSW) undertook an audit of commercial and industrial (C&I) waste being disposed of to landfill in the Sydney Metropolitan Area (SMA). The study consisted of a visual assessment of over 7,000 C&I waste loads (about 51,000 m^3 or 14,000 tonnes) at 16 waste disposal facilities. Table 1 below summarises the composition by volume and weight.

Table 1: Composition of commercial waste being disposed to landfill in the SMA

Categories†	Volume %	Weight %
Paper	4.7%	6%
Cardboard	16.2%	10%
Food	3.4%	4%
Garden	4.5%	3%
Wood products	7.0%	7%
Solid wood	10.0%	8%
Textiles	5.5%	4%
Rubber	0.3%	<1%
Glass	0.7%	1%
Plastic	14.6%	9%
Metal	3.6%	4%
C&D/inert	5.2%	14%
Hazardous	0.3%	<1%
Garbage bags of rubbish	19.1%	20%
Other	4.9%	10%

† *Categories are based on the Australian Waste Database Material Codes*

The following conclusions can be drawn about the composition of general commercial waste being disposed to landfill in the SMA;

- The largest single component was found to be bagged waste;
- A large amount of cardboard is being disposed of to landfill from commercial sources;
- A large proportion of the commercial waste stream is solid timber;
- Relatively little free paper or food organics were found in the commercial waste;
- Plastic was a major category by volume and was made up of a wide range of polymers in a plethora of forms and products. The major component is plastic film in the form of shrink-wrap and other plastic sheets.
- Only small amounts of materials in the 'hazardous', 'computers/office equipment', 'rubber' and 'glass' categories were observed.

The majority of the vehicles that deliver C&I waste to disposal facilities were either small or medium-sized. However, large vehicles, particularly compactor trucks, delivered most of the waste (by volume and weight).

The Sydney CBD and lower North Shore areas appeared to generate the most C&I waste, followed by the Eastern Suburbs and near Inner West.

The greatest potential for resource recovery appears to be by increased diversion of cardboard, either through disposal-based recovery or increased source-separation using a separate collection service. Wood, garden organics and plastics are also present in large quantities, which should be economically viable to segregate if market conditions for the recovered materials are suitable.

1. INTRODUCTION

Between May and July 2003, the Department of Environment and Conservation (NSW) (formerly Resource NSW) undertook an audit of commercial and industrial (C&I) waste being disposed to landfill in the Sydney Metropolitan Area (SMA). The aim of the project was to obtain the composition of C&I waste being disposed to landfill in Sydney in order to develop programs and projects to reduce C&I waste being disposed to landfill. The Department of Environment and Conservation (NSW) undertook the project management and data analysis.

This report presents the overall results of the audit. Results for individual waste facilities have been given only to the respective facilities, as per confidentiality clauses in the agreements with the participating facilities. The report also outlines the methodology employed in conducting the data collection and analysis.

1.1 Scope of the study

The study was a disposal-based audit that targeted C&I waste being delivered to selected waste facilities in the SMA receiving large quantities of C&I waste. The audit involved visual auditing and some physical sorting of C&I waste. The opportunity was also used to visually assess the Construction and Demolition (C&D) waste that arrived at the waste facilities.

A total of 16 waste facilities participated in the study. These were a mixture of Class 1 and Class 2 solid waste landfills and transfer stations. The waste audit data collection was outsourced to a number of waste audit contractors. Composition was assessed for direct haul loads only. No transfer vehicles were included in the assessments, avoiding the possibility of "double counting" of waste.

1.2 Methodology

The methodology used in this project was based on the NSW EPA's 1997 Draft Waste Data Collection Methodologies (EOA, 1997), and methodologies used by Waste Audit and Consultancy Services for a disposal-based waste audit in South Australia in 1999 (WACS, 2000). The methodology was tested in a pilot waste audit at one facility during December 2002. The outcomes and experience from the pilot audit was used to refine the methodology, and to develop detailed instructions for the waste audit contractors conducting the data collection for the large waste audit between May and July 2003.

1.2.1 Pre-audit preparation

Securing co-operation of sites. Participation in the waste audit was voluntary for waste facilities. A number of facility owners were approached and agreement was generally given after concerns about safety and confidentiality were addressed.

Preparation of briefing documents: As the project had a large number of stakeholders, project outlines were developed for each facility owner and the Department's staff to clearly state the aim of the project; methodology; each party's obligations; and the measures to be taken to maintain data confidentiality.

Finalisation of methodology: The methodology was specified in detail to ensure that all waste audit contractors collected data in a consistent manner. The methodology was tested in a pilot waste audit at one facility, and refined for the larger audit.

Preparation of data recording sheets: Three types of data recording sheets were used, namely, a gatehouse sheet, a visual assessment sheet and a physical sorting sheet. These were all numbered for quality assurance. A copy of the description of each material category given to the waste audit contractors is attached in Appendix A. Copies of the data recording sheets are presented in Appendix B. Material categories were based on those specified in the EPA's 1997

Draft Waste Data Collection Methodologies and in the Australian Waste Database (AWD). Sub-categories of material codes used in these documents were used for this audit, based on reprocessing capacity and/or ease of visual identification.

Tender process and engagement of contractors: As the project required waste audits to be conducted at a large number of sites in a relatively short period of time, a total of four waste audit companies were engaged, with each company conducting waste audits at between two and seven sites.

1.2.2 Data collection

The waste audit was conducted from May to July 2003. The majority of the waste audits were conducted in May. However, a number were postponed until June and July due to rain. Data collection was primarily by visual assessment. However, at some sites, a small number of loads were physically sorted into the separate material categories. The data collection methodology specified to the contractors is provided in Appendix A.

Figure 1 Visual assessment of waste composition

The visual assessment data collection methodology can be summarised as follows:

- Between two and four auditors stationed at the tipping area visually assessed all C&I and C&D loads. One audit team member was also stationed in the gatehouse.
- When a commercial vehicle stopped at the weighbridge, the driver was asked for details of the suburb and businesses from which the waste was collected. This information and the vehicle registration number were recorded.
- The visual auditors at the tipping area were informed via two-way radio that a C&I or C&D vehicle is approaching. The registration number was relayed and recorded by the visual audit team.
- The compaction level and waste composition was then recorded on the data sheet for the specific vehicle as identified by its registration number.

For sites where a physical audit was also conducted, an area was then set aside for the physical sorting. Vehicles to be physically audited were selected by the audit team member in the gatehouse. The registration was recorded at both the gatehouse and by the sorting team, having been conveyed by two-way radio. Drivers were requested to discharge their load in the sorting area. The load was then hand-sorted and classified across a range of categories (depending on the material and its amount in the load) into skip bins and mobile garbage bins (MGB). Each material category was then weighed and its volume visually assessed.

In analysing the data, the registration number was also used to obtain the net weight of each vehicle from the electronic weighbridge records and match this to its assessed composition. This allowed the estimation of material category densities, and the calculation of an overall waste composition by weight.

Figure 2 Physical sorting of waste

1.2.3 Data analysis

(a) Composition by volume

In the visual assessment of each load, the waste auditor recorded a total "observed volume" of the waste in the load, and an approximate breakdown by volume of the composition, as per the visual assessment data-recording sheet in Appendix B. For example, a load could have been visually assessed to have a total volume of about $20m^3$, consisting of 90% (by volume) dry cardboard, and 10% plastic film. The composition by volume was then calculated by,

1. multiplying the "observed volume" of the load by the composition estimate for each category for that load to obtain an estimate of the volume of each material category in each load;

   e.g., dry cardboard = $20m^3 * 90\% = 18m^3$

   plastic film = $20m^3 * 10\% = 2m^3$

2. totalling the volume of each category for all loads recorded over the audit period; and

3. calculating the percentage by volume of each category by dividing the total volume of that category by the total volume of waste.

Table 2 shows an example of calculations performed to estimate volume composition from the visual assessment data collected during the waste audit.

Table 2 Example calculation of composition by volume from visual assessment data

Load No.	Observed volume (m^3)	Office paper		Paper other		Dry Cardboard		……	TOTAL	
		vol %	Category volume (m^3)	vol %	Category volume (m^3)	vol %	Category volume (m^3)		vol %	Total volume (m^3)
1	20	5	1	10	2		0	…..	100	20
2	19		0		0	35	6.65	…..	100	19
3	5	80	4		0		0	…..	100	5
4	1		0		0	50	0.5	…..	100	1
5	2		0	10	0.2		0	…..	100	2
. . . . .	. . . . .	. . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
Total	3823		25		98		624			3823
Vol%			1%		3%		16%			

(b) Composition by weight

The composition by volume is converted to composition by weight by;

1. multiplying the volume of material category in each load by the density of the material category to get the weight of the material category in each load;

$$weight = volume * density$$

2. totalling the weight of each category for all loads recorded over the audit period; and,

3. calculating the percentage by weight of each category by dividing the total weight of that category by the total weight of waste.

