Waste Characterization Profile of the Electronics Industry

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FINAL REPORT

Prepared for

Clean Washington Center (CWC)

A division of the Pacific NorthWest Economic Region

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In association with the
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TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

1.0 ABSTRACT

This report, prepared for the Recycling Technical Assistance Partnership (ReTAP), a program of the Clean Washington Center, constructs a profile of waste generated in the electronics industry. The findings are based on a study conducted by the Cascadia Consulting Group in association with the American Electronics Association (AEA). The purpose of this study was to identify opportunities for increased recovery and recycling of electronic industry by-products. The project participants, members of the Washington State chapter of the AEA, are looking at ways to improve their recycling programs and saw the study as an opportunity to help them in their efforts.

Waste generation, disposal and recycling information was gathered from ten Washington companies, selected to represent a broad range of electronics manufacturing operations. Three techniques were used to secure data:

1. Characterizing each company's entire disposed waste stream by sorting and weighing waste placed in dumpsters,

2. Collecting, sorting and weighing all by-products (including those destined for recycling) generated over a one week period by a number of typical electronics industry processes,

3. Conducting onsite surveys to document current recycling and solid waste management practices.

FINDINGS

Dumpster sorts indicate that over 40% of the disposed material consisted of packaging waste ranging from cardboard boxes to plastic bubble wrap, to aluminum cans. The top six categories of waste, which account for 68% of all disposed waste, are listed in Table A-1. Paper, at 54% of the disposed waste stream, was the predominate commodity. The paper categories are

readily recyclable in the Puget Sound region. The next target components, plastic film and food, are potentially recoverable but collection infrastructures are not fully developed.

Table A-1: Largest Components of the Electronics Industry Waste Stream

Component Category	% of Waste Stream
Low Grade Recyclable (Paper)	20.4%
OCC/Kraft (Cardboard)	18.4%
Film and Bags (Plastic)	9.8%
Food Wastes	7.3%
Plastic/Other Materials	6.1%
High Grade Printing (Paper)	6.0%

Of the process areas, metal milling *generates* the most waste; however over 90% of these wastes are presently recycled. Plastic molding and cutting operations dispose the largest quantity of waste, an average of 320 pounds per week. Average weekly disposal, recycling, and employee generation rates are listed in Table A-2.

Table A-2: Generation, Disposal and Recycling by Process Area (Ranked by Average Weekly Disposal)

Process Area	Average Disposal (lbs/week)	Average Recycling (lbs/week)	% Recycled	Per-Employee Generation Rate (lbs/week)
Plastics Molding/Cutting	320	0	0%	1.22
Shipping & Receiving	93	56	38%	0.91
CB Assembly	92	6	6%	0.53
Metals Milling	73	671	90%	2.79
Sub/Final Assembly	71	35	33%	1.06
Surface Mount	69	6	8%	0.39
Transformers/Magnetics	39	30	43%	0.38
Soldering Operations	9	2	18%	0.04
Coating & Potting	5	0	0%	0.03

All ten of the participating companies have recycling programs. The most commonly recycled materials are scrap metals, high grade office paper, and cardboard. Various operational practices influence diversion rates. For example::

- Payment for recyclables and disposal regulations motivates recovery.
- Point-of-generation separation results in higher diversion levels.
- Clearly marked containers generate higher recovery volumes and less contamination.
- Packaging specifications decrease discards.
- Sharing disposal and recycling cost and quantity information motivates employees to recycle.
- Just-in-time delivery and change orders contribute to increased packaging waste.
- Space limitations hamper recovery efforts.
- Selection of a recycling service provider affects recycling rates.
- Coordination among departments minimizes waste generation.
- Employee interest in reusing shipping containers and other packaging is high.

CONCLUSIONS

While electronics manufacturers are realizing the benefits of recycling, many could do more to maximize their cost savings. Addressing packaging waste offers the greatest opportunities for added savings, as the electronics industry has established efficient production processes that contribute little to the disposed waste stream. The next challenge is to apply this efficient production model to reducing packaging.

2.0 INTRODUCTION

The U.S. Congress' Office of Technology Assessment and the Washington State Department of Ecology have cited the lack of information regarding industrial wastes as a major systemic problem for solid waste management and the development of new recovery and recycling options. In response, this study presents a profile of waste generated in the electronics industry, with a particular focus on measuring by-products associated with various manufacturing processes. The intent was to gather baseline data, assess current recovery efforts, and identify opportunities for the recovery and recycling of industrial by-products. Data was gathered through waste sorts (from both dumpsters and specific manufacturing process areas) and onsite surveys. With the cooperation of the Washington State chapter of the American Electronics Association, ten member companies participated in this study.

The report begins with an overview of the project. The sampling results are documented in Section 4, while the onsite surveys are discussed in Section 5. A summary of major findings concludes the report. Appendices provide more detail regarding the methodology. A guide for businesses wishing to conduct their own waste audits is also included in Appendix F.

3.0 PROJECT OVERVIEW

Members of the Washington State chapter of the American Electronics Association (AEA) within primary SIC codes 3400 - 3999 participated in the study. The AEA Environmental Health and Safety Committee assisted in developing the business selection criteria. Potential study members were ranked according to their willingness to participate, company size, and primary manufacturing operations. A total of ten businesses were selected–five for phase one (November/December) and five for phase two (April/May). Table 1 lists the selected participants, including location, primary SIC code and employment.

Table 1: Overview of Participants

Company Name	Location	Primary SIC Code	Facility Employment
Carlyle, Inc.	Tukwila	3661	85
Carver Corporation	Lynnwood	3651	143
Data I/O Corporation	Redmond	3829	325
Fluke Corporation	Everett	3823	350
GM Nameplate	Seattle	3993	350
Huntron Instruments Inc.	Mill Creek	3826	42
Interpoint	Redmond	3674	250
Korry Electronics Co.	Seattle	3721	410
Olin Aerospace	Redmond	3405	200
Sharp Microelectronics Technology, Inc.	Camas	3998	480

Reflective of the overall electronics industry, the participating companies represented a broad range of operations, from fabrication to assembly. They manufacture components (e.g. a computer chip) and/or final products (such as compact disc players).

The AEA Environmental Health and Safety Committee also assisted in identifying nine process areas common to most companies in the electronics industry. Many electronic manufacturers have two or more of these areas. The selected process areas, the materials inputs, and typical wastes associated with the respective areas are described below:

1. *Metals Milling* is where metal is milled, shaved, and/or laser cut into a variety of pieces that are used to assemble a final product. The main materials used in this area are stainless steel, aluminum, and brass. Most by-product is recovered, although some shavings are swept from the floor and disposed. Most other waste found in this area is "people waste" such as leftover food, tissues, and paper.

2. *Shipping & Receiving* is the area in which supplies enter and products leave the facility. Materials used in this area include cardboard boxes and other packaging materials such as electro-static dissipative (ESD) bags, foam peanuts, bubble wrap, foam-in-place and paper padding. Other types of materials used and disposed include mailing labels and backings,

office paper, and other general waste. Materials recovered from this area include cardboard, mixed paper, office paper, and polystyrene peanuts.

3. *Sub/Final Assembly* is the area in which fully-loaded circuit boards are encased in a near-final or final product. The process may involve connecting several electronic pieces that have been assembled elsewhere, such as a digital screen to a circuit board. The waste generated in this area includes ESD bags, cardboard, mixed paper and other packaging materials. This is also the area in which failed circuit boards and components are recovered for re-work and scrap.

4. *CB Assembly* is where capacitors and other components are soldered and inserted onto blank circuit boards. Waste generated in this area includes component reels and tubes, office paper, cardboard, faulty boards, ESD and other plastic bags. Other materials used in this area include tissues and cotton swabs for the application of cleaning alcohols and small quantities of lead solder.

5. *Plastics Molding/Cutting* is where plastic parts or sheets are fabricated. A variety of plastic resins are used for the fabrication of various parts and sheets. The scrap includes trimmings (break-aways and cutouts) and excess resin that is "bled" out of the machine before fabrication of a new part begins.

6. *Surface Mount* is the area where chips and other such components are electronically or manually inserted onto a board that has already been hard-wired in the CB Assembly area (or by subcontract). Waste includes component reels, office paper, cardboard, faulty boards, and plastic bags. Office paper and cardboard are recovered to some extent from these areas.

7. *Transformers/Magnetics* is the area in which transformers are assembled and/or fabricated. Typical materials include copper and solder dross (most of which is recovered), cardboard, mixed paper, and a variety of chemicals, including ethers, fluxes and epoxies.

8. *Soldering Operations* is where a series of components or wiring are affixed to a circuit board using lead, ethers, and applicants (tissues, cotton swabs). Only stand-alone soldering operations, usually flow-solder, were included in this study. Very little solid waste is generated in this area.

9. *Coating & Potting* is the area in which electronic components are encased in a hardened epoxy. The main materials used in this process are epoxies, hardening agents, alcohols, paper cups for holding the soft epoxy, and tissues. Very little solid waste is generated in this area.

The study provided the ten participants with comprehensive waste audits consisting of:

- an onsite survey,
- a waste sort of garbage disposed in their dumpster or compactor, and
- a week-long sampling of waste generated within four to five process areas

The dumpster sort looked only at disposed waste and did not measure recycling levels. It was intended to provide information about the levels of manufacturing waste compared to office and cafeteria waste at each of the facilities. The process area sorts measured both waste destined for recycling and disposal, and were designed to gain a detailed understanding of the types and quantities of by-products associated with different electronic manufacturing processes.

The waste audits began with an onsite tour of each of the facilities. Information was gathered about current recovery practices and solid waste management activities. The tour was also used to identify the targeted process areas and to schedule both the dumpster sort and the process area sorts.

