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CAPITAL REGIONAL DISTRICT

SOLID WASTE STREAM ANALYSIS

FINAL REPORT

PREPARED BY

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EXECUTIVE SUMMARY

A total of 53,787 lb. (24.39 tonnes) of solid waste was sorted in two sampling periods one in April, 1996 and the second starting in mid-October, 1996. During these periods 23,790 tonnes was delivered to the working face of the landfill. 222 samples were taken representing about 0.10% of the waste stream during the period. There were 57 residential, 23 commercial, 1 apartment, 23 construction and demolition and 102 mixed residential and commercial samples taken.

For sorting, the waste was divided into 16 primary categories and 56 secondary categories. In decreasing order the most significant primary categories were food waste (17.69%), paper (14.26%), plastic (13.59%), construction and demolition wastes (9.31%), yard waste (7.40%), paperboard (7.36%), composite materials (6.60%) and wood (5.45%). One category (other) consisted of miscellaneous materials and fines from sorting and comprised 7.58% of the total.

Readily compostable materials (food and yard wastes) comprise about 25% of the total. When other less readily compostable materials (paper, paperboard, wood and one-quarter of the other category) are added to this, the total for compostables comes to about 54% of the waste stream.

Commercial food wastes exceeds residential food waste slightly (24.9% vs. 20.4%) while the percentage of paper products for the commercial and residential is similar. Yard wastes comprise 6% of the commercial waste stream compared with 9% for residential. Hazardous wastes were slightly higher for residential than for commercial (0.39% vs. 0.35%). It is difficult to be specific about apartment wastes because only one sample was taken, however food wastes from apartments seem to be very high (39%) compared with residential (20%).

The quantity of construction and demolition wastes is relatively low (2.4%) but when roofing materials are added to this category the percentage rises to 9.3%.

When compared with the 1990 waste stream some of the notable changes are: food waste has increased from 9.1% to 17.7%; yard wastes has decreased from 10.5% to 7.4%; corrugated cardboard has declined from 9.1% to 2.1% over the period; the amount of drywall has decreased from 2.4% to 0.5%; hazardous wastes have decreased from 1.9% to 0.4% and tires have decreased from 0.26% to 0%.

The statistical analysis of the results showed that almost all categories were not normally distributed and that variance was relatively high. Because a statistical analysis showed a high correlation between the ranking of the categories between the two sampling periods, and because the category ranking is similar to other studies, there is reasonable confidence in the results provided that due consideration is given to the effects of weather (increasing weight due to moisture), the skewed distributions and the variance due to the relatively small sample size.

CHAPTER 1 - INTRODUCTION AND BACKGROUND

In February, 1996 the Capital Regional District requested proposals to carry out an analysis of the waste stream being disposed of at the Hartland Avenue landfill. The contract was awarded in March, 1996 and the first sorting operation was performed in April, 1996. The second sort was carried out between mid-October and early November, 1996.

The objectives of the study were to:

1. Identify the composition of the waste stream by material type.
2. Provide information so that the CRD could evaluate the effectiveness of existing solid waste diversion programs.
3. Provide information to aid in the design of additional future programs.
4. Provide information to aid in altering existing programs to increase diversion rates.
5. Determine if there were single contributors who had sufficient weights of materials to become targeted for waste reduction programs.
6. Determine the differences between residential, commercial, construction and demolition and apartment waste streams.
7. Determine seasonal variations by performing the analysis in both the spring and in the fall.

CHAPTER 2 - METHODOLOGY

2.1 Sampling Periods

In order to provide some insight into seasonal refuse variations, sampling took place in two phases. These were between April 1 and April 26, 1996 and between October 15 and November 6, 1996.

2.2 Staff, Equipment and Work Days

A beam scale, garbage cans for storing the samples prior to weighing, work tables, safety equipment, a tent to cover the work area, a bin for disposing of the weighed samples and a front end loader for collecting samples were provided by the CRD. The CRD also supplied a 6 person sorting crew with one of these people acting as a lead hand who had the responsibility to manage the day-to-day sorting operation and to enter the data on paper. A copy of the sample log sheet is included as Appendix B. The CRD also entered the daily data into a spread sheet set up by the consultant. The crew worked a five day week from Monday to Friday.

