

## **A Load of Garbage! – A study to understand movements of waste materials in an urban area**

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### **ABSTRACT:**

Heavy vehicle trip estimation processes have concentrated on movements made by ‘commodity-carrying’ vehicles and there is little information on the characteristics of trips made for garbage collection and disposal.

The Transport Data Centre has recently embarked on a data collection activity that aims at addressing this issue in order to produce more complete and reliable estimates of commercial vehicle movements. The Waste Movements Study involves the collection of data to better understand the characteristics of movements of household and industrial waste in Greater Sydney so that these trips can be more accurately reflected in the commercial vehicle estimation process.

This paper discusses the methodology used in this study, the issues encountered during the data collection and the major findings from these studies. It is hoped that through this paper, transport researchers involved in commercial vehicle trip estimation would gain some insight into the measurement of trips made for waste collection and disposal and how trips for this purpose impacts on urban traffic.

### **1. INTRODUCTION**

The Transport Data Centre (TDC) currently uses a recently developed freight movement model (FMM) that is similar to that used in a number of other Australian States. The model uses a commodity based approach in estimating heavy vehicle movements in an urban area such as Greater Sydney. The Sydney FMM starts by estimating the level of tonnages moved by road by commodity-producing industries, converting these tonnages into trips made by rigid and articulated trucks using loading factors, and then distributing the trips across the travel zones in Greater Sydney. (‘Travel Zones’ are TDC geographical units representing areas of relatively homogenous land use that generally fit in size between the smaller Australian Bureau of Statistics (ABS) Census Collector District and the larger Statistical Local Area (SLA). There are over 2,600 travel zones in Greater Sydney.)

One limitation of the FMM at this early development stage is that the production estimation process does not include movements for the purpose of collecting and disposing waste materials. It is important that these trips are included in the model to produce more accurate and complete estimates of heavy vehicle trips in Greater Sydney. TDC, therefore, decided to undertake a Waste Movements Study in May 2009 to obtain information on the number of waste trips in Greater Sydney, where they come from and where they go.

Given the limited resources available for this project, the study has been exploratory in nature with restricted sample sizes and using a mixture of methodologies that would allow for the collection of the data required in the trip estimation. Nevertheless, the data collected from the fieldwork has been augmented by publicly available waste production data that served as control totals in the estimation process.

This paper summarises the results of the Waste Movements Study contained in the study's final report submitted to TDC by its consultant who worked on this study, Parsons Brinckerhoff Australia Pty Ltd.

## **2. THE WASTE MOVEMENTS STUDY**

The Waste Movements Study was conducted in Greater Sydney over a period of eight weeks. Greater Sydney is composed of the Sydney Statistical Division, Newcastle Statistical Subdivision and Illawarra Statistical Division. A map of Greater Sydney is shown in Figure 1. TDC commissioned a private transport research consultant, Parsons Brinckerhoff, to undertake the research study.

While there has been a number of studies undertaken to obtain information on waste collection and disposal, this is the only study known to TDC that specifically focuses on understanding the travel movements of vehicles engaged in the collection and disposal of waste, and determining the level of trips involved.

Some of the questions TDC wanted to answer from this study include:

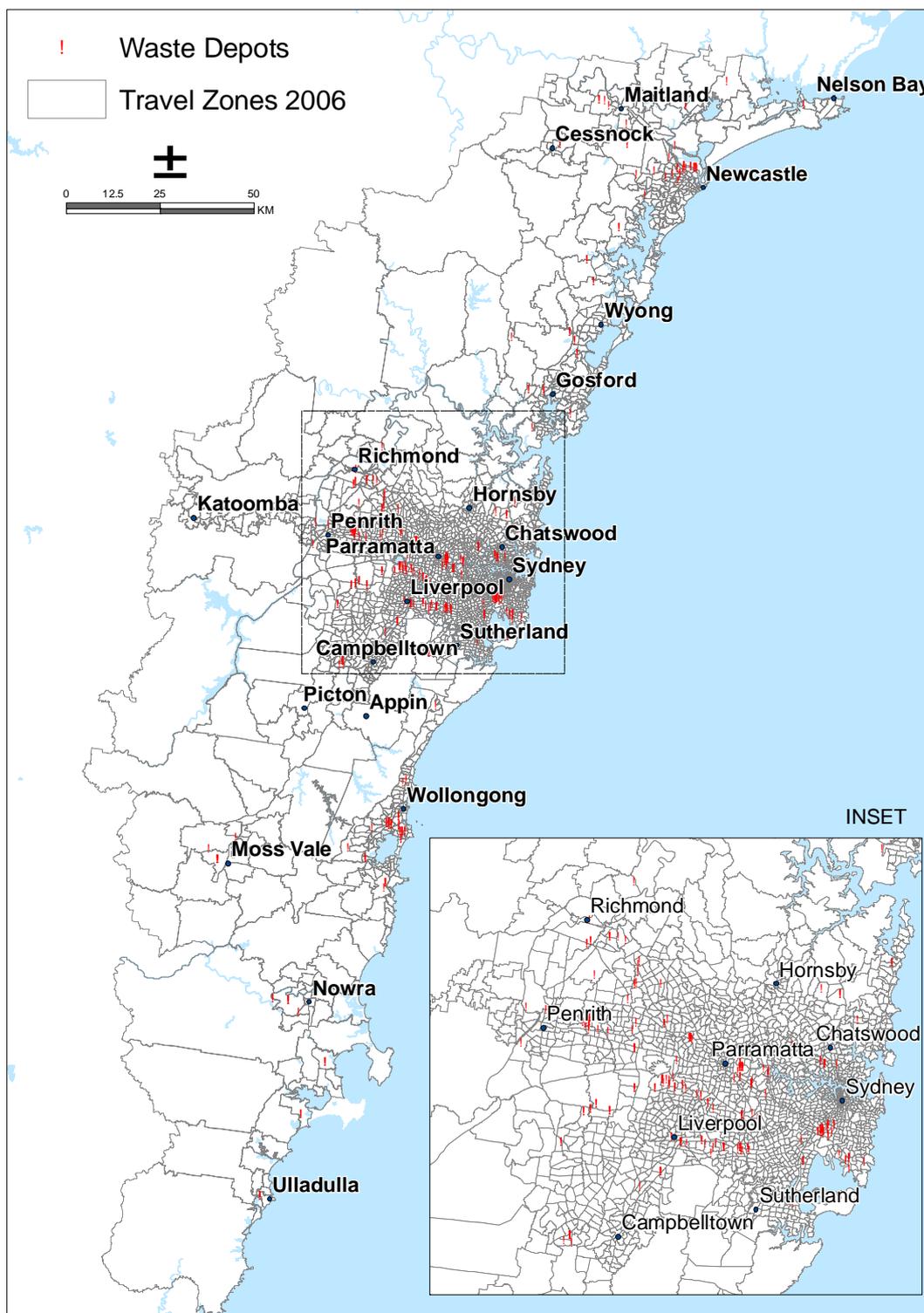
- What is the waste management process and who are the main players in the waste logistics chain?
- What data is available that we can use in estimating the trips made by the waste industry?
- What are the types of trips made by the waste industry, what vehicles are used, and what times of day do these vehicles travel?
- Where do waste trips originate and where do they go?

The activities that were undertaken to answer these questions, and the sections of the paper where they are discussed are as follows:

- Undertaking a waste industry scoping to understand the nature of the waste business and to identify major players in the waste industry (Section 3)
- Estimating the size of the waste industry, and the amount of waste generated (Section 4)
- Collecting data on waste vehicle trips (Section 5), using the following four survey methods:
  - Local council surveys - interviews with local councils in Greater Sydney and online research from local council websites
  - Waste depot surveys – interviews were conducted with five waste operators;
  - Classified counts study – collection of counts of vehicles entering the surveyed waste operators during operational hours; and
  - GPS pilot study – tracking of a small number of garbage vehicles to obtain further information on travel times, distances and waste trip origin and destination.

- Estimating trip productions and trip attractions by travel zone, and outlining the trip matrix estimation process (Section 6).