The dumpster sorts were performed when the receptacle was over half full. All waste contained in the dumpster was emptied onto the ground. Bulky items were removed, identified, and weighed. Next, a 200-300 pound sample of the remaining waste was selected for sorting into component categories and weighed. Each company's dumpster was sorted once.

For the process area sorts, all waste (garbage plus recycling) from within each targeted process area was collected separately at the end of each work day over a week-long period. The bagged waste was coded with the company name, date of collection, type of waste (garbage or recycling), and process area. Bags were then transferred off-site for sorting and weighing.

Appendix A includes a detailed description of the methodology used for both of the sorts. For businesses wishing to conduct their own waste audits, practical guidelines are included in Appendix F.

4.0 SORTING RESULTS

This section describes the results of the dumpster/compactor sort and the process-area sorts. All ten companies' results have been aggregated to provide a profile of waste in the electronics industry. Detailed waste results are found in Appendix C (Dumpster / Compactor Sort) and Appendix D (Process-Area Sorts).

4.1 DUMPSTER/COMPACTOR SORTS

As a means of identifying the types and quantities of materials disposed by the manufacturing facility, each participant's dumpster or compactor was sorted. In some cases, one dumpster or compactor serviced all departments in the company. In other cases, the waste receptacle serviced a portion of the facility. As expected, the size of waste containers and the frequency of collection varied from company to company.

The dumpster/compactor sort results were provided to the participating businesses for several reasons. First, many of the businesses were curious about what their overall waste looked like and believed that they could use the results of their audits for company-wide planning efforts. In particular, most felt that the information would be a useful gauge of their recycling efforts. Secondly, there was an interest in seeing how the overall waste composition differed from the process area waste composition. In particular, committee members and participants felt that cafeteria waste contributed significantly to the overall waste stream.

4.1.1 Results

The ten waste receptacles contained a total of 28,840 pounds of material. About 35% (10,053 pounds) of this amount was sorted.

Figure 1 shows the overall composition of disposed waste. Paper was the single most prevalent material in the disposed waste stream. Over 40% of the disposed material consisted of packaging waste, ranging from cardboard boxes to aluminum cans.

Figure 1: Composition of Disposed Waste in the Electronics Industry

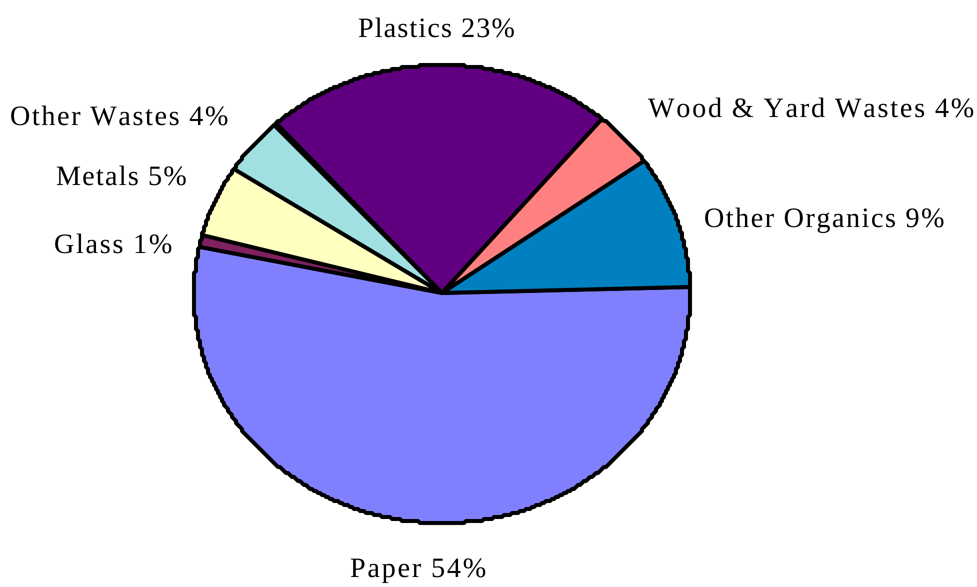

Table 2 examines the six categories that contribute the largest amounts (by weight) to the overall disposed waste stream. (Complete results are located in Appendix C.) Of these six components, three are readily recyclable through commercial recycling programs ("Low Grade Recyclable" paper, "OCC/Kraft," and "High Grade Printing" paper). All but one of the participants at the time of the study had collection services for these types of paper.

Table 2: Single Largest Components of the Electronics Industry Waste Stream

Component Category	% of Waste Stream	Ease of Recycling
Low Grade Recyclable (Paper)	20.4%	readily recyclable
OCC/Kraft (Cardboard)	18.4%	readily recyclable
Film and Bags (Plastic)	9.8%	infrastructure being developed
Food Wastes	7.3%	infrastructure being developed
Plastic combined with Other Materials	6.1%	difficult to recycle
High Grade Printing (Paper)	6.0%	readily recyclable

While "Film and Bags" and "Food Wastes" are recyclable, collection services are currently limited. It is expected that such services will increase significantly in the next several years. At 7% of the disposed waste stream, the "Food Wastes" results lend credence to participants' views regarding the cafeteria as a major waste generation area.

Of the top six waste components, the only item that is difficult to recycle is "Plastic combined with Other Materials." These items consist of plastic layered with paper, metal, wood, or some other material.

Table 3 compares the dumpster sorts with results from other commercial waste stream studies. The dumpster sorts indicate that "Low Grade Recyclable" paper is two to three times more prevalent in the electronics industry waste stream. A significant portion is packaging material associated with the shipment of production materials to and from the facility. "Film and Bags" also make up a larger percentage of the electronics industry waste stream. A good portion of this category are the ESD bags used to protect components from static. These results seem to indicate that in the electronics industry, packaging accounts for more of the disposed waste than is usually found in the commercial and industrial waste streams.

Table 3: Comparison of Waste Composition Results with Other Waste Composition Studies (Percent by Weight)

ReTAP Study "Top 10" Materials	ReTAP Study Estimate	King County Commercial (1994)[1]	Washington Dept. of Ecology "Other Industrial" (1992)[2]
Low Grade Recyclable (paper)	20.4%	5.61% - 7.49%	12.2%
OCC/Kraft (paper)	18.4%	8.65% - 12.37%	12.6%
Film and Bags (Plastic)	9.8%	4.61% - 6.33%	4.3%
Food Wastes	7.3%	9.93% - 15.21%	10.1%
Plastic/Other Materials	6.1%	0.59% - 2.77%	3.9%
High Grade Printing (paper)	6.0%	1.67% - 3.16%	3.5%
Other Wood (pallets)	3.6%	2.45% - 7.41%	N/A
Other Paper	3.6%	7.55% - 10.27%	8.0%
Other Packaging (plastic)	3.1%	0.26% - 0.74%	0.6%
Mixed Metals/Materials	2.9%	1.61% - 3.75%	0.2%

4.2 PROCESS AREA SORTS

As described in Appendix A, all wastes (garbage plus recyclables) from the nine targeted process areas were collected over week-long periods. The results described below are based on aggregated data from the 10 participating companies.

Table 4 indicates the number of participants who received sorts in each of the nine process areas. Detailed results can be found in Appendix D.

Table 4: Summary of Process Area Sorts

Process Area	Number of Participants
Metals Milling	3
Shipping & Receiving	9
Sub/Final Assembly	8
CB Assembly	7
Plastics Molding/Cutting	2
Surface Mount	7
Transformers/Magnetics	4
Soldering Operations	2
Coating & Potting	1

4.2.1 Results

Table 5 ranks each of the process areas in terms of average weekly disposal and lists the material that is most prevalent in the disposed waste stream. Per-employee generation rates are provided to enable relative comparisons between process areas. (These rates are calculated using total manufacturing employment at the facility as opposed to employment in each of the process areas.) Similar to the dumpster sort, these results also highlight the abundance of packaging materials. The small amount of scrap reflects the industry's emphasis on scrap reduction.

Table 5: Comparison of Generation, Disposal and Recycling by Process Area (Ranked by Average Weekly Disposal)

Process Area	Average Disposal (lbs/week)	Average Recycling (lbs/week)	% Recycled	Per-Employee Generation Rate (lbs/week)	Most Prevalent Material
Plastics Molding/Cutting	320	0	0%	1.22	Plastic Scrap
Shipping & Receiving	93	56	38%	0.91	Cardboard
CB Assembly	92	6	6%	0.53	Non-recyclable Paper
Metals Milling	73	671	90%	2.79	Non-recyclable Paper
Sub/Final Assembly	71	35	33%	1.06	Cardboard
Surface Mount	69	6	8%	0.39	Plastic Reels
Transformers/Magnetics	39	30	43%	0.38	Cardboard
Soldering Operations	9	2	18%	0.04	Paper Towels/Tissues
Coating & Potting	5	0	0%	0.03	Miscellaneous Metals

The results from each process area are summarized below.

[1] Range represents 90% confidence interval; includes a wide range of SIC codes
[2] Includes SIC 20-40.

Metals Milling

Waste from three Metals Milling areas was collected and sorted. A total of 2,234 pounds of disposed and recovered waste was weighed. The majority of the waste consisted of mixed metals (brass, aluminum, iron, etc.) which were recovered at a very high rate–over 90%.

Waste generation in the Metals Milling area averaged 2.79 pounds per employee per week. Metal scrap accounted for approximately 88% of the waste from this area. Table 6 highlights the top five materials found in Metals Milling.

Table 6: Top 5 Materials in Metals Milling

Material	Lbs. Disposed	Lbs. Recycled
Other Metals	14	1,421
Aluminum	40	517
Non-Recyclable Paper	83	0
Cardboard	1	76
Wood	29	0
All Other Materials	53	0
Total	**220**	**2,014**

The non-recycled portion of the "other metals" stream consisted mostly of metal slivers and scraps that had fallen on the floor and were then swept into the regular garbage. Non-recyclable paper consisted largely of protective linings and packaging. Unlike the other process areas sorted, the majority of waste in Metals Milling consists of manufacturing waste (89%) as opposed to packaging waste (4%) or other waste (6%).