The principal investigator spent the first two days of the first sampling period and the first day of the second sampling period with the crew to ensure that the methods were understood by the crew, to forestall any difficulties that might arise and to emphasize safety. Each of the crew members was given a sheet outlining the sorting categories and a description of some of the more difficult categories. A copy of this is included as Appendix C. A second visit in each phase was made during the second week to check the weights obtained and, if necessary, make any adjustments in the sampling.

2.3 Sampling Categories

Sixteen primary categories had been identified by the CRD. Following discussions between the consultant and the CRD these were then broken down into 56 secondary categories. The categories are shown in Table 2.1.

2.4 Sampling Methodology

The approach was to use a front end loader with a backhoe attachment. The loader either mixed the refuse using the loader bucket and/or the backhoe attachment to achieve the maximum degree of visual sample uniformity or, where the load appeared to be uniform, simply took a sample. The loader then picked up a sample and carried it to the sorting table. The amount picked up in the bucket each time was a predetermined volume based on the estimated weight required from the particular truck being sampled. The total sample weight was obtained by adding up the weights of the individual sorted materials. This judgmental sampling is the approach recommended by Klee and Carruth (1970) and supported by Hagerty, Pavoni and Heer (1971).

TABLE 2.1 - SAMPLING CATEGORIES

Paper products

- Newsprint
- Magazines
- White paper
- Telephone books
- Other paper

Paperboard

- Corrugated cardboard
- Coated corrugated cardboard
- Box board
- Milk cartons
- Other paperboard

Plastics

- PET bottles
- HDPE bottles
- Plastic food containers
- Film plastic
- Other plastic

Glass

- Deposit containers
- Other food and beverage containers
- Other glass

Ferrous metals

- Food cans
- Other 100% ferrous metals
- Other mostly (>75%) ferrous metals

Non-ferrous metals

- Aluminum beverage cans
- Aluminum foil, pastry plates
- Aerosol cans
- Other 100% non-ferrous metals
- Other mostly (>75%) non-ferrous metals

Yard wastes

Food wastes

Other putrescible materials

Wood products

- Pallets, skids
- Clean dimensional lumber
- Contaminated and treated wood
- Other clean wood
- Sawdust

Construction and demolition materials

- Demolition wood
- Drywall
- Stumps and slash
- Cedar shingles
- Asphalt shingles
- Inert demolition materials such as concrete, asphalt, soil and gravel.
- Other construction and demolition wastes

Textiles

- Clothing
- Other textiles

Rubber

- Vehicle tires
- Other rubber

Composite materials

- Disposable diapers
- Furniture
- Electronics
- Other composite materials

Hazardous materials

- Paint
- Household batteries
- Oil
- Oil filters
- Sharps
- Other hazardous materials

Other (Fines, dirt, ceramics)

2.5 Sample Size

Based on some research that had been carried out by Klee and Carruth (1970), Britton (1971) and Lohani and Ko (1988), a sample size of 125 kg was selected as being sufficient to provide confidence that the sample was reasonably representative of a given load. In addition, based on previous experience, this sample size was considered to be about the largest that could be reasonably piled on a 4 by 16 foot table which is about the maximum table size for sorting. From this it was determined that a sample size of about 1.2 cu m, as visually determined from the size of the loader bucket, would be used.

2.6 Number of Samples

Musa and Ho (1981) and Klee and Carruth (1970) had concluded that the number of samples required to provide high levels of confidence in the results would increase as the percentage of a category decreased. Klee and Carruth provided data which showed that 80 samples would be needed for a constituent comprising 0.40% of the waste stream to have a level of confidence of 90% that the estimate was within 2%. From past experience, it was felt that some of the primary categories would be less than 0.40% and that a number of the secondary categories would be less than 0.40%. It was assumed that 0.40% would be a reasonable cutoff point which indicated that a period of three weeks would be needed to sort 80 samples (27 samples per week). Inclement weather, staff turnover, illness, delays due to equipment breakdown and problems with getting a sample from a chosen vehicle at the appropriate time could all contribute to a reduction in the number of samples obtained. It was therefore decided that the first sampling period would be based on a four week period (approximately 108 samples).