**Figure 1. Map of Greater Sydney with locations of waste facilities**



### 3. THE WASTE SECTOR

Waste is defined in this paper in accordance with the definitions provided below:

*“Waste can be defined as any product or substance that has no further use or value for the person or organisation that owns it, and which is, or will be, discarded.”* (Productivity Commission, 2006)

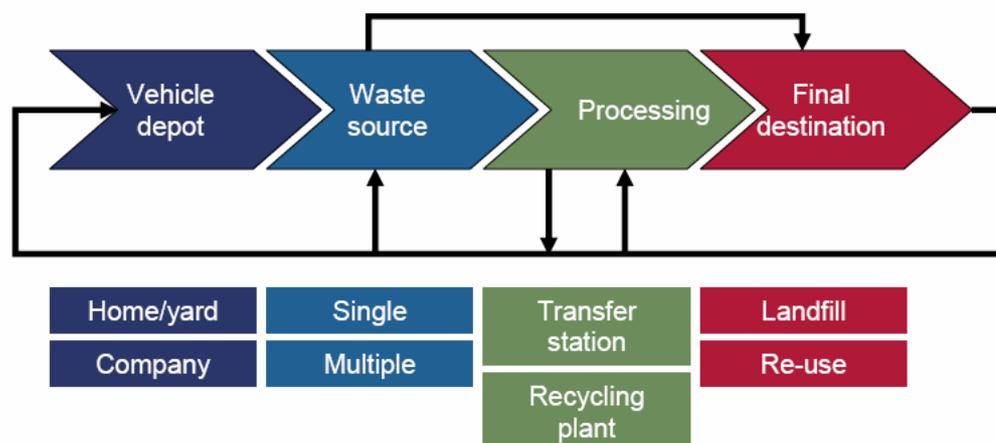
*“Wastes are materials that are not prime products (that is products produced for the market) for which the generator has no further use in terms of his/her own purposes of production, transformation or consumption, and of which he/she wants to dispose. Wastes may be generated during the extraction of raw materials, the processing of raw materials into intermediate and final products, the consumption of final products, and other human activities. Residuals recycled or reused at the place of generation are excluded.”* (The United Nations Statistics Division’s definition cited at the United Nations Environment Programme (UNEP GRID-Arendal website)

There are different ways that waste can be classified, such as by the type of material they contain (e.g. general solid waste, liquid waste, hazardous waste, special waste) or based on the primary source of waste, i.e. municipal, commercial and industrial, or construction and demolition waste. In this study, classification based on the primary source of waste was used in the collection and compilation of data.

*Municipal waste* refers to household waste and is predominantly general solid waste. *Construction and demolition (C&D)* waste consists of waste arising from construction and demolition activities, e.g. bricks, timber, concrete, steel. *Commercial and industrial (C&I)* waste consists of waste from business and commerce (e.g. waste from schools, restaurants, offices, retail and wholesale businesses, and manufacturing industries).

There are a number of vehicle movements associated with waste that was identified in the Waste Movements Study. These movements are shown in Figure 2.

**Figure 2. Waste Vehicle Movements**



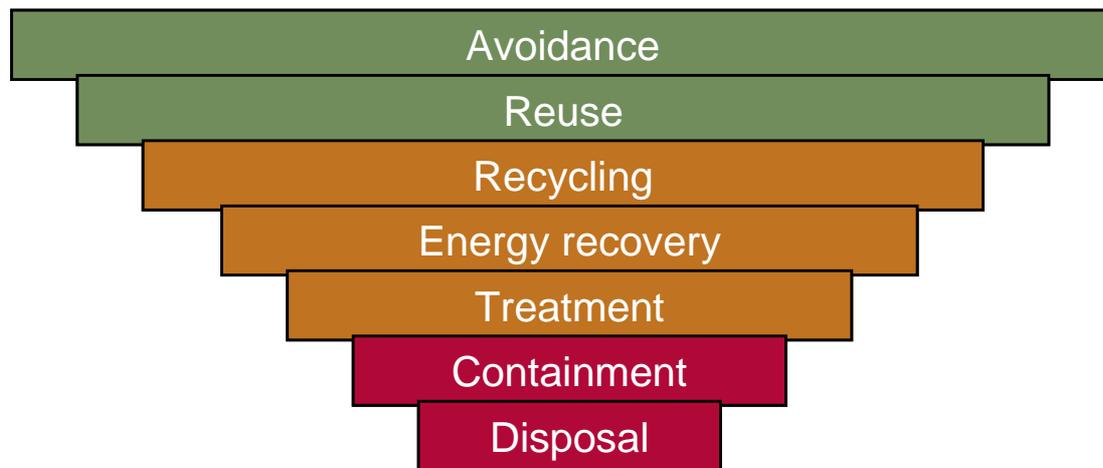
Source: 2009 Waste Movements Study Waste Movements Study, TDC