Shipping & Receiving

Waste from nine Shipping & Receiving areas was sorted. Of the 1,336 pounds of waste collected, a total of 834 pounds of waste was disposed and 503 pounds recycled, for a recycling rate approaching 38%. On a weight basis, the majority of the recycled material consisted of cardboard. Interestingly, over 70% of polystyrene peanuts in this area were recovered for recycling.

An average of 0.91 pounds per employee of waste was generated in the Shipping & Receiving areas. As shown in Table 7, cardboard was the most prevalent material in Shipping & Receiving, followed by mixed paper.

Table 7: Top 5 Materials in Shipping & Receiving

Material	Lbs Disposed	Lbs Recycled
Cardboard	343	447
Mixed Paper	279	20
PS Peanuts	14	36
Cardboard w/ Foam-in-Place or Foil Lining	24	0
Bubble Wrap	21	0
All Other Materials	153	0
Total	**834**	**503**

As expected, over 71% of the waste generated in Shipping and Receiving is packaging waste such as cardboard and packaging filler. Manufacturing waste accounted for 1% of the waste and other waste accounted for 29%. Other Waste consists of materials such as mixed waste paper, tape, and food waste.

Sub/Final Assembly

Waste from eight Sub/Final Assembly areas was sorted. A total of 842 pounds of waste was collected, 561 pounds of which were disposed and 281 pounds of which were recycled. Just over 33% of the waste was recycled. On a weight basis, the majority of the recycled material consisted of cardboard. The highest recovery rates, however, were found for loaded circuit boards and components which were unable to be re-worked.

Waste generation approached 1.06 pounds per employee in the Sub/Final Assembly areas. As shown in Table 8, cardboard was the most prevalent material in Sub/Final Assembly, followed by other bags.

Table 8: Top 5 Materials in Sub/Final Assembly

Material	Lbs. Disposed	Lbs. Recycled
Cardboard	149	223
Other Bags	60	0
Mixed Paper	24	21
Cardboard w/ Foam-in-Place or Foil Lining	38	0
Non-Recyclable Paper	32	0
All Other Materials	258	37
Total	**561**	**281**

Other materials found in relatively high volumes included paper reels (29 pounds), plastic scrap (22 pounds), paper towels (21 pounds), PETE bottles (17 pounds), metal scrap (13 pounds), and tab routs (12 pounds). Packaging waste makes up 72% of the Sub/Final Assembly waste stream, with manufacturing waste accounting for 13% and other waste the remaining 15%. Cardboard makes up the majority of the packaging waste.

CB Assembly

Waste from seven CB Assembly areas was sorted. Of the 687 pounds of waste collected, 645 pounds were disposed and 42 pounds were recycled. Only 6% of the waste generated in CB Assembly was recovered for recycling.

Waste generation approached 0.53 pounds per employee in the CB Assembly areas. As shown in Table 9, non-recyclable paper was the most prevalent material in CB Assembly, followed by paper reels. A large portion of the non-recyclable paper was the paper backing used to hold components.

Table 9: Top 5 Materials in CB Assembly

Material	Lbs Disposed	Lbs Recycled
Non-Recyclable Paper	210	0
Paper Reels	133	0
Mixed Paper	66	13
Component Tubes	54	0
Cardboard	33	14
All Other Materials	149	15
Total	**645**	**42**

In CB Assembly, packaging waste accounts for 76%, manufacturing waste for 4% and other waste for 19% of the waste stream.

Plastics Molding/Cutting

Waste from two Plastics Molding/Cutting areas was sorted. None of the 640 pounds of waste collected was recycled. Over 620 pounds of the waste from the Plastics Molding/Cutting area was plastic scraps (includes break-aways, cut-outs, molding machine bleeds and mixed resins).

Waste generation approached 1.22 pounds per employee in the Plastics Molding/Cutting areas. Table 10 lists the five most prevalent items found in the Plastics Molding/Cutting areas.

Table 10: Top 5 Materials in Plastics Molding/Cutting

Material	Lbs Disposed	Lbs Recycled
Plastics Scrap	621	0
Non-Recyclable Paper	9	0
Tape	5	0
Other Bags (Plastic)	3	0
Cardboard	1	0
All Other Materials	1	0
Total	**640**	**0**

In the Plastics Molding/Cutting areas, manufacturing waste made up 97% of the waste stream, with packaging waste accounting for 2% and other waste rounding out the remaining 1%.

Surface Mount

Waste from seven Surface Mount areas was sorted. Of the 528 pounds of waste collected, 487 pounds were disposed and 41 pounds were recycled. Approximately 8% of the waste generated in Surface Mount was recovered for recycling, the majority of which was office paper.

Waste generation approached 0.39 pounds per employee in the Surface Mount areas. As shown in Table 11, plastic reels were the most prevalent material, followed by office paper.

Table 11: Top 5 Materials in Surface Mount

Material	Lbs Disposed	Lbs Recycled
Plastic Reels	89	0
Office Paper	36	33
Cardboard	60	8
Scrap Plastic	54	0
Other Bags (plastic)	44	0
All Other Materials	204	0
Total	**487**	**41**

Other materials found in relatively high volumes include mixed paper (25 pounds), paper towels (19 pounds), rubber gloves/fingers (17 pounds), film wrap (12 pounds), and component tubes (12 pounds). Packaging waste accounted for 50% of the Surface Mount waste stream. The remainder consisted of 18% manufacturing waste and 32% other waste.

Transformers/Magnetics

Waste from four Transformers/Magnetics areas was sorted. A total of 275 pounds of waste was collected, just under half of which was recycled.

Waste generation approached 0.38 pounds per employee in the Transformers/ Magnetics areas. As shown in Table 12, lead dross was the most prevalent material, followed by cardboard.

Table 12: Top 5 Materials in Transformers/Magnetics

Material	Lbs. Disposed	Lbs. Recycled
Lead Dross	0	54
Cardboard	37	12
Mixed Paper	16	15
Other Chemicals	20	0
Other Paint/Coatings	14	0
All Other Materials	69	38
Total	**156**	**119**

Half of the Transformer/Magnetics waste stream consisted of manufacturing waste. Packaging waste accounted for 29% and other waste for 22%.

Soldering Operations

Waste from two Soldering Operations areas was sorted. No sorts were performed during the second phase of the study due to the minimal amounts of waste found in phase one. Of the 20 pounds of waste collected, 17 pounds were disposed and 4 pounds were recycled. Approximately 18% of the waste generated was recovered for recycling, all of which was lead dross.

Waste generation approached 0.04 pounds per employee in Soldering Operations. As shown in Table 13, paper towels/tissues were the most prevalent material.

Table 13: Top 5 Materials in Soldering Operations

Material	Lbs Disposed	Lbs Recycled
Paper Towels/Tissues	10	0
Cardboard	4	0
Lead Dross	0	4
Misc. Waste	1	0
Plastic Scrap	1	0
All Other Materials	1	0
Total	**17**	**4**

Manufacturing waste and packaging waste each accounted for 22% of the Soldering Operations waste stream, while other waste made up 56%.

Coating & Potting

Waste from one Coating & Potting area was sorted. No sorts of Coating & Potting were performed during the second phase of the study due to the minimal amounts of waste found in phase one. A total of five pounds of waste collected over the week-long period, all of which were disposed as shown in Table 14.

Waste generation approached 0.03 pounds per employee in Coating & Potting.

Table 14: Top 5 Materials in Coating & Potting

Material	Lbs Disposed	Lbs Recycled
Other Metals	1	0
Paper Towels/Tissues	1	0
Newspaper	1	0
Pink ESD Bags	<1	0
Plastic Scrap	<1	0
All Other Materials	1	0
Total	**5**	**0**

Manufacturing and other waste each accounted for 43% of the Coating & Potting waste stream. Packaging waste made up the remaining 14%.

5.0 SUMMARY OF ONSITE SURVEYS

This section of the report provides a snapshot of existing recovery and reuse efforts as well as a discussion of business practices that impact recycling, waste reduction, and reuse activities. The onsite visits provided an opportunity to witness the waste management and recycling practices of the participating companies. A copy of the survey is included in Appendix E.

Each of the participants currently uses commercial garbage collection services. Collection frequency varied from daily to on-call. For those businesses with on-call service, containers are usually emptied once every four-to-six weeks. Container sizes ranged from a 1 yd^3 dumpster to a 60 yd^3 compactor. Separate containers for recyclables range in size from large plastic bags for polystyrene (PS) peanuts to a 40 yd^3 compactor for cardboard.

5.1 RECOVERY EFFORTS

All ten companies have recycling programs. The most commonly recycled materials are scrap metals, high grade office paper and cardboard. Table 15 shows the number of participants recovering or generating specific materials and the relative overall benefit of recovering the materials (revenues minus costs). This table shows that more companies are recovering materials at no charge or at a net cost than are receiving revenue for recovered materials. What this table does not show, however, is that companies that recover materials at a net cost still achieve net savings as a result of avoided disposal costs. The cost of recovering materials is cheaper than the cost of disposing these materials.

Due to regulations prohibiting the disposal of lead, solder dross and circuit boards are being recovered at all but one of the companies. The companies pay from $0.30 to $0.75 per pound for the collection of circuit boards. A credit is given back to companies for the precious metals extracted from the board and components. For example, one company pays $14,000 per year for circuit board collection and receives approximately $3,000 per year in credits. After lead and precious metals are recovered, the remainder of the circuit board material is incinerated. The only company that does not have a regular solder collection program generates very small quantities and is not disposing this material. Instead, the company is slowly accumulating enough spent solder to ship to reclaimers.