2.7 Sample Sources

The procedure used was to stratify the sampling in order to match the sample sizes to the weight of the incoming refuse from the different sources. This procedure is somewhat similar to that of Klee and Carruth (1970) who matched the sample size to the bulk of the refuse load. In general terms the procedure was to (1) estimate the total weight that could be sampled for the sampling period, (2) obtain the scaled weight records for the different customers for a one month period and, (3) calculate the weight of sample required from each customer. This procedure would result in no samples being taken from those customers whose monthly weight was less than the calculated minimum sample size.

The weigh scale data from the one month period two months prior to sampling was used to determine the sample sizes.

The drop-off bins near the scale house were considered to be one customer.

In phase 1, for materials that were dropped off in the bins near the scale house, the assistance of the spotter was used. A count of bulky materials was made (large chairs, mattresses, box springs and couches) because these items were not amenable to being weighed on the beam scale. The

weights of these were then added to the waste stream sample in proportion to the sample weights taken from the bins. The weight corrections obtained in phase 1 were also used in phase 2 of the study.

In addition, where bulky items (such as pallets or large pieces of furniture) were seen in a load, a note was made on the daily log sheet and a proportionate weight added to the sample.

Following discussions with landfill staff it was concluded that the nature of the refuse delivered on Saturdays was not significantly different from that delivered during the week. No attempt was therefore made to obtain separate samples for Saturday.

2.8 Other Considerations

Total sample weights were calculated for each landfill customer. Where more than one sample was to be taken from a customer, the distribution of sampling for that customer was spread randomly over the sampling period. In addition, where a customer used more than one type of collection vehicle (front loader, rear loader, roll-off, side loader) samples were collected from the different types of vehicles in proportion to the number of specific vehicle types. Appendix D includes the lists of vehicles to be sampled, the sample sizes, the arrival frequency and approximate vehicle arrival times for phase 1. The same information for phase 2 is included as Appendix E.

The driver of each vehicle sampled was questioned as to the source of refuse. The main purpose of this questioning was to clearly ascertain whether or not the load was a "pure" load of either residential or commercial or construction/demolition refuse. This questioning did not apply to cash customers delivering refuse to the drop-off bins near the scales. The tables in succeeding chapters that show commercial and residential percentages include only those "pure" loads of commercial or residential refuse as ascertained from the drivers.

CHAPTER 3 - RESULTS

3.1 General

During phase 1 sampling a total of 13,735.52 tonnes was delivered to the working face of the landfill.

In phase 1, a total weight of 23,420 lb. (10,623.3 kg or 10.62 tonnes) was taken in the sampling. This sample size represented 0.077% of the waste stream delivered during the sampling period.

In phase 1, 106 samples were taken. This was broken down into 32 residential samples, 25 commercial samples, 40 mixed samples (both residential and commercial), 1 apartment sample and 8 construction and demolition samples.

Over the course of the phase 2 sampling period, a total of 10,054.3 tonnes was delivered to the working face of the landfill.

In phase 2, a total weight of 30,367 lb. (13,774 kg or 13.77 tonnes) was taken in the sampling. This sample size represented 0.14% of the waste stream delivered during the sampling period.

In phase 2, 116 samples were taken. This was broken down into 25 residential samples, 14 commercial samples, 62 mixed samples (both residential and commercial), and 15 construction and demolition samples.

3.2 Total Waste Stream - Main Categories and Tonnes

Table 3.1 gives the percentages and inferred total annual tonnes for the sixteen primary categories. These are listed in the decreasing order of percentages for phase 1. The inferred tonnages are based upon the total tonnes delivered to the working face of the landfill in 1995 and a weighted average of the percentages given for the two phases of the study.