Figure 2 shows different trip movements including:

- Forward trips - from vehicle depot to waste source; from waste source to processing plant; from processing plant to final destination; from waste source directly to final destination.
- Return trips (these are usually empty) - from final destination to vehicle depot; from final destination to waste source; from final destination to processing plant; from processing plant to final destination.
- Collection trips – trips that usually occur in minor streets to collect waste (e.g. household garbage collection). Although many of these trips occur on minor streets (within household blocks), major roads with residential frontages are also affected.

In Australia, most States and Territories adopt waste management strategies based on the model of a waste management hierarchy shown in Figure 3. The implementation of this hierarchy affects the level of trips associated with waste movements (e.g. movements to sorting facilities, various recycling facilities, transfer stations, landfills). For example, for household waste collection, there are separate trips to pick up mixed solid waste, recycled household waste and organics. The emphasis towards reuse and recycle of materials and the increasing concern of people towards the environmental impacts of waste may result in an increase in the number of vehicles (light and heavy) making trips for waste disposal such as trips to recycling facilities and other waste facilities.

**Figure 3. Waste Management Hierarchy**



Source: TDC Waste Movements Study Final Report, 2009 (*Adapted from Productivity Commission Report, 2006*)

#### **4. WASTE GENERATION IN GREATER SYDNEY**

Based on the 2006 Census Journey-to-Work data, the waste sector (classified under ANZSIC code ‘29’ described as “Waste collection, treatment and disposal services”) comprised around 0.2% of the total employment in Greater Sydney. Almost 60% of the jobs in the waste sector in Greater Sydney are blue-collar jobs such as machinery operators, drivers, labourers, technicians and trade workers, compared with only 28% for all industries (see Table 1).

Although the waste sector's share to total industry employment is not substantial, the sector by its very nature (i.e. garbage collection and disposal) generates significant vehicle movements from the waste sources (households and businesses) to waste destinations (vehicle depot, landfills, recycling plants, transfer stations).

**Table 1. Employment in the Waste Sector (Greater Sydney)**

	Waste Sector		All Industries		% Waste Sector
	Employment	Share	Employment	Share	
Managers and Professionals	899	18.8%	810,622	35.7%	0.1%
Clerical, administration, sales, community and personal services workers	990	20.7%	780,508	34.4%	0.1%
Machinery operators, drivers, labourers, technicians and trades workers	2,814	58.9%	634,810	28.0%	0.4%
Not stated/Inadequately described	76	1.6%	45,119	2.0%	0.2%
<b>Total Employment</b>	<b>4,779</b>	<b>100.0%</b>	<b>2,271,059</b>	<b>100.0%</b>	<b>0.2%</b>

Source: 2006 Journey-to-Work Data (Transport Data Centre, Ministry of Transport)

#### *Waste generation*

Data on total tonnage of waste materials produced in Greater Sydney is available from published reports. The most recent report on total tonnage of waste materials that the study collected is presented below.

**Table 2. Annual Waste Production in Greater Sydney (Tonnes), 2006-07\***

Waste Category	Greater Sydney*	NSW	% Greater Sydney
Municipal	2,753,000	3,890,000	70.8%
Commercial & Industrial	4,352,121	5,218,000	83.4%
Construction & Demolition	5,443,350	6,251,000	87.1%
<b>Total</b>	<b>12,548,471</b>	<b>15,359,000</b>	<b>81.7%</b>