For example, assuming all the loads in Table 2 above are compacted, the calculations would be as per Table 3 below.

Table 3 Example calculation of composition by weight from composition by volume data

Material category		Office paper		Paper other		Dry Cardboard		……	TOTALs	
Category density (t/m^3)		0.38		0.47		0.17		……		
Load	Observed volume (m^3)	Category volume (m^3)	Category weight (t)	Category volume (m^3)	Category weight (t)	Category volume (m^3)	Category weight (t)	……	Total volume (m^3)	Total weight (t)
1	20	1	0.38	2	0.94	0	0	……	20	4.25
2	19	0	0	0	0	6.65	1.1305	……	19	3.96
3	5	4	1.52	0	0	0	0	……	5	2.3
4	1	0	0	0	0	0.5	0.085	……	1	0.2
5	2	0	0	0.2	0.094	0	0	……	2	0.35
. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
Total	3823	25	11.25	98	29.4	624	93.6	……	3823	1560
Wt%			1%		2%		6%	……		

(c) Calculation of density of material categories

The densities used to convert the composition from volume (%) to weight (%) were calculated using three different methods:

1) Single material loads;
2) Method of least squares; and
3) Averages of data obtained from physical sorting.

The densities used to calculate the composition by weight are presented in Table 4 and Table 5 below.

(i) Single material loads

A number of loads were recorded where 100% of the load was classified as one material category. These were generally small, loose loads, although some larger, compacted loads were also recorded for some material categories. By plotting the load volume against the net load weight (recorded at the weighbridge), the density of the category can be estimated by fitting a line to the data. The slope of the line represents the density of the material. In Figure 3 below, the density of dry cardboard was estimated to be about 78 kg/m^3. The R^2 (correlation coefficient) of 0.89 shows that the line is a good fit, indicating that the slope of the graph is a reasonable estimate of the density of this material category.

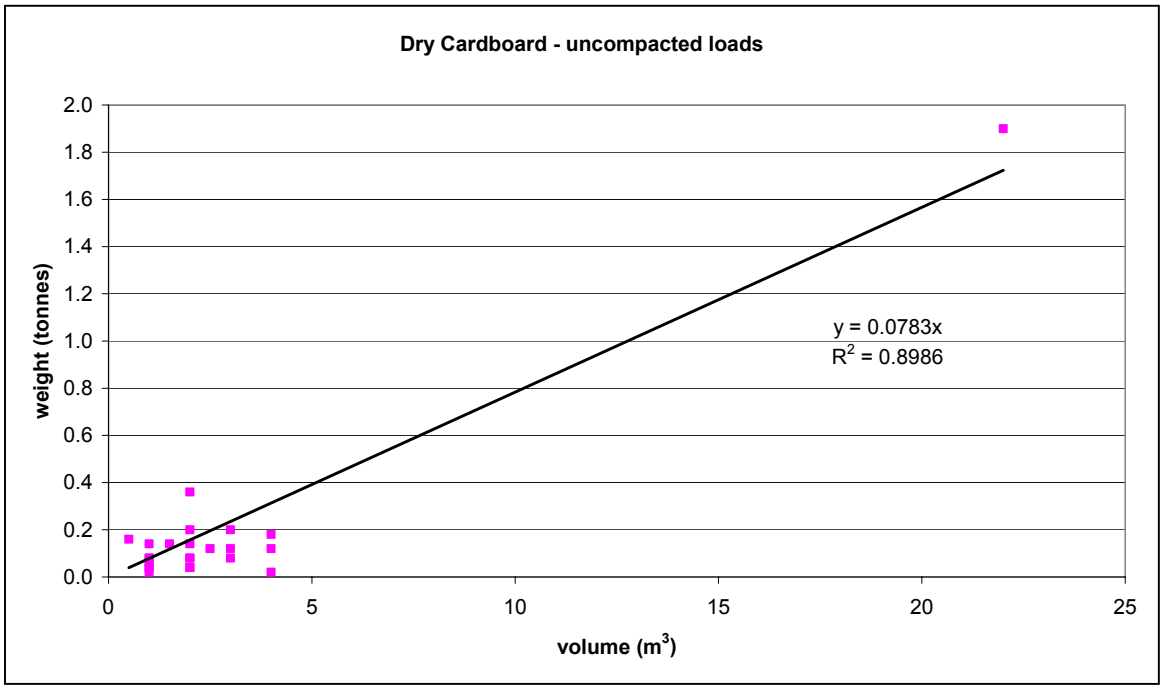

Figure 3 Density calculations for dry cardboard using single material loads

Table 4 lists a number of densities calculated using this method.

Table 4 Density of categories in single material loads

Material Category	Compaction Level	Density (t/m^3)	Correlation coefficient (R^2)
Bricks	All	1.3	0.826
Asbestos (bagged)	Uncompacted	0.34	0.927
Wood Furniture	Medium	0.245	0.975
Dry cardboard	Uncompacted	0.079	0.894
Plasterboard	All	0.286	0.80
Carpet	Medium	0.11	0.64
Carpet	Uncompacted	0.16	0.55

Figure 4 below highlights the problems with using visual assessment data for estimating densities, especially for smaller loads. Auditors round to the nearest m^3, or 0.5m^3. In addition, there can be variation between auditors, leading to either underestimation or overestimation in some cases. These errors are less significant in larger loads but can affect density estimates when most of the single material loads are small.

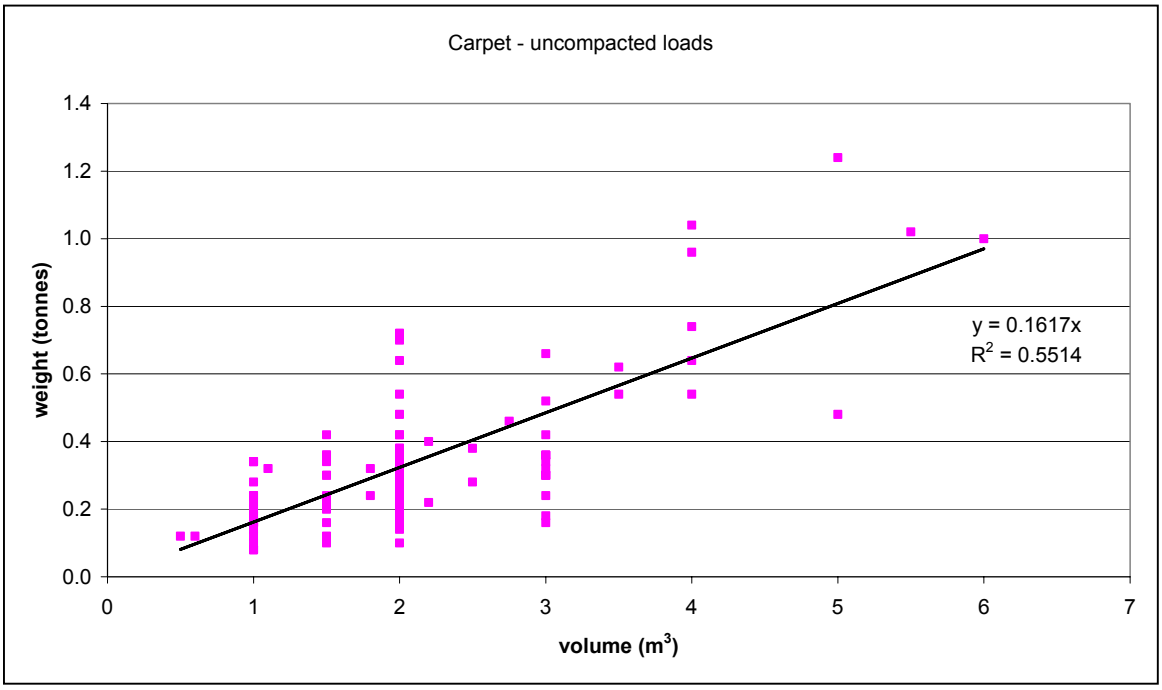

Figure 4 Density calculations for carpet using single material loads

(ii) Method of least squares

The method of least squares is a multivariate linear model fitting technique. In this case, the "best fit" densities are calculated using the estimates of volumes by category in each load and the net weighbridge weight of each load. In the classic matrix calculation:

$$Ax = b$$

The volumes of each material category in each load forms the "A" matrix, while the net weighbridge weight of the load is the "b" vector. The "x" vector is a vector of the densities of each of the material categories. Therefore, solving for "x" gives a list of densities by category.

Figure 5 demonstrates the concept of using matrices to estimate the densities for the material categories in mixed loads.