One company is experimenting with a collection program to separate un-impregnated tab routs (hardened plastic resins) for collection. These materials are being sent to a local company that fabricates wood replacement products. This program has just begun and only small quantities of materials have been collected so far.

Few participants have contracts for the collection of recoverable materials that stipulate collection costs, revenues, educational activities or other agreements. When asked, most participants did not think that they could specify such terms. By viewing these materials as resources with value rather than waste, and specifying contract terms accordingly, firms have ample potential to further optimize revenue.

Table 15: Number of Participants with Recovery Programs for Specified Materials. Total Participants = 10

Material	Recovering	Generating But Not Recovering	Not Generating	Realize Net Revenue[3]	Realize Net Cost[4]	Collected at No Charge[5]
Scrap Metals (other than copper)	9	1	0	8	1	0
High Grade Office Paper	10	0	0	5	1[6]	4
Copper	4	3	3	4	0	0
Cardboard	9	1	0	3	1	5
Mixed Waste Paper	4	6	0	1	0	3
Aluminum Cans	5	5	0	1	0	4
Polystyrene Peanuts	4	6	0	0	1	3
Circuit Boards	7	2	1	0	7	0

3 Material revenue minus collection charge is greater than zero; i.e. companies are paid for recovery of the material

4 Material revenue minus collection charge is less than zero; i.e. companies pay to recover material

5 Material is collected free of charge and no revenue is received

6 Cost is associated with handling of sensitive information

Table 15: (cont.)

Material	Recovering	Generating But Not Recovering	Not Generating	Realize Net Revenue[7]	Realize Net Cost[8]	Collected at No Charge[9]
Casings (mixture of materials)	2	3	5	0	0	2
Solder Dross	9	1	0	0	8	0
Other	6	4	0	0	4[10]	2[11]

5.2 REUSE EFFORTS

Several participants are making significant efforts to reuse packaging materials in-house and when conducting transactions with suppliers. Reuse efforts are difficult to measure but can be an important part of waste management solutions. Table 16 illustrates the range of materials reused by participants.

Table 16: Materials Currently Being Reused

Material	Number of Participants
Cardboard	7
ESD/Static Dissipative Bags	6
Shipping Materials (paper, bubble wrap, etc.)	5
PS Peanuts	5
Durable Shipping Containers	3
Reels (wood and plastic)	2
Component Tubes	2
Other	2

To encourage reuse, containers are placed strategically to capture a wide range of materials. For example, in CB Assembly, several participants have small boxes at each workstation for ESD bags. Employees use and reuse the bags as they accumulate in the boxes. When the

7 Material revenue minus collection charge is greater than zero; i.e. companies are paid for recovery of the material
8 Material revenue minus collection charge is less than zero; i.e. companies pay to recover material
9 Material is collected free of charge and no revenue is received
10 Materials include acids, wood pallets, and wood spools
11 Materials include fiberglass tab routs, wood pallets and spools

boxes are full, employees deposit the bags at a central location. When talking to employees, several mentioned that they have implemented reuse activities as a way of making their jobs easier.

Several participants are interested in expanding the use of durable or reusable shipping containers with suppliers and vendors, but have had negative experiences trying to implement such a program. In one case, a memorandum of understanding detailing reuse procedures for all shipments to and from a supplier was signed by the participant and the supplier. However, the supplier failed to act according to the specifications set out in the memorandum and eventually the idea was dropped. The participant is now hesitant to try this approach again given the failure of the first attempt.

5.3 RECYCLING PRACTICES

This section discusses operational practices that affect the diversion of materials (away from disposal and toward recovery).

Payment for Recyclables and Disposal Regulations Increase Recovery

Few materials that generate revenue, or are regulated, were disposed. For example, less than 2% of the disposed waste stream consisted of recoverable metals and only six lead-impregnated circuit boards were found. Also, no hazardous waste materials were found. Businesses pay attention to revenue-producing, or regulated, materials. However, few businesses consider the potential savings from avoided disposal costs when evaluating the feasibility of implementing a recovery program.

The distinction between receiving payment for a material with widely known prices and simply having collection is important. For example, metals markets operate largely as a commodities market with known prices. All businesses that recover metals expect, and receive, similar prices. Prices for paper collection, on the other hand, vary widely. In this study, the range for cardboard was $25/ton to $100/ton (compacted but not baled). Given the lack of an established pricing system, businesses are confused about the "fair" price for materials. They do not expect a consistent or substantial payment. Therefore, they do not monitor the disposal and/or recycling of paper, and other similar recyclables, as closely as they do metals.[12] Many of the businesses still think of paper as a waste product rather than a revenue-producing resource.

Point-of-Generation Separation Results in Higher Diversion Levels

In a point-of-generation separation system, each workstation or series of workstations has separate containers for garbage and recyclables. Frequently, individual employees are responsible for emptying the recycling containers at their workstations into centrally located stations. For example, a deskside paper box is emptied by the employee into a 90-gallon container in the copy room. The janitorial staff is then responsible for emptying the centrally located bins into the appropriate dumpster or large wire box on the loading dock or in the storage area. In other types of source-separated systems, a limited number of staff (usually the custodians) are responsible for the entire facility's waste. They must sort the recyclables from the garbage.

Anecdotal evidence indicates that source-separation at the point of generation is more successful than source-separation at any other point. For example, at one company that source-separates cardboard at the point of generation, cardboard accounted for just 6% of the disposed waste stream. At another company that relied on the janitorial staff to separate recyclables, cardboard accounted for 20% of the disposed waste stream.

Source-separation at the point of generation also appears to have important employee education benefits. Several employees in companies that do not source-separate at the point of generation were uncertain, when asked, about what materials were recycled at the company.

[12] Established prices are not the only factor contributing to the difference in metal and paper recycling rates, however. Metals are somewhat easier to recover–frequently, metals are generated at just one or two easily monitored points, while paper is generated throughout a facility. Weight is also important–it takes many more pieces of paper than metal to make a ton (a typical recycling unit).

Clearly Marked Containers Generate Higher Recycling Volumes and Less Contamination

Clearly marked containers include a description of what is acceptable and what is not acceptable. "Office Paper" and "Mixed Waste Paper" bins are frequently confused because there is no description of what constitutes one type of paper or the other. The confusion leads to the exclusion of recyclable materials from the recycling containers. Pictures and/or examples are useful, especially in cases of language barriers. No participant requested service providers to conduct employee training, which could have eased the confusion.

Packaging Specifications Decrease Unwanted Discards

One participant requested that its vendors and suppliers stop using polystyrene peanuts. Peanuts were cited by most participants as the one material they would most like to discontinue using. The desire to reduce or eliminate certain packaging materials (such as peanuts) must be communicated to vendors and suppliers. Once the policy has been established, when shipments arrive with the undesired material, a deduction for handling the unwanted material could be charged to the shipper. It is important that the vendors understand the new policy before unacceptable packages are returned.

Packaging specifications can also state preferences for recycled-content and recyclable packaging materials. Internally, the purchasing agent can order cardboard boxes and packaging materials with post-consumer content. These materials are widely available through normal suppliers and distributors. Some habits are difficult to change, as exemplified by several participants that use boxes containing no post-consumer content simply because they are "the boxes we've always used."

Packaging associated with clean rooms, particularly the clothes-changing area, contributes significantly to the amount of disposed waste. Nearly 50% of the clean room's waste was generated in the changing area - primarily in the form of plastic. Considerable waste reductions would be possible if alternative packaging were found.

Sharing Cost & Quantity Information Motivates Employees to Recycle

Tracking recycling and disposal costs and quantities enables managers to evaluate the effectiveness of various programs. Historically, this information has resided in the accounting department–beyond the access of most employees.

During the collection period, however, employees showed a great deal of interest in the study and recycling in general. Many took the time to show us small efforts that they have made to increase recovery or reduce use of materials, particularly in packaging. Most employees want to "do the right thing" environmentally. Sharing the recycling and disposal figures with these employees would have enabled them to see the financial effects of their actions. One company already posts this kind of data, prominently displaying scrap, recycling and productivity rates in the lunch room.

Sharing this information with employees accomplishes two goals. First, it indicates to employees that the company is serious about its recovery efforts. Second, it provides employees with a gauge for how well they are doing in their recovery efforts. In fact, the tracking and reporting can be used to challenge employees to reach a certain level of recycling by a given date and to monitor how well they are doing at achieving the goal.

Most participants shared the results of this study's sorts with employees and the information was well received. In one case, the facility manager was surprised at the quantity of office paper still being disposed even with a recovery program in place. He shared the results of the waste sorts with employees via e-mail and scheduled a luncheon meeting with interested employees the following week. During the interim, he wandered from office to office and collected all office paper he found in garbage containers. At the luncheon, he asked attendees how much paper they disposed the previous week and then proceeded to weigh the paper he had recovered from office garbage cans–a total of 12 pounds! Then the group discussed ways to improve the program. Other participants shared the results of the waste sorts through the company newsletter, e-mail, and luncheon discussions.

Just-In-Time Delivery & Change Orders Contribute to Packaging Waste

In general, more "padding" (i.e. bubble wrap, crumpled paper) is being shipped between vendors, suppliers, manufacturers, and clients largely due to the increased frequency of shipments and the smaller quantity of products being shipped at any one time. Several participants noted that these two business practices, which they had recently implemented, have substantially increased their packaging waste.

Space Limitations Hamper Recovery Efforts

Many businesses cite lack of storage space, coupled with the time it takes to accumulate sufficient quantities of some materials, as a reason for not recovering a broader range of recyclables. In certain cases, the space problem may be a logistical issue that could be easily solved by reorganizing the loading dock or other storage areas.

Some items generated in small quantities are accumulated and stored until there are enough for collection. These items generally include wood pallets, reels, and polystyrene peanuts. However, only a handful of employees usually know what materials are being accumulated and where materials are being stored.