TABLE 3.1 - TOTAL WASTE STREAM - 16 PRIMARY CATEGORIES - INFERRED ANNUAL TONNES

CATEGORY	PHASE 1 %	PHASE 2 %	WEIGHTED %	INFERRED ANNUAL TONNES
Food waste	15.19	21.10	17.69	24466
Paper	14.64	13.74	14.26	19722
Plastic	13.63	13.53	13.59	18795
Other	9.32	5.21	7.58	10483
Paperboard	8.42	5.91	7.37	10193
Construction and Demolition	7.84	11.32	9.31	12876
Composite materials	7.60	5.25	6.60	9128
Yard wastes	6.06	9.24	7.40	10234
Wood and wood products	5.80	4.97	5.45	7538
Textiles	3.52	2.89	3.25	4495
Ferrous metals	3.48	2.01	2.86	3955
Glass	2.77	2.06	2.48	3430
Non-ferrous metals	0.81	0.77	0.79	1093
Other organic wastes	0.42	1.28	0.78	1079
Rubber	0.26	0.13	0.21	290
Hazardous wastes	0.24	0.59	0.38	526
TOTAL	100.00	100.00	100.00	138303

About 25% of the waste stream is made up of food and yard wastes. If paper products (paper, paperboard) and other organic wastes are added to this, the total becomes about 47.5%. Adding wood to this total brings it to about 53%.

In Table 3.1 and in succeeding tables where the weighted percentages are given, these weighted percentages are based on the total tonnes delivered to the working face in each phase. For example, for food waste, a sample weighing 3557.5 lb. was obtained from a total sample weight of 23,420 lb. in phase 1. This comes to 15.190%. In phase 2, the respective numbers are 6410.50 lb. and 30386.05 lb. for 21.097%. The inferred total number of tonnes of paper delivered to the landfill in phase 1 is 15.190% of 13,735.52 or 2086.427 tonnes. In phase 2 the paper tonnage is 21.097% of 10,054.3 tonnes which is equal to 2121.141 tonnes. The total inferred tonnage of paper delivered to the landfill during the two sampling periods is 2086.427 plus 2121.141 tonnes for a total of 4207.568 tonnes. This is 17.69% of the 23789.82 tonnes delivered to the landfill working face during the sampling periods.

3.3 Waste Stream - 16 Categories - Total, Residential, Commercial and Apartments

Table 3.2 shows the breakdown of the waste stream into the sixteen primary categories for the total, residential, commercial and apartments for phase 1. These are based on the decreasing order of the total column.

TABLE 3.2 - TOTAL VS RESIDENTIAL VS COMMERCIAL VS APARTMENT - 16 PRIMARY CATEGORIES - PHASE 1

CATEGORY	TOTAL %	RESIDENCES %	COMM'L %	APTMT %
Food waste	15.19	14.36	23.98	38.73
Paper	14.64	16.60	11.72	21.28
Plastic	13.63	16.14	14.79	13.33
Other	9.32	8.71	8.05	1.47
Paperboard	8.42	9.40	11.78	7.35
Construction and Demolition	7.84	4.19	2.65	0.00
Composite materials	7.60	7.88	9.40	8.82
Yard wastes	6.06	7.75	3.61	0.00
Wood and wood products	5.80	0.33	3.80	0.00
Textiles	3.52	4.00	3.91	0.88
Ferrous metals	3.48	3.80	3.11	3.63
Glass	2.77	3.78	2.50	3.24
Non-ferrous metals	0.81	1.48	0.47	1.27
Other organic wastes	0.42	1.15	0.06	0.00
Rubber	0.26	0.09	0.00	0.00
Hazardous wastes	0.24	0.34	0.17	0.00
TOTAL	100.00	100.00	100.00	100.00

Table 3.3 provides the breakdown of the waste stream into the sixteen primary categories for the total, residential and commercial for phase 2. These are listed in the same order as the order in Table 3.2. Apartments were not sampled separately in phase 2. Note that the percentages given are percentages for the specific waste source. For example. the total percentage of 21.11% for the paper category includes construction and demolition and mixed wastes which is why this percentage is less than both the 28.58% for residential wastes and the 26.17% for commercial wastes.