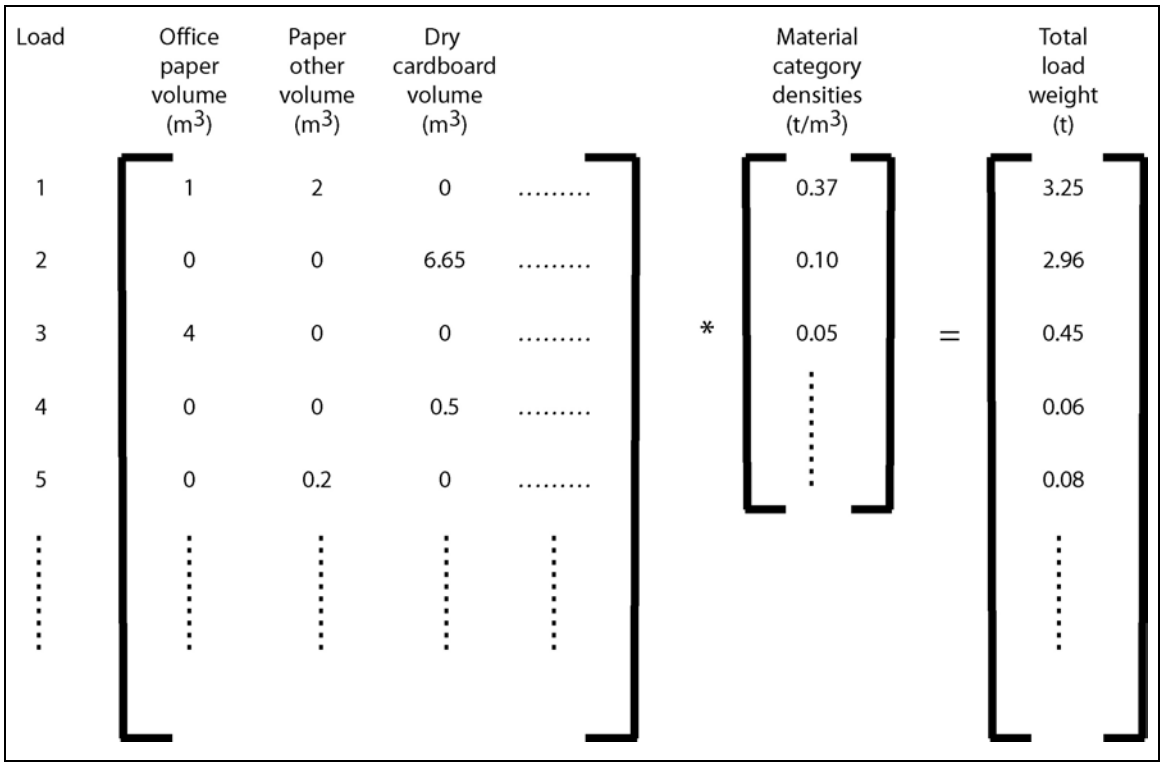

Figure 5 Matrix configuration for calculating densities and composition by weight

In this instance, a technique called "singular value decomposition" was used to solve the equation and calculate the densities. A short computer programme written in C++ performed the calculations. The code to perform the singular value decomposition was derived from "Numerical Recipes in C++" (Press, 2002).

The advantages of this method of estimating densities are as follows:

- It uses data from all the loads, and not just a small number of single-material loads.
- It reflects the "as presented" densities, i.e., in mixed loads, and also compacted loads where applicable.

Table 5 Density of categories in <u>mixed</u> loads, calculated from method of least squares

	Density (tonnes / m^3)		
Category	**Low compaction/uncompacted**	**Medium**	**Compacted**
Office Paper	0.37	0.38	0.38
Paper Other	0.1	0.25	0.47
Dry Cardboard	0.05	0.1	0.17
Wet Cardboard	0.5	0.5	0.5
Food/kitchen	0.33	0.33	0.33
Vegetation/Garden	0.15	0.23	0.22
Wood-Furniture	0.17	0.16	0.4
Wood-MDF	0.25	0.2	0.3
Wood Solid Untreated	0.12	0.16	0.36
Wood Solid Treated	0.18	0.22	0.26

	Density (tonnes / m^3)		
Category	**Low compaction/uncompacted**	**Medium**	**Compacted**
Textiles-Carpet	0.15	0.1	0.35
Textiles-Cloth	0.13	0.12	0.49
Textiles-Cloth Furniture	0.09	0.1	0.45
Textiles/Leather Other	0.07	0.07	0.24
Rubber-Tyres	0.2	0.2	0.2
Rubber Other	0.26	0.26	0.26
Glass Containers	0.28	0.28	0.28
Glass Plate	0.36	0.36	0.36
Plastic Containers	0.08	0.16	0.18
Plastic Film	0.07	0.12	0.2
Polystyrene Foam	0.03	0.03	0.06
Plastic Other	0.17	0.17	0.36
Ferrous	0.28	0.28	0.29
Metals Non-ferrous	0.25	0.45	0.44
Concrete/Cement	0.74	0.76	0.76
Bricks	0.59	0.32	0.32
Tiles	0.47	0.55	0.64
Plasterboard	0.32	0.21	0.2
Soil	0.93	0.9	0.8
Asphalt	0.68	0.68	0.68
Garbage bags of rubbish	0.23	0.29	0.3
Computers	0.15	0.05	0.05

It should be noted that these densities are calculated on the visually estimated volumes and volume composition as observed by the waste auditors, and represent the "best fit" for the data collected in this study. Caution should be exercised in using these density figures, as volume estimates will vary between auditors.

(iii) Averaging of physical sorting data

A number of loads were physically sorted into the various material categories. The material within each category was then weighed, and the volume visually estimated. The density can then be calculated by dividing the weight by volume. This method is useful as a check or where densities are unable to be estimated using other methods. However, the inaccuracies in the measurement of both weight and volume, the small number of loads represented and the distortion of the compaction due to sorting make this method of estimating density unreliable, especially for compactable materials.

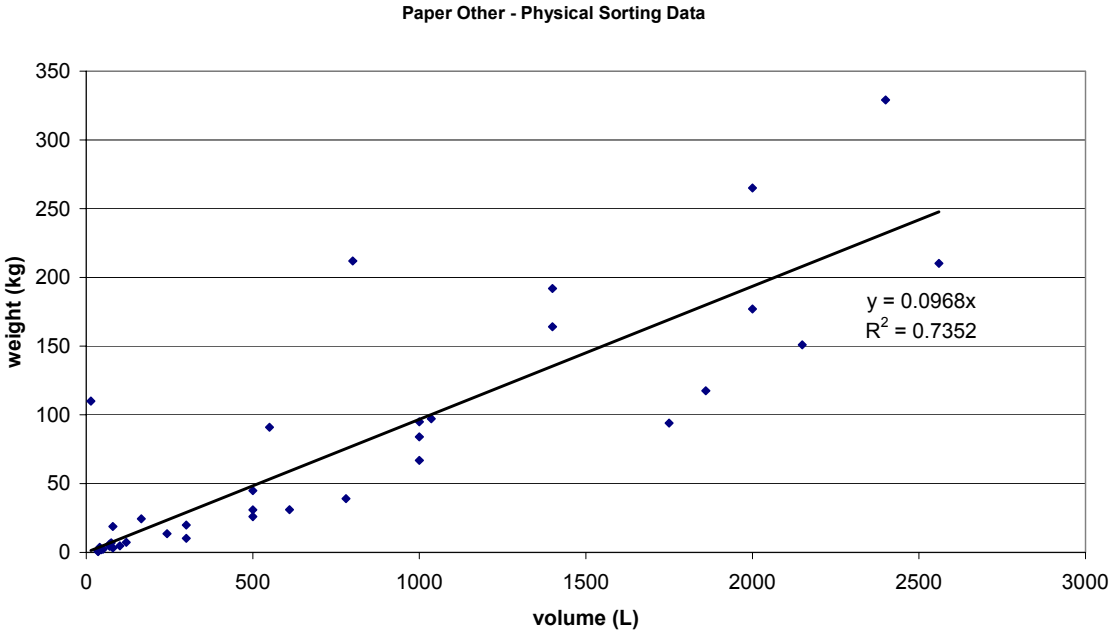

Figure 6 Use of physical sorting data to obtain density for "Paper Other" category

(d) Customer profiles

An analysis of the type of customers by number and by volumes of waste was conducted. Each load was classified as "small", "medium" or "large" according to the following criteria:

- Small – less than 2 m^3 or less than 1 tonne or a car or ute;
- Medium – between 2 m^3 and 10 m^3 or between 1 tonne and 2 tonnes or a small truck;
- Large – more than 10 m^3 or more than 2 tonnes.

(e) Geographical mapping of waste generation

The waste generation maps are based on information gathered from the vehicle drivers at the gatehouse about which suburb the waste had come from. The information is presented as numbers of vehicles by suburb, as well as volume of waste by suburb. The information is presented graphically, using the MapInfo mapping software program.

(f) Single material loads

The volume and weight of certain material categories arriving in loads that were 90% or more of one type of material were estimated. As for the composition by volume in each category, the volume for each material category of each load was calculated by multiplying the percentage in the load by observed volume of the total load. These figures were then added to give total volume of material delivered during the audit period in "single-material loads". Summing the net weighbridge weights for those loads approximated the total weight of the material.