Use of an Aggressive Recycling Service Provider Increases Recovery Levels

Participants would prefer having one contractor handle all recyclables. However, several participants indicated that they are not recovering some materials because their recycler does not handle them. In addition, there is a lack of knowledge about which companies service what materials. Participants are not accustomed to comparing the services of recyclers.

For example, no participant had told their hauler that they would switch to a different recycler if they did not start collecting a specific material. It is quite feasible, however, to change service providers or to work with existing haulers to handle a broader range of materials.

Coordination Among Departments Minimizes Waste Generation

Participants cited lack of coordination as a cause of excessive waste generation for a wide range of materials including office paper. Participants also noted that a lack of coordination hampers reuse, recovery, and buy-recycled efforts. For example, one participant indicated they could reuse a much higher number of component reels if all departments knew that the supplier had agreed to reload reels. Unfortunately, until this project, many departments were not aware of the agreement and were therefore discarding reels. In many cases, department heads have few opportunities to share ideas on waste management.

Employee Interest in Reusable Shipping Containers is High

Several participants have attempted to use durable shipping containers with little success. Participants are aware of the volume of waste generated by the shipping and receiving functions and see reusables as a partial solution to the problem. Again, there is a willingness to try new technologies, but participants are often unable to implement programs due to a number of factors, including lack of time or resources to fully research and document cost-savings potential.

6.0 CONCLUSIONS

All participating companies are looking for ways to improve their recycling programs and saw this study as an opportunity to gain important information to help them in their efforts. Participants shared the results of their study with employees, with several using the results as a way of beginning a company-wide dialogue about how to improve their recycling program.

Significant findings in this study include:

- Packaging materials, primarily paper and plastic, comprise the majority of the electronics industry waste stream. This finding is supported by both the dumpster sorts and the process area sorts. Just-in-time production schedules may actually contribute to increased use of packaging materials. (The overall cost impact of just-in-time production was not measured in this study.) One way to reduce the impact of added packaging materials is to require the use of recyclable or reusable materials by suppliers. Some packing materials such as foam-in-place and cardboard boxes secured with large amounts of tape are not currently recyclable.

- The Plastics Molding/Cutting areas in this study generated the largest quantity of disposed waste. This waste consists largely of plastic scrap in the form of cut-outs and break-aways. The Metals Milling area generated the highest quantities of recycled by-products, with approximately 90% of the by-products from this area being recycled.

- Of the process areas studied, Shipping & Receiving disposes the second highest quantity of waste. This makes sense, since the department handles all items that come into and leave the facility. It is also the department that can achieve the most gains in recycling. This is due both to the quantity of material being generated in the department and the fact that the majority of the material is highly recyclable. Table 17 shows waste generation by process area.

Table 17: Comparison of Disposal by Process Area (Ranked by Average Weekly Disposal)

Process Area	Average Disposal (lbs/week)	Most Prevalent Disposed Material
Plastics Molding/Cutting	320	Plastic Scrap
Shipping & Receiving	93	Cardboard
CB Assembly	92	Non-Recyclable Paper
Metals Milling	73	Non-Recyclable Paper
Sub/Final Assembly	71	Cardboard
Surface Mount	69	Plastic Reels
Transformers/Magnetics	39	Cardboard
Soldering Operations	9	Paper Towels/Tissues
Coating & Potting	5	Other Metals

- Recovery efforts can be improved significantly. Regulated materials and materials for which the company receives money are recycled at very high rates. Other materials, such as cardboard and paper, are being recycled much less efficiently. Capture rates barely reach 20% for these materials. Providing employees with information on current disposal and recycling levels is one way to motivate employees to achieve higher diversion rates. Educating managers about the value of by-products is also effective.

- The office and cafeteria functions of a business are large contributors to disposed waste. The results of the dumpster sorts showed that relatively small quantities of manufacturing waste, other than packaging materials, are being discarded.

- Employee involvement in recovery activities seems to improve recovery rates. Employee involvement can be as simple as providing deskside bins. Also, companies should be encouraged to use recycling service providers to educate employees through staff meetings or seminars/workshops. Some particular areas of confusion include what types of paper are considered “office paper” versus “mixed paper.” Signage with pictures and words is helpful for minimizing confusion.

- Coordination between work groups and departments is essential to minimizing waste generation and maximizing the recovery of materials.

- Employees continually look for ways to reuse materials ranging from cardboard boxes to plastic bags. Many pink ESD bags are reused multiple times prior to disposal. Some companies have tried more formal arrangements with suppliers and vendors with conflicting results. Persistence and continual dialogue about the goals of a reuse program are important to the success of such a program.

- Opportunities for using recycled-content materials for feedstock are limited in the ten participants' facilities. There are several exceptions, including the Plastics Molding/Cutting area and Shipping & Receiving. Recycled resins could be used as well as post-consumer cardboard, packaging paper, and film wrap. Both the individual business and their suppliers could use recycled-content and recyclable materials for shipping.[13] A third option is specific to one company that uses a large number of non-foam polystyrene rigid trays for carrying components. These trays could be made of post-consumer material, including material collected within the company.

[13] However, some Department of Defense specifications may conflict with using recycled-content packaging.

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This document is printed on recycled paper: 50% total recycled content; 20% post-consumer.

APPENDIX A

METHODOLOGY

Ten members of the Washington State chapter of the American Electronics Association (AEA) within primary SIC codes 3400 - 3999 were selected to participate in this study. The AEA Environmental Health and Safety Committee assisted in developing the business selection criteria. Cascadia Consulting Group completed the project scope of work. The Clean Washington Center's Recycling Technology Assistance Partnership (ReTAP) provided funding for completion of the work, with in-kind assistance provided by the AEA.

APPROACH

The project scope included three parts:

- process-area sorts
- dumpster sorts
- on-site surveys

In the process area sorts, information was complied for selected process areas. Garbage and recyclables generated in each of these departments were collected separately over a week-long period, then sorted.

The full dumpster sort was considered valuable as it would provide information for the facility as a whole and could be used in firm-wide discussions about waste management options. In addition, several Committee members felt that the office and cafeteria generate large quantities of waste which would be identified in this sort. Therefore, it was decided that each participating business would have their dumpster sorted one time.

The study included six stages:

1. selecting process areas
2. identifying material sorting categories
3. selecting study participants
4. conducting on-site visits
5. collecting and sorting waste (process-specific and full dumpster)
6. analyzing data

Each stage is fully described in the following sections of this Appendix.

1. Select Process Areas

The Committee drafted a list of manufacturing processes thought to be common to most electronics companies. The list was finalized after further research and the initial on-site visits with participating firms. Nine process areas were identified for this study:

1. *Metals Milling* is where metal is milled, shaved, and/or laser cut into a variety of pieces that are used to assemble a final product. The main materials used in this area are stainless steel, aluminum, and brass. Most by-product is recovered, although some shavings are swept from the floor and disposed. Most other waste found in this area is "people waste" such as leftover food, tissues, and paper.

2. *Shipping & Receiving* is the area in which supplies enter and products leave the facility. Materials used in this area include cardboard boxes and other packaging materials such as electro-static dissipative (ESD) bags, foam peanuts, bubble wrap, foam-in-place and paper padding. Other types of materials used and disposed include mailing labels and backings, office paper, and other general waste. Materials recovered from this area include cardboard, mixed paper, office paper, and polystyrene peanuts.

3. *Sub/Final Assembly* is the area in which fully-loaded circuit boards are encased in a near-final or final product. The process may involve connecting several electronic pieces that have been assembled elsewhere, such as a digital screen to a circuit board. The waste generated in this area includes ESD bags, cardboard, mixed paper and other packaging materials. This is also the area in which failed circuit boards and components are recovered for re-work and scrap.

4. *CB Assembly* is where capacitors and other components are soldered and inserted onto blank circuit boards. Waste generated in this area includes component reels and tubes, office paper, cardboard, faulty boards, ESD and other plastic bags. Other materials used in this area include tissues and cotton swabs for the application of cleaning alcohols and small quantities of lead solder.

5. *Plastics Molding/Cutting* is where plastic parts or sheets are fabricated. A variety of plastic resins are used for the fabrication of various parts and sheets. The scrap includes trimmings (break-aways and cutouts) and excess resin that is "bled" out of the machine before fabrication of a new part begins.

6. *Surface Mount* is the area where chips and other such components are electronically or manually inserted onto a board that has already been hard-wired in the CB Assembly area (or by subcontract). Waste includes component reels, office paper, cardboard, faulty boards, and plastic bags. Office paper and cardboard are recovered to some extent from these areas.

7. *Transformers/Magnetics* is the area in which transformers are assembled and/or fabricated. Typical materials include copper and solder dross (most of which is recovered), cardboard, mixed paper, and a variety of chemicals, including ethers, fluxes and epoxies.

8. *Soldering Operations* is where a series of components or wiring are affixed to a circuit board using lead, ethers, and applicants (tissues, cotton swabs). Only stand-alone soldering operations, usually flow-solder, were included in this study. Very little solid waste is generated in this area.

9. *Coating & Potting* is the area in which electronic components are encased in a hardened epoxy. The main materials used in this process are epoxies, hardening agents, alcohols, paper cups for holding the soft epoxy, and tissues. Very little solid waste is generated in this area.

2. Identify Material Sorting Categories

Once process areas were chosen, it was necessary to identify materials commonly found in those areas. As a starting point, the Committee reviewed categories used by the King County (WA) Solid Waste Division for municipal waste sorts and a listing from the Industrial Materials Exchange (IMEX). Due to methodological differences in conducting the process-specific dumpster sorts versus the dumpster sorts, two separate category lists were developed. Sorting categories for dumpster sorts and process area sorts are described in detail in Appendix B.