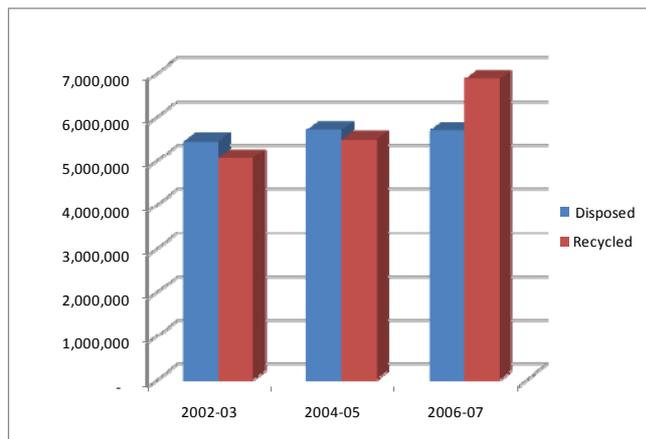
Source: NSW Department of Environment and Climate Change (DECC), 2008

(\*Data for 'Greater Sydney' from this publication includes Sydney Metro, Hunter, Central Coast and Illawarra regions. TDC's Study Area does not cover the entire Hunter but only includes Newcastle Statistical Subdivision.)

The table shows that total waste production in Greater Sydney for 2007 was 12.5 million tonnes and over 80% of the total waste generated in NSW.

Waste recovery in Greater Sydney has been increasing over the years. Figure 4 shows the level of waste recycling in Greater Sydney for the years 2000-03 (48%), 2004-05 (49%) and 2007 (55%).

**Figure 4. Waste Disposed and Recycled, Greater Sydney (tonnes)**



	Total Waste	% Recycled
2002-03	10,482,000	48%
2004-05	11,169,500	49%
2006-07	12,548,471	55%

Source of raw data: DECC, 2008

## 5. WASTE TRIP CHARACTERISTICS

This section outlines the collection of waste trip data, as well as the characteristics of waste vehicle trips based on the analysis of this data.

### *Local Council Surveys*

The local council survey is an important component of the study because the information collected from this component provided TDC with the waste generation rates used to estimate the truck movements for household waste.

There are 52 local government areas (LGA) in Greater Sydney. The councils for all LGAs were approached for information, and information from council websites was also collected, in order to obtain data on the:

- amount of waste generated by type of waste;
- schedule of household waste collections;
- number of vehicles that are used in the waste collection;
- areas that they serve; and
- general routes that they take during the collection process.

The response rate from councils was over 70%. The information collected from the councils was incorporated in the main output from this study – the Waste Movements Database. The main findings are listed below:

- Most councils contract out household waste collection and disposal to private contractors.
- Councils set performance benchmarks and set the conditions on waste collection (e.g. service hours on clearways and major highways during peak periods).
- Private service providers would be responsible for vehicle scheduling and routing, and in most instances would determine at which facilities to dispose the waste.
- A small number of councils own landfill facilities which are mainly managed for them by private operators.

- Councils have separate bins for general garbage and recycled waste but currently not all councils have a separate bin for garden organics.

The amount of waste generated by each local council, along with information on household counts at the local council was used to estimate the council's waste generation rate per household. This rate was then applied to the number of households in the travel zones under the local council to estimate the waste generated at the travel zone level.

### ***Entry-gate counts at waste disposal sites***

The data collection at waste disposal sites provided TDC with information on the average load of vehicles entering the waste facilities. This is used to convert the estimated waste generated by households, commercial and industrial into heavy vehicle trips.

The study collected classified vehicle counts from six waste disposal depots in metropolitan Sydney. The counts were undertaken at the entrance to the disposal facilities during operational hours (between 6:00am and 5:00pm on a weekday). The counts collected included the number of vehicles entering the site, the type of vehicle and the times when the vehicles entered the site.

The vehicles were classified into:

- Light vehicles (box trailers, utes, cars, panel van)
- Small trucks (2-3 tonne)
- Medium trucks (4-10 tonne)
- Large trucks (10+ tonne)

All trucks were further classified into collector truck, tip-truck, skip bins, flat-bed/box, and tanker. Table 3 summarises the data collected from the gate-entry counts.

**Table 3. Daytime breakdown of trips to a typical depot**

<b>Light Vehicle</b>	<b>Small truck</b>	<b>Medium truck</b>	<b>Large truck</b>	<b>No. of vehicles observed</b>
42%	11%	10%	37%	999

Source: TDC Waste Movements Study Final Report, 2009

It was an interesting result of the study that the daytime distribution of vehicles reveals that a large proportion of the vehicles entering the sites are light vehicles. Based on site observation, many of these trips were carrying garden and landscaping waste, presumably by home owners and tradesmen.