1.2.4 Reporting and dissemination of results

Each facility owner was provided with preliminary results showing composition by volume for each facility as soon as practicable after the audit. This was followed by a more detailed report.

The overall waste composition for Sydney was calculated by aggregating data collected during the waste audit from all sites. A preliminary analysis was conducted to calculate composition by weight and by volume of C&I waste going to landfill. These results were presented at a meeting of the Waste Management Association Australia (WMAA) on 14 October 2003. The preliminary results were also summarised into an information sheet, which is available on the Internet website of the Department of Environment and Conservation (NSW).

2. RESULTS

2.1 Composition of C&I waste

About 51,000 m^3 or 14,000 tonnes of C&I waste was audited, the composition of which is shown in Table 6, Figure 7 (by volume) and Figure 8 (by weight).

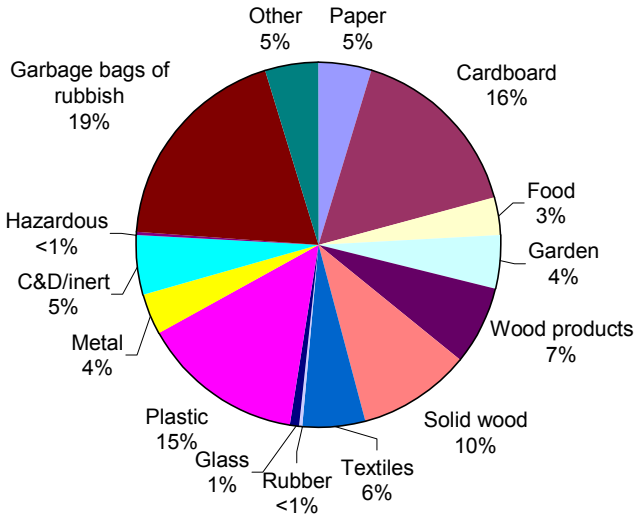

Figure 7 Composition by volume of commercial waste to landfill in the SMA

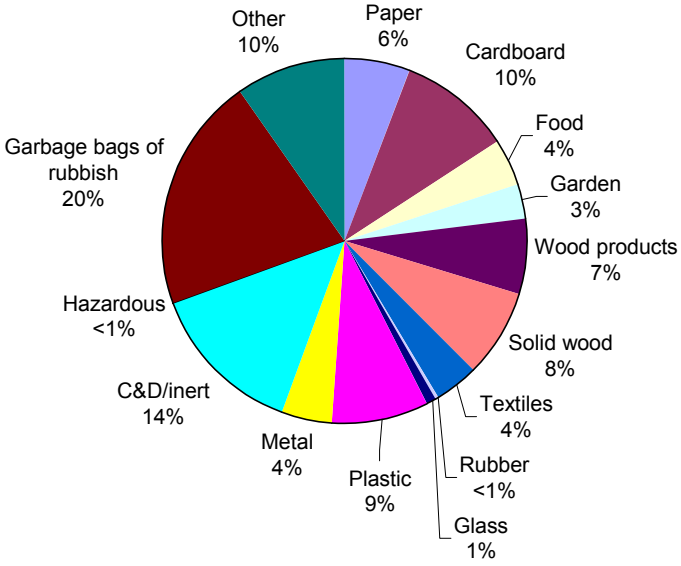

Figure 8 Composition by weight of commercial waste to landfill in the SMA

The largest component of the C&I waste stream was garbage bags of rubbish, followed closely by cardboard. Timber, wood products and plastics also make up large proportions of the C&I waste stream. Wastes in the "Other" category mainly consisted of specialist waste types from manufacturing processes or items highly composite in nature.

Table 6: Commercial waste composition in the SMA

Category	Volume %	Weight %
Office Paper	1.1%	2%
Paper Other	3.5%	4%
Dry Cardboard	14.1%	6%
Wet Cardboard	2.1%	4%
Food/kitchen	3.4%	4%
Vegetation/Garden	4.5%	3%
Wood-Furniture	2.8%	2%
Wood-MDF	4.2%	4%
Wood Solid Untreated	7.0%	5%
Wood Solid Treated	3.0%	2%
Textiles-Carpet	2.8%	2%
Textiles-Cloth	1.3%	1%
Textiles-Cloth Furniture	1.1%	1%
Textiles/Leather Other	0.3%	<1%
Rubber-Tyres	0.2%	<1%
Rubber Other	0.1%	<1%
Glass Containers	0.5%	<1%
Glass Plate	0.2%	<1%
Plastic Containers	1.1%	1%
Plastic Film	6.9%	4%
Polystyrene Foam	2.5%	<1%
Plastic Other	4.1%	4%
Ferrous	2.9%	3%
Metals Non-ferrous	0.7%	1%
Concrete/Cement	0.7%	2%
Bricks	0.6%	1%
Tiles	0.3%	1%
Plasterboard	1.5%	2%
Soil	2.1%	8%
Asphalt	<0.01%	<1%
Hazardous / Special	0.3%	<1%
Garbage bags of rubbish	19.1%	21%
Computers	0.5%	<1%
Other	4.4%	10%

2.2 Comparison of putrescible and non-putrescible waste facilities

An overall estimate was made of the composition of waste being disposed to putrescible and non-putrescible waste facilities. The results are presented in Figure 9 and Figure 10 below.

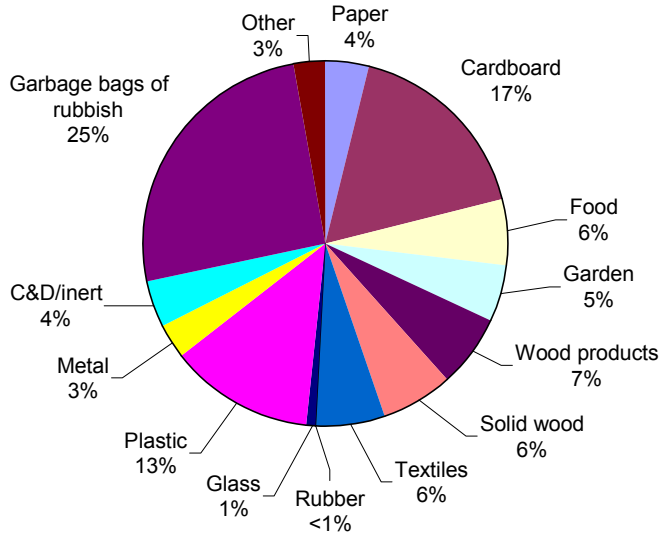

Figure 9 Composition by volume of commercial waste delivered to participating <u>putrescible</u> waste facilities during the waste audit period

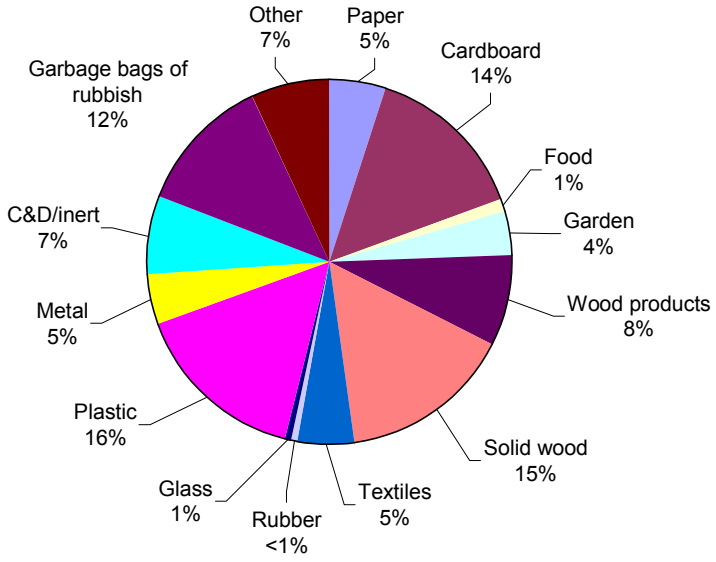

Figure 10 Composition by volume of commercial waste delivered to participating <u>non-putrescible</u> waste facilities during the waste audit period

2.3 Composition of observed C&D loads

A number of small loads of C&D waste were recorded during the waste audit. For those loads that were clearly C&D, the overall composition is presented in Figure 11 below. The total amount of C&D waste delivered to the participating facilities (a mixture of Class 1 & Class 2 waste disposal facilities) was about 2,600 m^3.