For the process-area sorts, the IMEX categories appeared more relevant. Hazardous wastes are beyond the scope of this study; therefore, these items were not included. Based on input from the Committee, the following materials were added to the list:

- Pink and mirrored electro-static discharge (ESD) bags and tubes
- Circuit boards, with a differentiation between loaded and unloaded boards
- Pallets
- Copper wire

Originally, the plastics category was divided along resin lines. The list was later determined to be too lengthy for sorting purposes (for example, many categories with very small quantities in each). Thus, general plastics categories were used unless large quantities of specific resins were found. In that case, the particular plastic was identified and weighed as a separate category.

The dumpster sort category list is based on the King County Solid Waste Division categories. The sorting crew took additional notes when specific materials related to manufacturing were found. For example, ESD bags, copper, and circuit boards were all tracked separately.

3. Select Study Participants

A total of ten businesses were to be selected–five for phase one (November/December) and five for phase two (April/May). The Committee identified a number of AEA member firms that were likely to participate in the study. The CEO or President of each targeted company was sent a project description, printed on AEA letterhead and signed by AEA Executive Director Terry Byington.

Cascadia followed up with a telephone call and was referred to an appropriate contact person. As determined by the Clean Washington Center and the Committee, selection criteria included:

1. Willingness and eagerness to participate
2. Range of manufacturing processes
3. Size of firm, measured by number of employees (weighted toward small firms)
4. Ability to compile survey data
5. Location (primarily Puget Sound; at least one outside Puget Sound)

Many of the small companies contacted were not interested in participating. Some indicated that production levels were too low; others did not volunteer a reason.

The companies selected are listed below:

Company Name	Location	Primary SIC Code	Employees at Facility
Phase One			
Data I/O	Redmond	3829	325
Fluke	Everett	3823	350
Huntron Instruments	Mill Creek	3826	42
Korry Electronics	Seattle	3721	410
Olin Aerospace	Redmond	3405	200
Phase Two			
Carlyle	Tukwila	3661	85
Carver Corporation	Lynnwood	3651	143
GM Nameplate	Seattle	3993	350
Interpoint	Redmond	3674	250
Sharp Microelectronics	Camas	3998	480

4. Conduct On-site Visit

Meetings were scheduled with each participant prior to sampling. The purpose of these meetings was two-fold. The first objective was to tour the facility, identify the process areas, locate dumpsters, and meet contact people. The second was to gather survey information.

The first visit enabled Cascadia to get a sense of the entire facility, with follow-up visits used to map out the exact process areas from which waste would be collected. As described above, the study includes nine process areas. Four to five of these areas were chosen at each company. The specific areas selected depended on the individual participant's preferences, along with the need for continuity from firm to firm (in order to aggregate results).

For the week-long study period, arrangements were made to collect the waste samples prior to janitorial services. For some participants, this involved attending additional meetings with the janitorial staff. Process-area staff were briefed about the study so that they would not be surprised when strangers showed up to take their garbage and recyclables away.

The second purpose of the on-site visit was to conduct a brief survey. A copy of the questionnaire can be found in Appendix E. The survey tracks five types of data:

- *General Information*, including primary SIC code
- *Employment Information*, including sales volume
- *Waste Management Practices*, including recovery activities
- *Site-Specific Manufacturing Processes*, including scrap rates
- *Plant Capacity & Utilization*, including recycling investments

In addition, attempts were made to determine how special recyclables (i.e., circuit boards) are being used. This was accomplished by contacting the participant's recycling haulers.

5. Collect and Sort Waste

Two separate methodologies, for process-specific and dumpster sorts, are described below.

Process-Area Sorts

In some cases, the boundaries between one process area and another were not clearly marked, so it was very important to specify the exact location of garbage and recycling containers. Receptacles to be included in the study were marked with a color-coded sticker when appropriate. Collection took place prior to regular janitorial service–generally at the end of the day shift.

Each day during a one-week period, the consultant emptied the selected garbage cans and recycling bins into separate plastic bags. The bags were labeled with the company name, process area and date, then transferred off site for storage, weighing, and sorting.

Occasionally, the large volumes of recyclables (particularly in the Shipping & Receiving areas) prevented the consultant from taking the materials off site. In these cases, the materials were weighed on site each day and recorded. Potentially hazardous or particularly valuable recyclables, such as lead dross, copper wire, circuit boards, tab routs and other special materials, were measured on site at the end of the study week.

In addition, if unusually high volumes of a specific material were noted, the consultant contacted the company liaison in order to identify how the waste was generated. Plastic resins were identified by asking the plastics engineer.

Once the material was off site, a two-person crew sorted and weighed all waste. Each bag was weighed, then emptied and sorted into component categories. Every material over two inches was sorted. Material under two inches was included in the "Misc. Other" category. Each component was then weighed. A scale accurate to one-tenth of a pound was used for weighing all materials over a pound. For smaller amounts, a postal scale accurate to one tenth of an ounce was used. The weight of the empty bag was also measured. All weights were then added to ensure that the weight of the empty bag and contents matched that of the full bag. The materials were then taken to the transfer station for proper disposal or recycling.

In addition to measuring disposed and recycled wastes, this study also attempted to track reuse of materials. This proved to be difficult since most reused materials are not segregated from first-use supplies or recyclables. Exceptions include paper and plastic reels, which are generally shipped back to the vendor. At the end of the collection week, the reels were weighed on site and recorded as reused materials.

Dumpster/Compactor Sorts

Cascadia worked with the participating companies and their waste haulers to schedule the sorting day. Sorts were completed November 21, December 9 and 14, and April 15, 27 and 28.

Each participant had sufficient parking lot space, which was blocked off the previous day, to allow for on-site sampling. For roll-off containers, special arrangements were made with the waste haulers for unloading the containers. Smaller dumpsters were tipped by hand. All wastes were dumped onto a tarp to prevent ground water contamination.

The dumped load was first inspected visually. All bulky items (over one foot) were pulled and sorted into their component categories.[14] Next, a 200-300 pound sample was randomly selected and put aside for sorting. (For smaller loads, the contents of the entire dumpster were sorted.) The composition of the sample was applied to the weight of the remaining load.

The sample was hand-sorted into the prescribed component categories and placed in labeled laundry baskets. The components were weighed on a scale accurate to one-tenth of a pound. The weights of the bulky items were recorded separately. After the sample was sorted and weighed, all materials were returned to the dumpster. To make sure that no residue remained, the sorting site was swept clean. All data were then checked by the field supervisor and entered into a spreadsheet.

6. Analyze Data

Process-Area Sort

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[14] Cascadia has found that removing and weighing all large items prior to selecting a 200-300 pound sample reduces error associated with the presence (or absence) of bulky items. This technique has been shown to reduce error rates for municipal solid waste sorts.

To calculate the waste characterizations, the weight of each component material was divided by the total weight of the process area's waste. Specific calculations were made for each process area studied within the participating company. Per-employee generation rates were also estimated. The individual results are not discussed in this report. Rather, the data are being shared with the participants. Aggregated results, which are the average of each company's individual numbers, are discussed in the main section of the report.

Dumpster/Compactor Sort

As described above, each dumpster load was divided into three parts:

- bulky materials
- a 200- to 300-pound sample
- remaining load

The bulky materials were sorted into component categories as they were pulled from the load. The waste characterization for the sample was calculated in the same manner as the process-area data, above. Next, the sample composition was applied to the remaining load. The results, by component category, were then added to the components of the bulky materials, characterizing the total dumpster load. Again, individual company results are not discussed, but aggregate numbers are presented in this report. These overall numbers are weighted averages, based on estimated annual volumes.

APPENDIX B

SORTING CATEGORIES FOR DUMPSTER SORTS

PAPER

- Newspaper
- OCC/Kraft
- Low Grade Recyclable
- High Grade Printing
- Computer Paper
- Bleached Polycoats
- Paper/Other Materials
- Other Paper

PLASTICS

- PET #1 Bottles
- HDPE #2 Bottles
- Other Containers
- Polystyrene Foam
- Film and Bags
- Other Packaging
- Plastic Products
- Plastic/Other Materials

WOOD & YARD WASTES

- Dimension Lumber
- Treated Wood
- Contaminated Wood
- Roofing & Siding
- Stumps
- Large Prunings
- Yard Wastes
- Other Wood

OTHER ORGANICS

- Food Wastes
- Textiles/Clothes
- Carpet/Upholstery
- Disposable Diapers
- Rubber Products
- Tires
- Animal Carcasses
- Animal Feces
- Misc. Organics

GLASS

- Clear Containers
- Green Containers
- Brown Containers
- Refillable Beer
- Other Glass

METALS

- Aluminum Cans
- Other Aluminum
- Tinned Food Cans
- Other Ferrous
- Other Nonferrous
- Mixed Metals/Materials

OTHER WASTES

- Const/Demo Wastes
- Ashes
- Nondistinct Fines
- Gypsum Wallboard
- Furniture/Mattresses
- Small Appliances
- Misc. Inorganics

HAZARDOUS/SPECIAL WASTES

- Used Oil
- Vehicle Batteries
- Household Batteries
- Latex Paint
- Oil-Based Paint
- Solvents/Thinners
- Adhesives/Glues
- Cleaners and Corrosives
- Pesticides/Herbicides
- Gas/Fuel Oil
- Antifreeze
- Medical Waste
- Other Hazardous

COMPONENT DEFINITIONS - DUMPSTER SORT

PAPER

a. Old Newspaper (ONP)—printed groundwood newsprint and other minimally bleached groundwood. This category also includes some glossy paper typically used in newspaper insert advertisements, unless found separately.

b. Corrugated Cardboard (OCC/Kraft Bags)—Kraft linerboard, containerboard cartons and shipping boxes with corrugated paper medium (unwaxed). This category also includes Kraft (brown) paper bags. Excludes waxed and plastic-coated cardboard, solid boxboard, and bags that are not pure unbleached Kraft.

c. Low Grade Recyclable—magazines, phone books, junk mail, used envelopes, other material with sticky labels, construction paper, blueprint and thermal copy paper (NCR paper), fax paper, bright-dyed paper (fiesta or neon colors), paperback books, and groundwood catalogues. This category also includes other low-grade recyclable papers used in packaging, including chipboard and other solid boxboard (not poly-coated), clothing forms, egg cartons (molded pulp), and other boxes.

d. High grade—printing and writing papers, including both groundwood and thermo-chemical pulps. This category is composed of high-grade paper, which includes white ledger, colored ledger, computer cards, bond, copy machine paper, and carbonless paper. Excludes glossy coated paper such as magazines, bright papers, and pure groundwood publications such as catalogs.

e. Computer Paper—continuous-feed computer printouts and forms of various types; does not include multiple-copy carbonless paper.

f. Bleached Polycoated Paperboard—polycoated bleached paperboard cartons used for milk, ice cream, and juice (including aseptic packaging). Does not include frozen food, microwave boxes, cups, or other non-food packaging.

g. Paper and Other Materials—items that are primarily paper, but combined with other materials. Includes juice cans, oil cans, paper or boxboard with foil laminates, notebooks, aluminum foil boxes, and other similar packages or products.

h. Other Paper—paper not included above that is not easily recyclable. Includes carbon paper, tissue, photographs, paper normally soiled through use such as paper plates and paper towels, waxed cardboard, poly-lined chipboard, foil-lined papers, Christmas wrapping paper, microwave containers, frozen food boxes, and hard cover books.