TABLE 3.3 - TOTAL VS RESIDENTIAL VS COMMERCIAL - 16 PRIMARY CATEGORIES - PHASE 2

CATEGORY	TOTAL %	RESIDENCES %	COMMERCIAL %
Food waste	21.10	28.58	26.17
Paper	13.74	14.03	14.14
Plastic	13.53	14.68	11.85
Other	5.21	6.73	3.90
Paperboard	5.91	6.09	8.61
Construction and Demolition	11.32	1.97	8.50
Composite materials	5.25	5.22	6.36
Yard wastes	9.24	9.98	9.88
Wood and wood products	4.97	1.04	2.71
Textiles	2.89	2.78	2.09
Ferrous metals	2.01	2.41	1.63
Glass	2.06	2.40	2.11
Non-ferrous metals	0.77	0.98	1.29
Other organic wastes	1.28	2.64	0.14
Rubber	0.13	0.02	0.03
Hazardous wastes	0.59	0.45	0.59
TOTAL	100.00	100.00	100.00

Table 3.4 provides the combined data for residential and commercial wastes for the 1996 study using the weighted results. The same cautionary note in the preceding paragraph regarding the percentages in the total column applies to this table as well.

TABLE 3.4 - TOTAL VS RESIDENTIAL VS COMMERCIAL - 16 PRIMARY CATEGORIES - WEIGHTED

CATEGORY	TOTAL %	RESIDENCES %	COMMERCIAL %
Food waste	17.69	20.37	24.91
Paper	14.26	15.51	12.74
Plastic	13.59	15.52	13.55
Other	7.58	7.87	6.30
Paperboard	7.37	8.00	10.44
Construction and Demolition	9.31	3.25	5.12
Composite materials	6.60	6.76	8.12
Yard wastes	7.40	8.69	6.26
Wood and wood products	5.45	0.63	3.34
Textiles	3.25	3.49	3.14
Ferrous metals	2.86	3.21	2.48
Glass	2.48	3.20	2.33
Non-ferrous metals	0.79	1.27	0.82
Other organic wastes	0.78	1.78	0.09
Rubber	0.21	0.06	0.01
Hazardous wastes	0.38	0.39	0.35
TOTAL	100.00	100.00	100.00

The major item of note in Table 3.4 is the significant difference in the percentages of food waste between residential and commercial. The yard waste category for commercial appears to be high but may be attributable to yard wastes from apartments , townhouses or condominiums which are considered to be commercial rather than residential by truck drivers. Most other category differences are not too surprising when the source of the waste is considered.

3.4 Total Waste Stream - 56 Secondary Categories

Table 3.5 provides a detailed breakdown of the total waste stream into the 56 secondary categories in descending order for phase 1. The data for phase 2 are presented in Table 3.6 using the same sequence of categories as in Table 3.5. Note that the ranking of the categories is not too different between the two phases of the study.

Tables 3.7 and 3.8 provide the breakdown of the total waste stream for phases 1 and 2 respectively. These breakdowns are grouped according to the major categories. Because the ranking is slightly different in the two phases, the order in the table has been left in the sequence used for recording the data on the field data sheets.