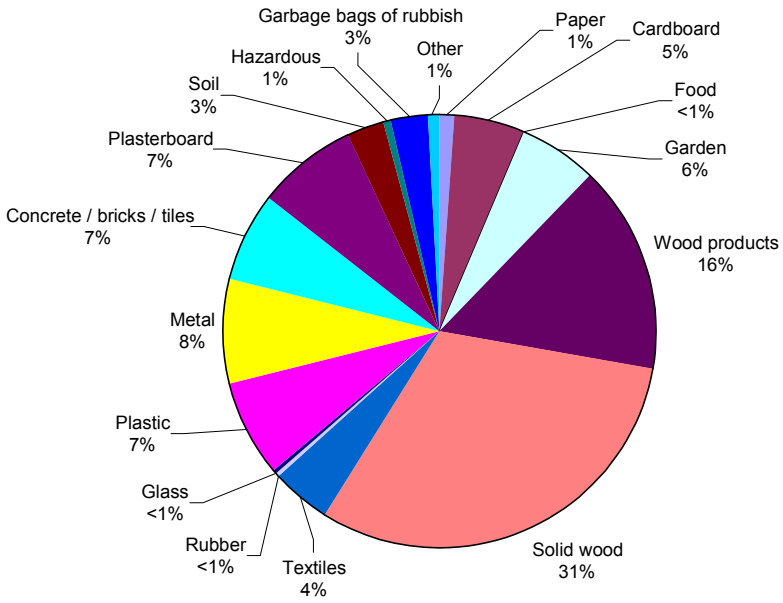

Figure 11 Composition by volume of observed C&D loads

2.4 Geographical sources of commercial waste

Figure 12 and Figure 13 show the suburb from where the waste was collected for each facility. While catchment information was not obtained for all facilities that participated in the waste audit, the information gathered does present useful insights into peak waste generation locations. Most notable is the concentration of waste generation in the Sydney CBD and surrounding areas, such as the lower North Shore and the Eastern Suburbs.

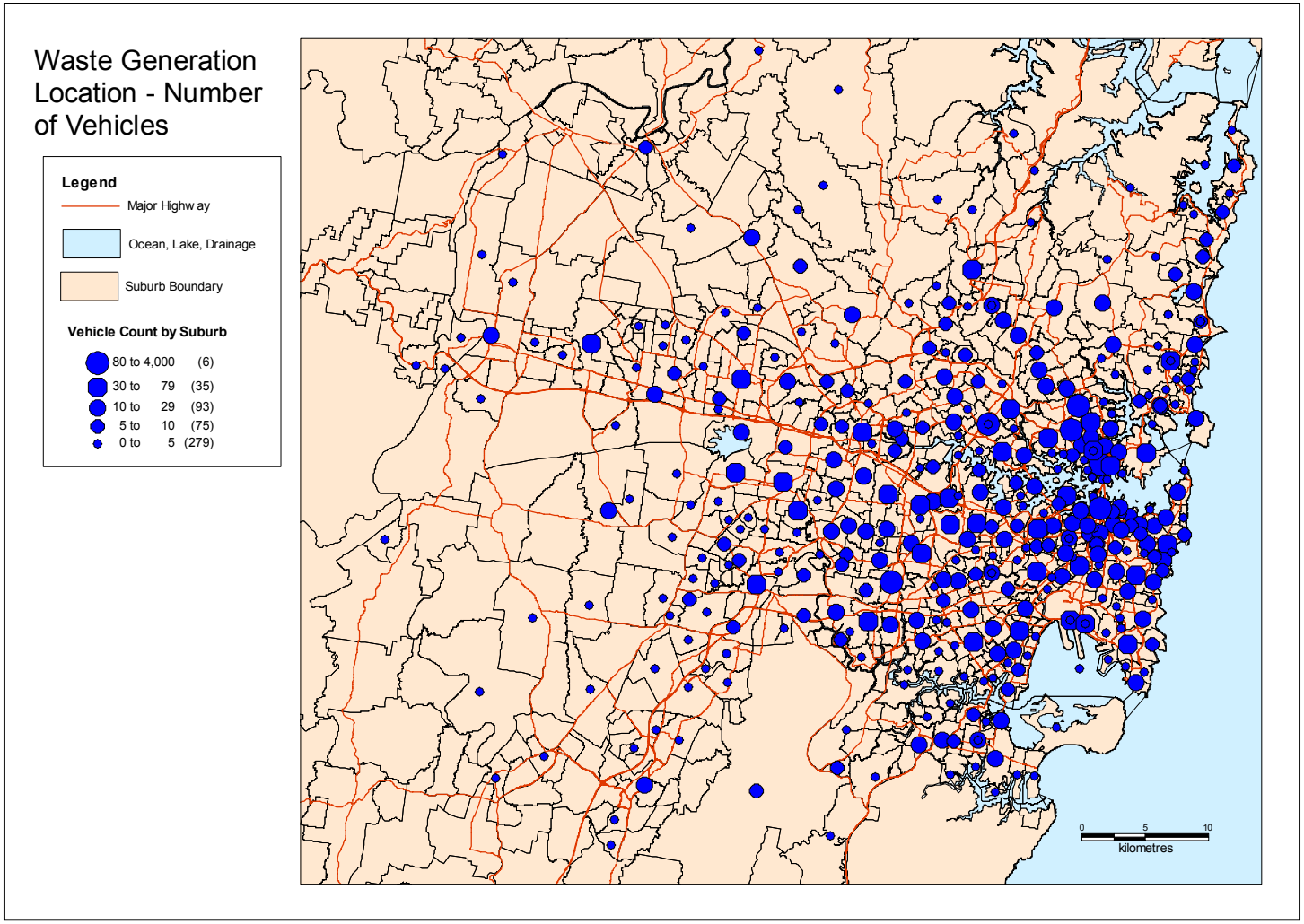

Figure 12 Map of sources of commercial waste – number of vehicles from each Suburb

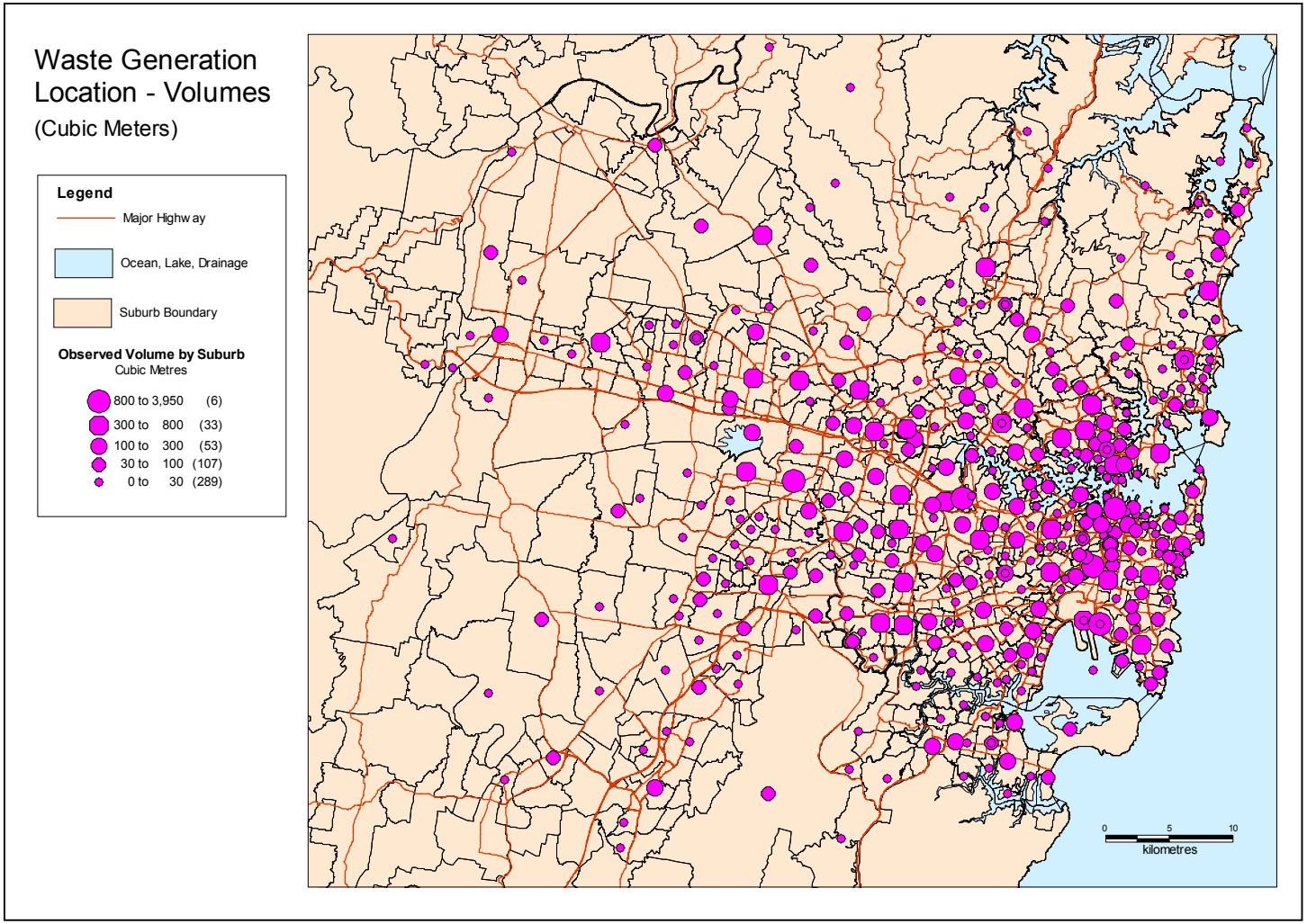

Figure 13 Map of sources of commercial waste – estimated volumes of waste by suburb

2.5 Commercial load profiles

Table 7 shows that although most of the vehicles delivering C&I or C&D waste to Class 1 and Class 2 facilities are small to medium in size, large vehicles account for delivery of nearly two-thirds of the volume of commercial waste that was audited.