In addition to the classified counts, a detailed vehicle log for a typical waste depot was obtained in the study with the following information:

- types of waste disposed at the site;
- time of vehicle entry and exit;
- net weight of the vehicle; and
- amount of waste disposed.

The information collected was used to determine the average weight of waste carried by the vehicles entering waste facilities. Although we could not link specific types of waste to specific vehicle types, observations showed that all vehicle types are used for all waste types.

The reason for this is that many private contractors (e.g. building contractors and garden services) use their own vehicles to dispose of their waste. Although these can range from light vehicles to heavy vehicles, they consist mainly of light vehicles and small trucks. Third party contractors use mainly medium and large trucks to transport waste. However, only large trucks were used in transporting depot-depot waste. Table 4 presents the average load of vehicles entering the waste facilities.

**Table 4. Average amount of waste per vehicle (tonnes)**

	<b>Municipal</b>	<b>Commercial &amp; Industrial</b>	<b>Construction &amp; Demolition</b>	<b>Depot-Depot trips</b>
Tonnes of waste per vehicle	6.25	11.56		25.92

*\*Average load calculations do not include trips made when vehicles are empty.*

Source: TDC Waste Movements Study Final Report, 2009

Because the data provided by waste depots could not distinguish between C&I and C&D waste, it was decided that the same loading factor be used for these two waste streams until a study that could collect this information separately can be undertaken.

### ***On-board vehicle surveys (GPS)***

The small GPS study obtained 22 weekly datasets from 15 garbage collector trucks. Some of this data came directly from the GPS data of a waste operator and others were collected directly over a period of two weeks using a GPS logger.

The aim of this study was to obtain additional information on the times of waste vehicle operations. Other information generated by this study will also provide information that can be used in the full matrix estimation (although this is beyond the scope of the current study because of time and resource constraints of the project). This includes:

- average daily distance travelled, in and out of service
- vehicle routing efficiency and route choice
- origin and destination of waste with external quantum of movements

Together, the GPS and the entry-gate data provided information that allowed the estimation of the time of day parameters that can be used in vehicle trip estimation. Table 5 compares the time period estimates from both surveys and the parameter estimates used in the Waste Movement Database.

**Table 5. Distribution of waste movements**

<b>Time period</b>	<b>Entry gate counts*</b>	<b>GPS data**</b>	<b>Waste Movements Database parameter</b>
AM peak: 7am - 9am	19%	19%	19%
Inter-peak: 9am - 3pm	71%	48%	60%
PM peak: 3pm - 6pm	10%	4%	7%
Evening: 6pm - 7am (following day)	-	29%	14%

\* Entry-gate counts were only undertaken during daylight hours.

\*\*GPS data were based on the average vehicle distance travelled and therefore include distance covered during the collection process. Given the mix of vehicles which was fitted with GPS devices, these were heavily weighted towards municipal and commercial waste collection.