PLASTICS

a. PET Bottles—all bottles made from polyethylene terephthalate (PET), consisting of pop, oil, liquor, and other types of bottles (SPI code 1).

b. HDPE Bottles—all bottles made of high density polyethylene (HDPE), such as milk, juice, detergent, and other bottles (SPI code 2).

c. Other Containers—all other rigid containers with SPI codes 3 through 7, and PET and HDPE containers other than bottles.

d. Polystyrene Foam—expanded polystyrene packaging, food trays, cups, plates, clamshells, and other foam packaging.

e. Plastic Film and Bags—all film, bags and thin plastic packaging, including wrappings, vacuum-formed packaging, bubble packs, and other films, as well as plastic strapping and other thin flexible plastic packaging. Also includes shower curtains, plastic sheeting, trash bags, and other thin plastic products.

f. Other Packaging—all other non-film packaging that does not fit into the above categories including caps, closures, and other miscellaneous items.

g. Plastic Products—primarily rigid or solid consumer items including dishware, utensils and other household items, vinyl products, all-plastic furniture and toys, car parts, and hangers. Also includes thermoset plastics such as formica, fiberglass, and other related products.

h. Plastic and Other Materials—items that are predominantly made of plastic, but are combined with other material, such as kitchenware and car parts with wood or metal components.

WOOD AND YARD WASTES

a. Dimension Lumber—wood commonly used in construction for framing and related uses, including 2 x 4's, 2 x 6's, and sheets of plywood.

b. Treated Wood—wood treated with preservatives such as creosote, including dimension lumber. This category may also include some plywood, strandboard, chemically treated and other wood.

c. Contaminated Wood—wood contaminated with other wastes in such a way that they cannot easily be separated, but consisting primarily (over 50 percent) of wood. Examples include wood with sheetrock attached.

d. Roofing and Siding—wood from demolition or construction wastes that is commonly used for siding or roofing of buildings. This category includes only wood products, such as cedar shingles or shakes.

e. Stumps—stumps of trees and shrubs, with any adhering soil.

f. Large Prunings—other natural woods, such as logs and branches in excess of four inches in diameter (four inches is the limit used for defining prunings as yard wastes).

g. Yard Wastes—leaves, grass clippings, garden wastes, and brush up to four inches in diameter

h. Other Wood—other types of wood including wood products that do not fit into the above categories.

OTHER ORGANICS

a. Food Wastes—wastes from food preparation and leftover food that was not consumed. Includes food in the original or another container when the container weight is less than 10% of the total weight.

b. Textiles: Clothes & Other Recyclables—fabric materials including natural and man-made textile materials such as cottons, wools, silks, woven nylon, rayon, polyesters and other materials. This category includes clothing, rags, curtains, and other fabrics.

c. Textiles—carpets/upholstery, shoes, and other nonrecyclable products including leather products.

d. Disposable Diapers—diapers and similar products made from a combination of fibers, synthetic, and/or natural, and made for the purpose of a single use. Diapers that are all cloth and not originally intended for single use will be classified as a textile. This category includes fecal matter contained within, sanitary napkins and tampons, and adult disposable protective undergarments.

e. Rubber Products (except tires)—items made of natural rubber, including door mats, foam rubber, and other products.

f. Tires—whole tires from automobiles, trucks, motorcycles, bicycle, and other vehicles.

g. Animal Carcasses—carcasses of small animals and pieces of larger animals, unless the waste was the result of food storage or preparation.

h. Animal Excrement—feces from animals.

i. Miscellaneous Organics—hair, wax, soap, and other organics not otherwise classified.

GLASS

a. Clear Containers—bottles and jars that are clear, and were used for food, soft drinks, beer, and wine.

b. Green Containers—bottles and jars that are green in color, and were used for food, soft drinks, beer, and wine.

c. Brown Containers—bottles and jars that are brown in color, and were used for food, soft drinks, beer, and wine.

d. Refillable Beer Bottles—beer bottles that can be returned for a deposit and refilling within King County; including local brewery bar bottles and "stubbies".

e. Other—window glass, mirrors, light bulbs, cooking wear, and other glass and ceramic products which are not easily recyclable.

METALS

a. Aluminum Cans—beverage cans composed of aluminum only.

b. Other Aluminum—other types of aluminum containers such as pans and trays; includes foil and foil products or packages and all other aluminum materials including furniture, house siding, cookware, and scrap.

c. Tinned Food Cans—tin-plated steel cans (food cans), does not include other bi-metals, paint cans, or other type of steel cans.

d. Other Ferrous—ferrous and alloyed ferrous scrap materials derived from iron, including household, industrial, and commercial products including other cans and containers. This category includes scrap iron and steel to which a magnet adheres.

e. Other Non-Ferrous—metals that are not materials derived from iron, including copper, brass, bronze, aluminum bronze, lead, pewter, zinc, and other metals to which a magnet will not adhere. Metals that are significantly contaminated are not included.

f. Mixed Metals and Other Materials—composite metal products and metals combined with other materials, such as engines, electric motors, umbrellas, coated wire, and aerosol cans.

OTHER WASTES

a. Construction/Demolition Waste (except wood)—construction, demolition, or land clearing waste that cannot be placed into one of the above categories, such as concrete, plaster, rocks, gravel, bricks, and insulation of various types.

b. Ashes—material remaining after the combustion process, present in the waste stream as ash from fireplaces and wood stoves, used charcoal from grills, and similar materials.

c. Nondistinct Fines—soil, sand, dirt, and similar non-distinct materials.

d. Gypsum Wallboard

e. Furniture, Mattress, etc.—furniture and mattresses made of mixed materials and in any condition.

f. Small Appliances—small household appliances such as televisions, stereos, radios, toasters, broilers, can openers, blenders, etc.

g. Miscellaneous Inorganics—non-CDL, plaster of paris, concrete items, etc., not otherwise classified.

HOUSEHOLD HAZARDOUS WASTE

a. Used Oil—used lubricating oils, primarily used in cars but including other types with similar characteristics.

b. Vehicle Batteries—car, motorcycle, and other lead-acid batteries used for motorized vehicles.

c. Household Batteries—batteries of various sizes and types, as commonly used in households.

d. Latex Paint—water-based paints and similar products

e. Oil-Based Paint—solvent-based paints, varnishes, and similar products.

f. Solvents and Thinners—various solvents, including chlorinated and flammable solvents, paint strippers, solvents contaminated with other products such as paints, degreasers and some other cleaners if the primary ingredient is (or was) a solvent, and alcohols such as methanol and isopropanol.

g. Adhesives and Glue—glues and adhesives of various sorts, including rubber cement, wood putty, glazing, and spackling compounds, caulking compounds, grout, and joint and auto body fillers.

h. Cleaners and Corrosives—various acids and bases whose primary purpose is to clean surfaces, unclog drains, or perform other actions.

i. Pesticides and Herbicides—variety of poisons whose purpose is to discourage or kill pests, weeks, or microorganisms. Fungicides and wood preservatives, such as pentachlorophenol, are also included.

j. Gasoline and Fuel Oil—gasoline, diesel fuel, and fuel oils.

k. Antifreeze—automobile and other antifreeze mixtures based on ethylene or propylene glycol, also brake and other fluids if based on the same compound.

l. Medical Waste—wastes related to medical activities, including syringes, IV tubing, bandages, medications, and other wastes.

m. Other Hazardous Waste—asbestos-containing wastes if this is the primary hazard associated with the waste; gunpowder, unspent ammunition, picric acid and other potentially explosive chemicals; radioactive materials (but smoke alarms are classified as "other plastic"); and other wastes that do not fit into the above categories.