Table 7 Analysis of size of commercial loads (both C&I and C&D) observed at all facilities during the waste audit period

Vehicle size	Number of vehicles	Volume of waste (m^3)
Large vehicles	1,938	39,876
Medium vehicles	4,028	14,509
Small vehicles	771	771
Unknown size	456	NA

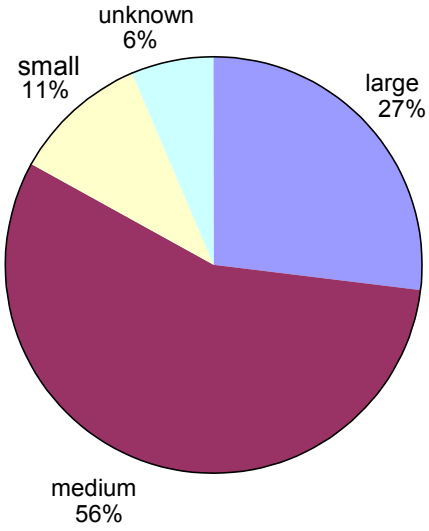

Figure 15 Percentage breakdown of commercial loads numbers by size for all facilities

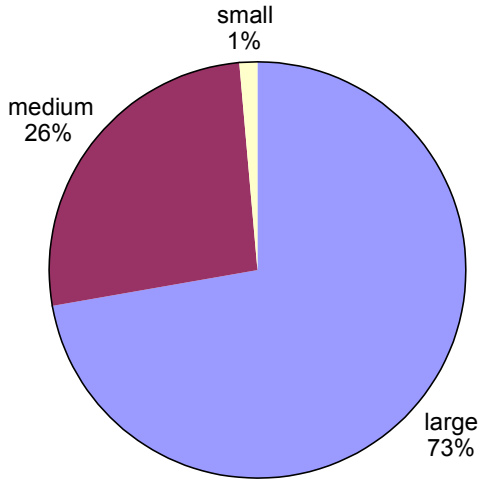

Figure 14 Percentage breakdown of commercial waste volume by vehicle size for all facilities

2.6 Single material loads

Single material loads could present an opportunity for easy recovery of recyclable material. Analysis of loads containing only one type of material indicates whether operational changes to capture this material would yield significant amounts of recyclable material.

The figures in Table 8 are conducted over the entire waste audit. The waste audits at most sites were for 4 days. Therefore, Table 8 shows the number and volume of single loads across all facilities that could be expected in a four-day period.

Table 8 Summary of single material loads observed during the audit

Material category	number of loads with ≥ 90 vol% material	Approximate volume of material in loads with ≥ 90 vol% material (m^3)
Office Paper	3	8
Paper Other	7	51
Dry Cardboard	79	464
Wet Cardboard	6	60
Food/kitchen	13	52
Vegetation/Garden	178	661
Wood-Furniture	58	244
Wood-MDF	50	127
Wood Solid Untreated	94	715
Wood Solid Treated	83	369
Textiles-Carpet	245	687
Textiles-Cloth	16	97
Textiles-Cloth Furniture	26	121
Textiles/Leather Other	3	49
Rubber-Tyres	2	32
Rubber Other	0	0
Glass Containers	0	0
Glass Plate	0	0
Plastic Containers	2	19
Plastic Film	16	129
Polystyrene Foam	7	24
Plastic Other	29	164
Ferrous	38	100
Metals Non-ferrous	1	20
Concrete/Cement	12	24
Bricks	10	27
Tiles	12	20
Plasterboard	36	176
Soil	69	267
Asphalt	2	3
Hazardous / Special	11	96
Garbage bags of rubbish	147	972
Computers	12	24
Other	58	1603
TOTAL	**1325**	**7406**

3. DISCUSSION

3.1 Issues affecting results of waste audit

At each facility, there were site-specific logistical issues that could potentially affect the quality and quantity of data collected. The main issues during the waste audit are as follows:

- About half of the waste audits were conducted during heavy rain. A number of sites that had originally agreed to participate in the project could not be included due to the weather. In some cases, substitute waste facilities were found, and in other cases the audit for the site was postponed. The rain may have deterred a number of self-haul customers, and most likely reduced the amount of C&D loads observed. However, it is unlikely that the bulk of commercial waste was not collected during the period due to adverse weather conditions. The greatest impact of the rain would have been on where the waste was delivered (transfer stations are favoured over landfills during wet weather) and the amount of liquid in the waste. Some loads during the first week of the audit contained up to 5 vol% liquid. This may have an effect on the category density calculations.

- A large number of different people were employed to conduct the visual assessments. There appears to be a variation between the waste audit contractors' abilities to consistently and uniformly estimate volumes using visual assessment techniques. While this is less than ideal, it was anticipated in the study design. Hence, the project was designed to maximise the number of "samples", which would ameliorate the overall effect of the errors on individual load observations.

- Although waste audit contractors were instructed to record compositions for all C&I and C&D vehicles presenting at the waste facilities during the audit period, a small number of vehicles were missed. This occurred for a number of reasons, including, safety concerns, high number of vehicles during busy times, vehicles declaring themselves as a recycling load at the gatehouse then disposing into the pit/tip face. The overall percentage of vehicles missed was very low, and is unlikely to affect the overall results.

- A greater concern is the number of loads where the waste audit contractor either failed to record the load's "observed volume" or the total sum of the volume percentages recorded for a load did not add to 100. In both these cases, the information recorded cannot be used. For most sites, the amount of data that had to be discarded was 2% to 3%, which is unlikely to have an affect on the overall waste composition. However, for a few sites the amount of data that had to be discarded was up to 11%, which has a high potential to affect the accuracy of the composition estimated for that facility, if not for the SMA as a whole.

3.2 Potential areas for resource recovery

The materials with the most obvious potential for increased recovery are:

- **Cardboard**: There is a strong domestic and export market for used paper and cardboard. The quantity of these materials recovered could be greatly increased without impacting on the stability of the market.

- **Metal**: The market for scrap metal is extremely strong. Therefore, there is a surprising amount of metal still being disposed to landfill. The reason for this seems to be that the metal arrives in mixed loads, and is therefore more difficult to separate. However, given the value of this material, there appears to be some further potential for increased recovery.

- **Green waste**: While the market for recycled organics products is not as strong for cardboard and metal, most of the sites that participated in the study already had facilities for accepting separated green waste loads. As most of the green waste from the C&I sector appears to come from professional gardeners/landscapers, there does appear to be a significant potential for increased diversion of this material. This is supported by the high number of "green waste only" loads that were observed during the audit period (see section 2.6).

- **Wood/timber**: The market for solid, untreated timber is still emerging. However, once appropriate quality assurance protocols can be finalised and adopted, there is likely to be a demand for waste timber as a supplementary fuel for coal-fired boilers. While secure markets are still some time in the future, the study does show that the C&I waste stream is a significant source of solid timber as a base resource.

- **Plastic**: Clean plastic can be recycled. However, plastic recovery at the point of disposal is unlikely to be suitable for recycling. A residual waste stream high in plastic would have a high calorific value, possibly making it suitable for Refuse Derived Fuel. This may be an option for the future.

3.2.1 Small vehicle traffic

Small vehicle loads are mainly loose, or of low compaction, and are unloaded by hand by the customer. Therefore, even though small loads represent a small proportion of the overall commercial waste stream, they could be relatively easy targets for waste diversion. If appropriate, convenient, well-signed recycling facilities are made available to small vehicle customers, then the amount of recyclable material collected could increase.

3.2.2 Large vehicle traffic

The majority of commercial waste, and hence recyclable material from commercial sources, going to landfill is presented at disposal facilities in large, mixed, compacted loads. So, while the amount of material in these loads makes recovery of recyclable material potentially economical, the extraction is more difficult, and hence more costly. However, there does appear to be potential for disposal-based recovery of higher value materials, such as cardboard and metals, to be economically viable.

Another possible option for increased recovery is to encourage more source-separation by clients of garbage collection companies. Waste collection contractors could offer customers a cardboard or metal recycling collection as part of an integrated garbage and recycling collection service.