TABLE 3.5 - BREAKDOWN OF TOTAL WASTE STREAM - 56 SECONDARY CATEGORIES - PHASE 1

CATEGORY	WEIGHT LB.	PER CENT
Food waste	3557.50	15.19
Other paper	2469.00	10.55
Other (fines, dirt, ceramics)	2182.75	9.32
Yard waste	1418.25	6.06
Film plastic	1374.75	5.88
Other plastic	1253.75	5.35
Other composite products	781.25	3.34
Disposable diapers	659.00	2.81
Asphalt shingles	654.50	2.79
Other clean wood	651.00	2.78
Boxboard	648.50	2.77
Other glass food containers	481.25	2.06
Corrugated cardboard	462.25	1.97
Newsprint	452.25	1.93
Other textiles	440.25	1.88
Clean dimensional lumber	437.00	1.87
Ferrous food & beverage containers	400.25	1.72
Coated cardboard	399.50	1.71
Clothing	384.25	1.64
Cedar shingles	370.25	1.58
Other ferrous metals - not food & beverage	357.00	1.52
Other construction and demolition	303.75	1.30
Milk cartons	295.75	1.26
Magazines	251.50	1.07
Electronics	244.25	1.04
Plastic food containers	233.00	0.99
White paper	215.25	0.92
HDPE bottles	212.75	0.91
Inert demolition materials	212.25	0.91
Contaminated and treated wood	195.50	0.83
Other paperboard	166.75	0.71
Drywall	139.00	0.59
PET bottles	117.50	0.50
Other glass	106.50	0.45
Other putrescible	98.50	0.42
Aluminum beverage cans	98.25	0.42
Furniture	93.00	0.40
Stumps and slash	87.50	0.37
Demolition wood waste	69.50	0.30
Deposit container glass	61.75	0.26
Other rubber products	61.00	0.26
Other mostly ferrous materials	57.25	0.24
Sawdust	54.00	0.23
Aluminum foil and plates	53.25	0.23
Telephone books	41.50	0.18
Aerosol cans	37.25	0.16
Other hazardous wastes	30.75	0.14
Pallets, skids	21.50	0.09
Paints	8.00	0.03
Household batteries	7.75	0.03
Oil filters	7.25	0.03
Sharps	3.00	0.01
Other mostly non-ferrous	0.50	0.00
Other 100% non-ferrous	0.25	0.00
Vehicle tires	0.00	0.00
Oils	0.00	0.00
TOTAL	**23420.00**	**100.00**

TABLE 3.6 - BREAKDOWN OF TOTAL WASTE STREAM - 56 SECONDARY CATEGORIES - PHASE 2

CATEGORY	WEIGHT LB.	PER CENT
Food waste	6410.50	21.11
Other paper	2827.25	9.31
Other (fines, dirt, ceramics)	1581.75	5.21
Yard waste	2805.00	9.24
Film plastic	1139.00	3.75
Other plastic	2546.75	8.39
Other composite products	680.00	2.24
Disposable diapers	564.25	1.86
Asphalt shingles	1324.50	4.36
Other clean wood	1095.00	3.61
Boxboard	598.75	1.97
Other glass food containers	404.00	1.33
Corrugated cardboard	653.75	2.15
Newsprint	848.50	2.79
Other textiles	585.50	1.93
Clean dimensional lumber	90.50	0.30
Ferrous food & beverage containers	304.75	1.00
Coated cardboard	151.50	0.50
Clothing	292.00	0.96
Cedar shingles	496.00	1.63
Other ferrous metals - not food & beverage	170.00	0.56
Other construction and demolition	1095.50	3.61
Milk cartons	278.25	0.92
Magazines	153.50	0.51
Electronics	114.00	0.38
Plastic food containers	157.75	0.52
White paper	273.50	0.90
HDPE bottles	168.50	0.55
Inert demolition materials	343.50	1.13
Contaminated and treated wood	144.25	0.48
Other paperboard	112.75	0.37
Drywall	141.00	0.46
PET bottles	98.00	0.32
Other glass	188.75	0.62
Other putrescible	388.50	1.28
Aluminum beverage cans	63.50	0.21
Furniture	235.00	0.77
Stumps and slash	0.00	0.00
Demolition wood waste	37.00	0.12
Deposit container glass	34.00	0.11
Other rubber products	39.50	0.13
Other mostly ferrous materials	136.00	0.45
Sawdust	110.50	0.36
Aluminum foil and plates	68.00	0.22
Telephone books	65.85	0.22
Aerosol cans	9.25	0.03
Other hazardous wastes	147.50	0.49
Pallets, skids	67.00	0.22
Paints	20.50	0.07
Household batteries	3.50	0.01
Oil filters	5.00	0.02
Sharps	2.75	0.01
Other mostly non-ferrous	63.25	0.21
Other 100% non-ferrous	30.75	0.10
Vehicle tires	0.00	0.00
Oils	1.00	0.00
TOTAL	**30366.85**	**100.00**