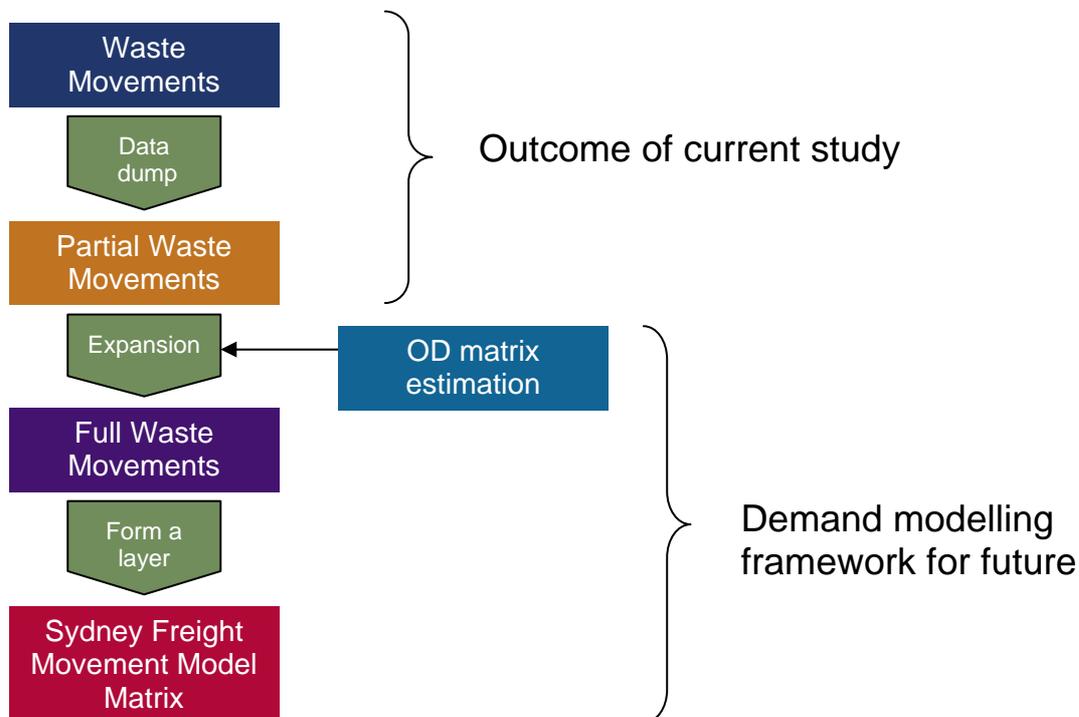
Source: TDC Waste Movements Study Final Report, 2009

Note that it is difficult to compare the counts for the entry gate and the GPS data because they have different base total (i.e. the entry gate survey did not include evening counts). However, if only the daytime GPS data is used, 67% of “GPS trips” would have occurred during the inter-peak, compared to 71% of entry gate counts.

## 6. TRIP ESTIMATION PROCESS

Due to the short duration allocated to this study, only a partial trip matrix was completed at this stage, i.e. estimates of waste trips to (*trip attraction*) and from (*trip production*) each travel zone in Greater Sydney. Additional work will need to be undertaken to bring the output up to a full waste trip matrix ready to be applied to Sydney’s freight movement model. TDC will be undertaking this work as the next step to this study. Figure 5 shows the full trip matrix estimation process for this study.

**Figure 5. Waste Trip Matrix Estimation Process**



Source: TDC Waste Movements Study Final Report, 2009

### *Trip estimates*

Trip productions at the travel zone level were estimated using the following data collected from the study.

- Total waste produced in Greater Sydney by waste source – 2007 data from DECC. The total waste production for Greater Sydney is shown in Table 2.
- Waste generation rates were estimated from the study data and consist of:
  - Municipal waste generation per household (for each LGA)

- C&I waste generation per employee (for each LGA)
- C&D waste generation per employee (for each LGA)

The study found that waste generation rates can vary significantly between some local councils. After summing up the local council estimates based on each council's waste generation rates, the following *average* waste generation rates were obtained for the entire Study Area:

- Municipal waste - 1.07 tonnes per household per year
- C&I waste – 1.74 tonnes per employee per year
- C&D waste - 2.18 tonnes per employee per year
- Annual tonnages were converted to average work day using year-to-day factor of 250 workdays per year.
- Tonnages were converted to vehicle trips using average tonnes per vehicle estimated from the study and shown previously in Table 4.

The number of waste trips attracted by the travel zones in Greater Sydney was estimated using the locations of waste operators. To distribute the total waste generated to the waste operators, a proxy variable (number of waste licences of the operator) was used as this was the only data available during the study. Waste operators may have one or more licences to allow them to conduct various waste-related activities (e.g. landfill, waste treatment, recycling, etc.). The number of licences of operators was, therefore, used as a measure of size for the companies when distributing the waste destinations across Greater Sydney. In the future, other information such as facility employment may be collected and used for the waste distribution process.

In addition to *source-to-depot* trip estimates, an estimate of *depot-to-depot* trips (to incorporate trips for recycling) was also estimated using available recycled waste tonnage data as presented in Table 6 (and in Figure 4 earlier).