4. CONCLUSIONS

4.1 Composition of commercial waste

The following conclusions can be drawn about the composition of general commercial waste being received at waste disposal facilities in the SMA:

- The largest single component was found to be bagged waste.
- Large amounts of cardboard are being disposed of to landfill from commercial sources.
- A large proportion of the commercial waste stream is solid timber.
- Relatively little free paper or food organics were found in the commercial waste.
- Whilst plastic is a major category by volume, this is made up of a wide range of polymers in a plethora of forms and products. The major component is plastic film in the form of shrink-wrap and other plastic sheets.
- Only small amounts of materials in the “hazardous”, “computers/office equipment”, rubber” and “glass” categories were observed.

4.2 Commercial traffic profiles

Most of the vehicles that deliver C&I waste to disposal facilities were either small or medium-sized. However, large vehicles, particularly compactor trucks, delivered most of the waste (by volume).

4.3 Geographical sources of commercial waste

While source information was not collected for all facilities that participated in the waste audit, sufficient data was collected to highlight some key areas that appear to have high commercial waste generation. The Sydney CBD and lower North Shore have the highest density of waste generation, followed by the Eastern Suburbs and near Inner West.

4.4 Potential areas for resource recovery

The greatest potential for resource recovery appears to be in increased diversion of cardboard, either through disposal-based recovery or increased source-separation with a separate collection service. Wood, garden organics and plastics are also present in large quantities, which could be economically viable to segregation if the market conditions are suitable.

5. REFERENCES

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APPENDIX A – METHODOLOGY

Resource NSW Disposal-based Waste Audit, 2003
Waste Audit Contractor Methodology

Pre-audit

All waste audit contractors and their audit team members will be required to undergo a safety induction for each site they are to conduct an audit at. Waste audit contractors will be given a site contact and will be required to arrange for the safety induction to occur prior to the audit commencing.

Contractors should also arrange a pre-audit site visit to inspect the site and the physical sorting area, if applicable.

At the gatehouse

At least one audit team member will need to be stationed in the gatehouse at all times during the audit. The role of the person in the gatehouse is to record basic information about the load and alert the visual auditors and physical sorters of vehicles headed for the tip face or the sorting area. At sites where physical sorting is being conducted, they are also largely responsible for selecting suitable loads for physical sorting, in accordance with the number of each type of load per site specified in the audit brief.

Information must be recorded for every vehicle entering the facility during the audit period. This means the visual auditors will need to be at the facility from when it opens to when it closes each day of the audit. Information is to be recorded on the gatehouse data-recording sheets provided. The information required is:

- Vehicle registration number
- Date
- Time of entry
- Type of vehicle / container, for example;
    - Small vehicle / car / ute
    - Small open trucks / tray-tops / vans
    - Compactor – 1m3, 5m3, 8m3, 10m3
    - Compactor garbage truck – 19m3
    - Open 20m3 trailer
    - Etc.
- Vehicle volume
- Load classification as used by the facility, for example
    - Wet
    - Dry
    - C&D
    - Green waste
    - Timber
    - Mixed recycling
    - Other
- Type of business/es where the waste was generated, for example
    - Office buildings
    - Restaurants/cafes
    - Manufacturing
    - Construction site
    - Demolition site
- Suburb where the waste was generated / picked up
- Disposal point as used by the facility, for example
    - Recycling area
    - Green waste area
    - Brick pile
    - Concrete pile
    - Timber pile
    - General waste
    - etc

The procedure to be followed by the waste audit team member stationed in the gatehouse is as follows;

1. As each vehicle approaches the weighbridge, note the vehicle registration number and time.
2. Once the vehicle stops, ask the driver what type of business the waste came from and the suburb the waste was collected from. This will need to be co-ordinated with the site's gatehouse staff. The driver might also be asked the volume capacity of their vehicle.
3. If the load is to be re-directed to the sorting area, you will need to give instructions to the driver before they leave the weighbridge.
4. Note the rest of the information (you may need to get some of it from the site's gatehouse staff)
5. If the vehicle is bound for either the sorting area or the general waste tipping area, alert the relevant audit team to the vehicle's approach, giving the vehicle registration and a description of the vehicle.

The waste audit contractor will be responsible for obtaining/hiring a set of two-way radios for the audit.

Visual Audit Methodology

A visual assessment of the composition must be conducted on each commercial and C&D load being disposed as general waste. Visual assessments are to be recorded on the data-recording sheets provided. Data sheets will be pre-numbered to ensure all data recording sheets are returned after the audit. Waste audit contractors are not to copy the sheets or use their own sheets. The auditor using any particular sheet will need to write their name at the top of the sheet and initial the chain of custody at the bottom of the sheet.

For each load, an estimate of the volume of the total load and then two composition assessments (columns V1 and V2) are made. The auditor can often obtain a better estimate of the composition after watching the load being moved by the front-end loader in the tipping area or by walking around the tipped load (if this can be done safely). A composition should be recorded in the V1 column as soon as the load is discharged. If time permits, a second composition estimate should be made and recorded in column V2.

As far as practicable, the material categories on the sheet should be used for recording composition. Space has been allowed for recording other categories, such as specific items present in large quantities or items made from unknown/composite materials. However, use of these categories should be reserved for special cases and not used as a matter of course.

Compositions are recorded as a volume percentage of the total load. Category materials or target items that are present only in very small quantities should be recorded as 1%, or <1%. This is to identify that they were present, without attempting to make an exact estimate of the volume percentage.

All completed visual audit recording sheets are to be kept in a central location at the audit site, and must be made available to Resource NSW for collection when requested. Resource NSW will enter the data into a database. This will occur concurrently to the on-site audit processes. Therefore, it is imperative that the data sheets are available when requested.

Waste audit contractors will be responsible for providing all equipment necessary for conducting the visual audits, including:

- Two-way radios;
- Dusk masks;
- Safety glasses;
- Safety reflector vests;
- Clipboards; and
- Pens.

As visual auditors are close to the tipping area, they must wear safety shoes at all times during the audit.

Physical sorting methodology

The physical sorting of a number of loads occurs as a complementary activity to the visual auditing. The purpose of the physical sorting is to obtain a more accurate picture of the composition of large, highly mixed loads. The composition of these types of loads is difficult to estimate visually. The physical sorting results will be used to adjust the visual assessment estimates to be more accurate. Therefore, it is important that the physical sorting is carried out to a high degree of accuracy.

Selecting loads for physical sorting

The minimum number of each type of load to be physically sorted is stipulated in the tender brief. Only mixed loads from commercial premises are to be physically sorted. C&D loads are not to be physically sorted as part of this project. The lead auditor at the physical sorting site will need to communicate with the team member in the gatehouse as to what type of loads should be directed to the physical sorting area.

Set up of sorting area

The facility's site manager will designate an area where the physical sorting is to occur. The contractor should arrange to inspect this area as part of the pre-audit preparations. This site will be chosen on the following basis:

- Space – sufficient space for 15 skips to be stored and manoeuvred, discharging and storing of loads, and manoeuvring of garbage trucks;
- Access – easy access for diverted trucks; and
- Safety – sufficiently far enough away from the tipping face that the physical sorting team can work safely.

The waste audit contractor will be responsible for organising and providing all equipment necessary for conducting the audit, including:

- Scales – capable of weighing at least 500kg. Contractors may choose to have two sets of scales, one for weighing skips and another for weighing smaller containers.
- Skip bins – for weighing large amounts of timber, cardboard, etc.
- MGBs, tubs, other containers for weighing smaller quantities of materials
- Tables for sorting bags of wet waste
- Shovels
- Personal Protective Equipment (PPE) for all audit team members – puncture-resistant gloves, dusk masks, safety glasses, reflector vests
- Pens, clipboards, marker pens, etc.
-

Contractors will be responsible for hiring a skip bin operator to manoeuvre skip bins around the site.

During the audit set up, each of the containers that waste will be sorted into must be weighed and the weight of each container recorded. The container should be weighed each morning, and a new tare weight sheet completed. A copy of the waste container tare weight sheet will need to be handed to Resource NSW. This is essential for conducting the data analysis.

Conducting the sort

The waste audit contractor will be responsible for ensuring all audit team members are adequately trained to conduct the audit properly. In particular, sorting team audit members must be able to identify all the material and items listed on the physical sorting data-recording sheet.

Once a load has been directed to the sorting area, the audit team leader will need to instruct the driver where to discharge the load. After the load has been discharged, it is sorted into containers according to the categories listed on the physical sorting data-recording sheet. There is space for alternative categories to be used in the case of special materials occurring in large quantities or items that are difficult to assign to one material type. Generally, the nominated categories should be used wherever possible. The sorted waste is then weighed and the weights recorded on the physical sort data-recording sheet provided. A visual assessment of the volume of each category of the sorted waste must be made for each load. This assists in calibrating the visual audit data and estimating densities for each waste component.

After the load has been sorted and weighed, the waste can be disposed of at the tip face. Contractors may elect to hire a large skip bin to accumulate waste and tip several times per day, or to have the skip bin operator deliver waste directly from weighing to the tip face.