TABLE 3.7 - PHASE 1 BREAKDOWN OF MAJOR CATEGORIES

Paper		**14.64%**
	Newsprint	1.93%
	Magazines	1.07%
	White Paper	0.92%
	Telephone Books	0.18%
	Other Paper	10.54%
Paperboard Products		**8.42%**
	Corrugated Cardboard	1.97%
	Coated Cardboard	1.71%
	Boxboard	2.77%
	Milk Cartons	1.26%
	Other Paperboard	0.71%
Plastics		**13.63%**
	PET Bottles	0.50%
	HDPE Bottles	0.91%
	Plastic Food Containers	0.99%
	Film Plastic	5.88%
	Other Plastic	5.35%
Glass		**2.77%**
	Deposit Container Glass	0.26%
	Other Food Glass	2.06%
	Other Glass	0.45%
Ferrous Metals		**3.48%**
	Food and Beverage Containers	1.72%
	Other All (100%) Metal Objects	1.52%
	Other Mostly Metal Objects	0.24%
Non-ferrous Metals		**0.81%**
	Aluminum beverage cans	0.42%
	Aluminum foil, plates	0.23%
	Aerosol cans	0.16%
	All other 100% ferrous metal	0.00%
	Other mostly non-ferrous metal	0.00%
Yard Wastes		**6.06%**
	Yard Waste	6.06%
Food Waste		**15.19%**
	Food Waste	15.19%
Other Organic Waste		**0.42%**
	Other Putrescible	0.42%
Wood and Wood Products		**5.80%**
	Pallets/Skids	0.09%
	Clean Dimensional Lumber	1.87%
	Contaminated and Treated Wood	0.83%
	Other Clean Wood	2.78%
	Sawdust	0.23%

TABLE 3.7 - PHASE 1 BREAKDOWN OF MAJOR CATEGORIES (Cont.)

Construction/Demolition Materials			**7.84%**
	Demolition Wood Waste	0.30%	
	Drywall	0.59%	
	Stumps and Slash	0.37%	
	Cedar Shingles	1.58%	
	Asphalt shingles	2.79%	
	Inert Demolition Materials	0.91%	
	Other C/D Wastes	1.30%	
Textiles			**3.52%**
	Clothing	1.64%	
	Other Textiles	1.88%	
Rubber			**0.26%**
	Vehicle Tires	0.00%	
	Other Rubber Products	0.26%	
Composite Products			**7.60%**
	Disposable Diapers	2.81%	
	Furniture	0.40%	
	Electronics	1.04%	
	Other	3.35%	
Hazardous Wastes			**0.24%**
	Paints	0.03%	
	Household Batteries	0.03%	
	Oils	0.00%	
	Oil Filters	0.03%	
	Sharps	0.01%	
	Other	0.14%	
Other			**9.32%**
	Other (fines, dirt, ceramics, etc.)	9.32%	
TOTAL		100.00%	**100.00%**