**Table 6. Recycled Waste, Greater Sydney, 2007**

	<b>Total Recycled Waste</b>
Municipal	1,153,000
Commercial & Industrial	1,882,364
Construction & Demolition	3,829,880
<b>Total</b>	<b>6,865,244</b>

Source of raw data: DECC, 2008

The summary of results from the study is presented in Tables 7 and 8.

**Table 7. Workday estimates of trips to waste receiving facilities**

Waste Type	Sydney Metro	Newcastle & Illawarra	Total
Municipal	1,213	549	1,762
Commercial & Industrial	1,126	230	1,356
Construction & Demolition	1,328	367	1,695
<b>Total</b>	<b>3,667</b>	<b>1,146</b>	<b>4,813</b>

Source: TDC Waste Movements Study Final Report, 2009

**Table 8. Workday return trips by waste category**

Waste Type	Return Trips		
	Source-depot	Depot-depot	Total
Municipal	1,762	160	1,922
Commercial & Industrial	1,356	261	1,617
Construction & Demolition	1,695	532	2,227
<b>Total</b>	<b>4,813</b>	<b>953</b>	<b>5,766</b>

Source: TDC Waste Movements Study Final Report, 2009

## 7. FUTURE WORK ON THE WASTE MOVEMENTS STUDY

The resources available for this project only allowed for the production of a partial trip matrix. To produce a reliable full trip matrix, additional work would need to be undertaken to:

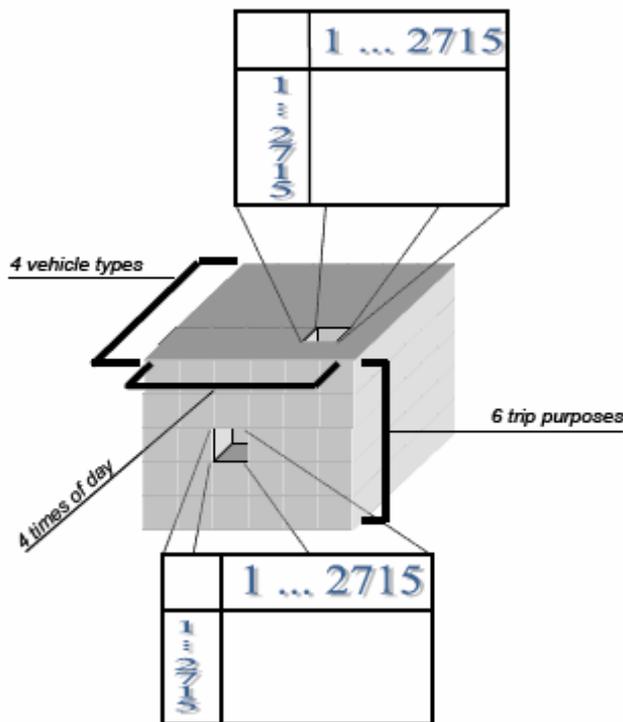
- Validate the estimation parameters (e.g. trip generation rates, tonnes to vehicle factors) used in the study;
- Obtain more data, particularly on the commercial & industrial and construction & demolition waste components. In particular, to collect information that can be used to more accurately distribute trip productions to the waste operators.
- Collect more GPS and/or classified counts data to enable accurate estimation of trips over the four time periods (AM peak, Inter-peak, PM peak and Evening) and trip routes. Ensure that the future classified counts study will collect 24-hour information and preferably over 7 days.
- Complete the Waste Movements Database to incorporate estimations by time of day, vehicle type, and trip purposes. Where budget permits, the study has recommended consideration for a 3D matrix array with 4 vehicle types, 4 times of day and 6 trip purposes as shown in Table 9 and Figure 6.

**Table 9. Workday return trips by waste category**

4 vehicle types	4 times of day	6 primary purposes
Light vehicles	AM peak: 7am - 9am	Waste source to processing facility
Small trucks	Inter-peak: 9am - 3pm	Processing facility to final destination
Medium trucks	PM peak: 3pm - 6pm	Waste source to final destination
Large trucks	Evening: 6pm - 7am	Final destination to waste source
		Final destination to processing
		Processing to waste source

Source: TDC Waste Movements Study Final Report, 2009

**Figure 6. Recommended origin-destination matrices of waste movements**



Source: TDC Waste Movements Study Final Report, 2009

## 8. ACKNOWLEDGMENTS

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