Clean up

The waste audit contractor will be responsible for ensuring that the sorting area is tidy at then end of each day, and that it is completely cleared at the end of the audit. Particularly, the sorting area must be free of litter and equipment when the waste audit contractor leaves the site at the end of the audit

Data recording sheets

Resource NSW will provide all physical sorting data-recording sheets. The sheets will be numbered to ensure all sheets are returned to Resource NSW at the end of the audit. Waste audit contractors are not to use photocopies of the sheet or make up their own data-recording sheet – they must use the sheets provided. Waste audit contractors can request as many sheets as they need, but all sheets must be returned to Resource NSW at the end of the audit.

Resource NSW will be entering the data into a database. This will occur concurrently with the onsite auditing. Therefore, it is imperative that the data-recording sheets are returned to Resource NSW when requested.

Audit category explanations

Material categories	Includes
Office paper	Photocopy paper, books, printing and writing papers
Paper – all other	Magazines, newspapers, brown kraft paper, rolls of low-grade paper, hand towels
Dry cardboard	Dry cardboard boxes, cardboard rolls, clean dry cardboard
Wet cardboard	Wet cardboard, soiled cardboard
Food / kitchen	Pre- and post-consumer fruit, vegetable, meat, fat, bone
Vegetation / garden	Plant material, leaves, grass, small branches
Wood – furniture, painted wood	Wardrobes, painted fence posts, varnished furniture, wooden chairs, doors, etc
Wood – chipboard, MDF	Any engineered timber products, old kitchen benches, chipboard,
Wood – board/pole, untreated	Pieces of solid timber without any visible signs of treatment. May include timber off-cuts, pallets, posts
Wood – board/pole, treated	Pieces of solid timber with visible signs of chemical treatment. CCA treated timber has a green tinge, eg “coppers logs”.
Textiles – carpet & underlay	Rolls of carpet, carpet off-cuts, carpet tiles, felt underlay, synthetic underlay (but not rubber or plastic underlay)
Textiles – cloth	Clothes, rags, rolls of fabric, fabric off-cuts
Textiles – cloth- & leather-covered furniture	Material/leather-covered chairs and couches, cloth mattresses. NB: if mattresses, make a note in “comments”
Textiles / leather other	Leather offcuts
Rubber - tyres, tubes	All tyres and inner-tubes
Rubber other	Rubber mats, rubber tubes, rubber washers, foam rubber
Glass – containers	Glass bottles and jars
Glass – plate	Window glass, non-recyclable glass such as wine glasses
Plastic – containers recyclable	Plastic bottles and jars – food/beverage containers (PET & HDPE)
Plastic – film	Film wrap, plastic bags (not filled),
Plastic – polystyrene foam	Packaging foam
Plastic – other	All other plastics not elsewhere classified – include industrial plastic containers, plastic drums (not 1 or 2)
Metals – ferrous (steel)	Any items that are mainly steel/iron
Metals – non-ferrous	Aluminium siding, aluminium foil, copper wire, any items that are mainly metal but not steel/iron
Concrete / cement	Any concrete, bags of cement dust, etc
Bricks	Full-bricks, broken bricks
Tiles	Roof tiles, clay tiles – whole or broken
Plasterboard	Plasterboard, gypsum
Rock/dirt/soil	Stones, uncontaminated soil, Inert material not elsewhere classified
Asphalt	Asphalt, bitumen
Hazardous / special	Batteries, chemicals, clinical waste, contaminated material (note type)
Garbage bags of rubbish	Enclosed bags of garbage.
Computers / office equipment	Computers, monitors, photocopiers, fax machines, printers
Toner cartridges	Toner cartridges from photocopiers, printers, etc
Other items	There is space on the form to record amounts of other items presenting in significant quantities.
	Put “ceramics” into “other and make a note.

APPENDIX B – DATA RECORDING SHEETS

Visual audit data-recording sheet

Date: Site: Auditor: Audit Co.

Details	Vehicle 1		Vehicle 2		Vehicle 3	
Time of entry						
Vehicle rego						
Type of vehicle						
Disposal point						
Observed volume (m^3)						
Degree of compaction (Loose, Medium, Compacted)						

Material categories	V1 %	V2 %	V1 %	V2 %	V1 %	V2 %
Office paper						
Paper – all other						
Dry cardboard						
Wet cardboard						
Food / kitchen						
Vegetation / garden						
Wood – furniture						
Wood – pallets						
Wood – chipboard						
Wood – board, untreated						
Wood - board, treated						
Textiles – carpet & underlay						
Textiles – cloth						
Textiles – cloth- & leather-covered furniture						
Textiles / leather other						
Rubber - tyres, tubes						
Rubber other						
Glass – containers						
Glass – plate						
Plastic – containers						
Plastic – film						
Plastic – polystyrene foam						
Plastic – other						
Metals – ferrous (steel)						
Metals – non-ferrous						
Concrete / cement						
Bricks						
Tiles						
Plasterboard						
Rock/dirt/soil						
Asphalt						
Hazardous / special						
Garbage bags of rubbish						
Computers / office equipment						
Other						

Vehicle	Comments

Physical sorting data-recording sheet

Date: Site: Auditor: Audit Co.

Details	Vehicle 1		Vehicle 2		Vehicle 3
Time arrived at sorting point					
Vehicle rego					
Type of vehicle					
Disposal point					
Observed volume (m^3)					
Degree of compaction (Loose, Medium, Compacted)					

Material categories	kg	L		kg	L		kg	L
Office paper								
Paper – all other								
Dry cardboard								
Wet cardboard								
Food / kitchen								
Vegetation / garden								
Wood – furniture								
Wood – pallets								
Wood – chipboard								
Wood – board, untreated								
Wood - board, treated								
Textiles – carpet & underlay								
Textiles – cloth								
Textiles – cloth/leather furniture								
Textiles / leather other								
Rubber - tyres, tubes								
Rubber other								
Glass – containers								
Glass – plate								
Plastic – PET & HDPE containers								
Plastic – other containers								
Plastic – film								
Plastic – polystyrene foam								
Plastic – other								
Metals – ferrous (steel)								
Metals – non-ferrous								
C&D inert								
Hazardous / special								
Computers / office equipment								

Vehicle	Comments

Physical sorting tare weight sheet

Date: Site: Auditor: Audit Co.

Container	Weight of empty container (kg)

Gatehouse data-recording sheet

Date: Site: Auditor: Audit Co.

Details	Vehicle 1	Vehicle 2	Vehicle 3
Rego			
Time			
Truck/container type			
Truck volume (m^3)			
Load classification			
Disposal point			
Type of businesses			
Suburb waste was collected from			

Details	Vehicle 4	Vehicle 5	Vehicle 6
Rego			
Time			
Truck/container type			
Truck volume (m^3)			
Load classification			
Disposal point			
Type of businesses			
Suburb waste was collected from			

Vehicle	Comments

Non-disclosure Agreement

This non-disclosure agreement is to be signed my all audit team members and returned to Resource NSW.

Date: _____ Audit site _____ Audit Contractor_____

BACKGROUND TO CONFIDENTIALITY AGREEMENT

A. [Audit-Contractor] has been contracted to carry out and report on a Waste Audit project for Resource NSW at [details].

B. This project will involve handling information and materials that may be sensitive for the site owner or others involved. [Audit Contractor] is performing the work on the condition that all information in relation to the Waste Audit project is kept confidential and [Audit Contractor] relies on you to do the same. This applies now, during the work and afterwards indefinitely.

C. All information relating to this project is to be treated as "confidential". This applies to everything you write, read, see, hear, touch, smell, feel, or find out about, even if you are not told that the information is confidential or if it is not marked "confidential".

D. Your obligations relating to this work and confidential information are as follows, which you are asked to read and sign. Your signature will indicate that you have read, understood and agreed to the obligations.

CONFIDENTIALITY AGREEMENT

1. I, [Employee/ Contractor] have been engaged by [Audit-Contractor] to undertake work in relation to waste audits to be carried out for Resource NSW.

2. I agree that:

- I will not disclose or record anything about any waste audit undertaken or contract entered into by [Audit Contractor], unless necessary to carry out my obligations to [Audit Contractor], or where required by law to disclose information.
- I will not take any material, object, document or information from any site entered as part of my work unless necessary to carry out my obligations to [Audit Contractor].
- At the conclusion of my engagement I will not keep any information or material, however stored or in whatever form, in relation to my work but will return all information or material to [Audit Contractor].
- My obligation of confidentiality includes any information or material that I produce, record, sense (eg see or hear) and includes information or material that originates from any source (eg audit site, Resource NSW).

3. I understand that this obligation of confidentiality is a condition of my engagement and that [Audit Contractor] may take action to discipline, dismiss me or take other action against me (such as recovery of monetary loss) if I do not comply.

4. I understand that my obligations under this Confidentiality Agreement will continue after my participation in any waste audit for [Audit Contractor] comes to an end, and I will continue to keep all matters referred to above confidential.

Signed _____ (name) Date _____ Witness _____
(name and address)