SORTING CATEGORIES FOR PROCESS AREA SORTS

ACIDS

ALKALIS

SOLVENTS

OTHER CHEMICALS

OIL & WAX

PLASTIC & RUBBER

- **Bottles/Containers**
  - *#1 PETE*
  - *#2 HDPE*
  - *#3 PVC*
  - *#4 LDPE*
  - *#5 PP*
  - *Other*
- **Rigid Packaging**
  - *Component Tubes*
  - *Reels*
  - *Buckets/Pails*
  - *PS foam shapes*
  - *Foam in place*
- **Film**
  - *Pink ESD bags*
  - *Mirror ESD bags*
  - *Other bags*
  - *Bubble wrap*
  - *Flexible PS wrap*
  - *Film wrap*
- **Other Plastics**
  - *PS peanuts*
  - *Food service PS*
  - *Tab routs - no lead*
  - *Hardened epoxy*
  - *Casings*
  - *Scrap*
- **Rubber**
  - *Hose*
  - *Rubber fingers/gloves*

TEXTILE & LEATHER

- **Cloth Rags**
- **Leather**
- **Lint free wipes**

WOOD/PAPER

- **Corrugated**
  - *Plain*
  - *Waxed*
  - *w/ Foam in place*
- **Newspaper**
- **Office Paper**
- **Mixed Paper**
- **Paper Reels**
- **Non-Recyclable Paper**
- **Paper Towels/Tissues**
- **Labels & Post-it Notes**
- **Q-Tips**
- **Wood Reels**
- **Wood**

METALS

- **Aluminum**
  - *Cans*
  - *Other*
- **Copper**
  - *Wire*
  - *Block*
- **Lead Dross**
- **Other**

CIRCUIT BOARDS

- **Raw boards (w/lead)**
- **Loaded boards**
- **Components**

GLASS

- **Container Glass**
- **Flat Glass**
- **Ceramics**

PAINT & COATING

- **Latex paint**
- **Oil based paint**
- **Paint filters**
- **Other**

MISC

- **Food waste**
- **CDL**
- **Tape**
- **Other**

PACKAGING AND MANUFACTURING WASTE IDENTIFICATION

Packaging

PLASTIC & RUBBER

- **Bottles/Containers**
  - *#1 PETE*
  - *#2 HDPE*
  - *#3 PVC*
  - *#4 LDPE*
  - *#5 PP*
  - *Other*
- **Rigid Packaging**
  - *Component Tubes*
  - *Reels*
  - *Buckets/Pails*
  - *PS foam shapes*
  - *PS Rigid*
- **Film**
  - *Pink ESD bags*
  - *Mirror ESD bags*
  - *Other bags*
  - *Bubble wrap*
  - *flexible PS wrap*
  - *film wrap*
- **Other Plastics**
  - *PS peanuts*

WOOD/PAPER

- **Corrugated**
  - *plain*
  - *waxed*
  - *w/ plastic or aluminum*
- **Paper Reels**
- **Wood Reels**
- **Non-Recyclable Paper***

METALS

- **Aluminum**
  - *Cans*

Manufacturing

ACIDS

ALKALIS

SOLVENTS

OTHER CHEMICALS

OIL & WAX

PLASTICS

- **Tab routs - no lead**
- **Hardened epoxy**
- **Casings**
- **Scrap**

METALS

- **Aluminum**
  - *Other*
- **Copper**
  - *Wire*
  - *Block*
- **Lead Dross**
- **Other**

CIRCUIT BOARDS

- **Raw boards (w/lead)**
- **Loaded boards**
- **Components**

PAINT & COATINGS

- **Latex paint**
- **Oil based paint**
- **Paint filters**
- **Other**

* Only the paper component backing tape portion of this category is considered packaging waste. All other non-recyclable paper is considered other waste.

All other sorting categories are included as Other Waste in the report.

APPENDIX C

RESULTS OF DUMPSTER/COMPACTOR SORTS

(Not included in this electronic file)

APPENDIX D
RESULTS OF PROCESS AREA SORTS

(Not included in this electronic file)

APPENDIX E

ON-SITE SURVEY

Not included in this electronic file

APPENDIX F

A GUIDE FOR BUSINESSES WHO WISH TO CONDUCT THEIR OWN WASTE ASSESSMENT

The methodology used in this study is a valuable tool for planning any company's waste management programs. Other firms interested in the type of information this study generated may want to perform their own study. To assist companies in such an effort, a step-by-step overview of the ReTAP study is included here.

1. Assemble a Project Team

Involve management, purchasing, shop and janitorial staff in planning your waste assessment. Solicit ideas to tailor the study to your company. What do you want to learn about your waste generation, disposal and recycling? List your current waste management programs and policies, such as recycling, reusing materials, and purchasing products with reduced packaging and/or recycled content.

In the ReTAP study, waste from several manufacturing areas and from the company's dumpster was sorted and weighed. How precise do your waste composition figures need to be–is a visual inspection of waste containers sufficient, or should you physically sort and weigh a sampling of the process-area and dumpster waste?

2. Select Process Areas

Because participants in the ReTAP study felt it would be valuable to link waste composition data to the actual procedures that generated the waste, sampling took place in selected manufacturing sub-departments, or "process areas". If your company wants to compare individual results to the overall ReTAP study, use a few of the process areas described below. If these do not suit your company, determine which departments would provide the most useful information.

In some instances, the boundaries between one process area and another may be difficult to distinguish. If necessary, map out the departments and label the waste containers to be sampled.

- *Circuit Board (CB) Assembly.* Involves soldering and inserting capacitors and other components which are "hard-wired" onto the board. Tasks are usually performed at a series of workstations.

- *Coating & Potting.* In this process, components are encased in epoxies and resins which are heated until hardened. This is generally a stand-alone operation.

- *Plastics Molding*. Plastic parts are fabricated, from raw resin to end-product, in this process area.

Metals. In this area, metals are milled, shaved and/or laser cut. This work is accomplished using a variety of machines.

- *Shipping & Receiving*. While not a manufacturing process per se, Shipping & Receiving is an integral part of operations, especially as companies move toward "just-in-time" production schedules.

- *Soldering Operations*. Stand-alone soldering operations are included in this process category.

- *Transformers/Magnetics*. Transformers and similar devices are assembled and/or fabricated here. Tasks are usually performed at a series of workstations.

- *Surface Mount*. Involves inserting chips and other such components, either manually or by machine, onto the board. (Sometimes this process is referred to as auto-insertion or clean-room assembly.)

- *Sub/Final Assembly*. Partially or completely assembling loaded circuit boards into casings or other parts (such as digital screens) as a final or near-final product.

3. Identify Material Sorting Categories

The categories used in the ReTAP study are attached. One list was for the process-specific waste sort, and the other was used to characterize the overall dumpster. Review these categories and revise them, if necessary, to best measure your company's waste stream.

Make several photocopies of the final category list to use when recording your company's information.

4. Process-Specific Waste Collection & Sorting

If you only need a general estimate of the process-specific waste, visually inspect the garbage and recycling containers in the selected areas. Note the approximate proportion of materials on the category list. If you want to duplicate the ReTAP study, more work is required.

First, arrangements should be made to collect the waste prior to janitorial services. In addition, process-area staff should be informed about the study so that they will not be surprised when their department's garbage and recyclables are labeled and taken for study.

Each day during a one-week period, empty the selected garbage cans and recycling bins into separate plastic bags. Label the bags with the process area and date.

The "bag and tag" method may be cumbersome if a particularly large volume of material is generated. In that case, the material should be weighed in the process area and recorded daily. Potentially hazardous or particularly valuable recyclables, such as lead dross, copper wire, circuit boards, tab routs and other special materials, can be measured at the end of the study week.

For each bag that is taken from each process area, perform the following steps:

a) Weigh the filled bag and record it on the data sheet.

b) Empty the bag and sort the waste into the categories listed on your component list. For the ReTAP study, all items over two inches were sorted. Small quantities of material under two inches was included in the "Misc. Other" category.

c) Weigh each pile of material and the empty bag. If possible, use a scale accurate to one-tenth of a pound for weighing all materials over a pound. For smaller amounts, a scale accurate to one tenth of an ounce can be used. (Hint: a postal scale from shipping/receiving will work fine.)

d) Add all the weights to verify that the weight of the empty bag and contents match that of the full bag.

e) Recycle or dispose of the sample.

5. Dumpster Sort

Again, determine the level of detail required by your company's needs and priorities. A visual inspection and an estimation of material proportions may be enough to suggest improvements to your company's waste management programs. If more specific data is needed, follow the steps used in the ReTAP study:

Identify an area large enough to tip the dumpster for sorting. Working with your waste hauler, schedule a sorting day. Roll-off containers will need to be dumped by your waste hauler; smaller dumpsters can be tipped by hand. All wastes should be dumped onto a tarp to prevent ground water contamination.

Sorting involves the following steps:

a) Inspect the dumped load visually. Pull all bulky items (over one foot) and sort into their component categories.

b) Record the weights of the bulky items using a scale accurate to one-tenth of a pound.

c) Randomly select a 200-300 pound sample and separate it from the rest of the dumped load. (For smaller loads, the contents of the entire dumpster can be sorted.)

d) Sort the sample into the prescribed component categories.

e) Weigh the piles on a scale accurate to one-tenth of a pound.

f) Return all items to the dumpster.

g) Ask the waste hauler for the total weight of the dumpster load.

6. Analyze Data

Process-Specific Sort

To calculate the waste composition, or the percentage of any one given material to total waste, divide the weight of each material by the total weight of the process area's waste.

Dumpster Sort

As described above, each dumpster load was divided into three parts:

- bulky materials
- a 200- to 300-pound sample
- remaining load

Calculations must be made for each part of the dumpster load, then the results added together. To estimate the dumpster's waste composition percentages, perform the following:

- Characterize the 200- to 300-pound sample (in the same manner as the process-area data, above).

- Subtract the weight of the bulky materials from the overall load weight supplied by the waste hauler.

- Apply the sample composition to the weight of non-bulky load. (Multiply the component percentages by the weight of the dumpster load minus the bulky materials.)

- Add the results of the non-bulky characterization, by component category, to the bulky materials.

An estimate of annual composition can be made by applying the dumpster characterization to the year's total disposed waste. Make adjustments, if necessary, for seasonal or product cycle variations.

These calculations will help determine what your company sends to the landfill and what it recycles. Knowing what materials to target for recycling, and what materials could be kept out of the waste stream entirely (by not creating the waste in the first place) will make your company’s waste management programs more efficient and decrease the amount of money spent each month on hauling away garbage.