TABLE 3.8 - PHASE 2 BREAKDOWN OF MAJOR CATEGORIES

Paper		**13.73%**
Newsprint	2.79%	
Magazines	0.51%	
White Paper	0.90%	
Telephone Books	0.22%	
Other Paper	9.31%	
Paperboard Products		**5.91%**
Corrugated Cardboard	2.15%	
Coated Cardboard	0.50%	
Boxboard	1.97%	
Milk Cartons	0.92%	
Other Paperboard	0.37%	
Plastics		**13.53%**
PET Bottles	0.32%	
HDPE Bottles	0.55%	
Plastic Food Containers	0.52%	
Film Plastic	3.75%	
Other Plastic	8.39%	
Glass		**2.06%**
Deposit Container Glass	0.11%	
Other Food Glass	1.33%	
Other Glass	0.62%	
Ferrous Metals		**2.01%**
Food and Beverage Containers	1.00%	
Other All (100%) Metal Objects	0.56%	
Other Mostly Metal Objects	0.45%	
Non-ferrous Metals		**0.77%**
Aluminum beverage cans	0.21%	
Aluminum foil, plates	0.22%	
Aerosol cans	0.03%	
All other 100% ferrous metal	0.10%	
Other mostly non-ferrous metal	0.21%	
Yard Wastes		**9.24%**
Yard Waste	9.24%	
Food Waste		**21.11%**
Food Waste	21.11%	
Other Organic Waste		**1.28%**
Other Putrescible	1.28%	
Wood and Wood Products		**4.97%**
Pallets/Skids	0.22%	
Clean Dimensional Lumber	0.30%	
Contaminated & Treated Wood	0.48%	
Sawdust	0.36%	
Other Clean Wood	3.61%	

TABLE 3.8 - PHASE 2 BREAKDOWN OF MAJOR CATEGORIES (Cont.)

Construction/Demolition Materials		**11.32%**
Demolition Wood Waste	0.12%	
Drywall	0.46%	
Stumps and Slash	0.00%	
Inert Demolition Materials	1.13%	
Cedar Shingles	1.63%	
Asphalt Shingles	4.36%	
Other C/D Wastes	3.61%	
Textiles		**2.89%**
Clothing	0.96%	
Other Textiles	1.93%	
Rubber		**0.13%**
Vehicle Tires	0.00%	
Other Rubber Products	0.13%	
Composite Products		**5.25%**
Disposable Diapers	1.86%	
Furniture	0.77%	
Electronics	0.38%	
Other	2.24%	
Hazardous Wastes		**0.59%**
Paints	0.07%	
Household Batteries	0.01%	
Oils	0.00%	
Oil Filters	0.02%	
Sharps	0.01%	
Other	0.49%	
Other		**5.21%**
Other (fines, dirt, ceramics, etc.)	5.21%	
TOTAL	**100.00%**	**100.00%**

Table 3.9 combines the results shown in Tables 3.7 and 3.8 into a weighted list of percentages for the 16 primary and 56 secondary categories.

TABLE 3.9 - WEIGHTED BREAKDOWN OF MAJOR CATEGORIES - PHASES 1 AND 2

Paper			**14.26%**
	Newsprint	2.30%	
	Magazines	0.83%	
	White Paper	0.91%	
	Telephone Books	0.19%	
	Other Paper	10.03%	
Paperboard Products			**7.37%**
	Corrugated Cardboard	2.05%	
	Coated Cardboard	1.20%	
	Boxboard	2.43%	
	Milk Cartons	1.12%	
	Other Paperboard	0.57%	
Plastics			**13.59%**
	PET Bottles	0.43%	
	HDPE Bottles	0.76%	
	Plastic Food Containers	0.79%	
	Film Plastic	4.97%	
	Other Plastic	6.64%	
Glass			**2.48%**
	Deposit Container Glass	0.20%	
	Other Food Glass	1.75%	
	Other Glass	0.53%	
Ferrous Metals			**2.86%**
	Food and Beverage Containers	1.41%	
	Other All (100%) Metal Objects	1.12%	
	Other Mostly Metal Objects	0.33%	
Non-ferrous Metals			**0.79%**
	Aluminum beverage cans	0.33%	
	Aluminum foil, plates	0.23%	
	Aerosol cans	0.10%	
	All other 100% ferrous metal	0.04%	
	Other mostly non-ferrous metal	0.09%	
Yard Wastes			**7.40%**
	Yard Waste	7.40%	
Food Waste			**17.69%**
	Food Waste	17.69%	
Other Organic Waste			**0.78%**
	Other Putrescible	0.78%	
Wood and Wood Products			**5.45%**
	Pallets/Skids	0.15%	
	Clean Dimensional Lumber	1.20%	
	Contaminated and Treated Wood	0.68%	
	Sawdust	1.76%	
	Other Clean Wood	1.66%	

TABLE 3.9 - WEIGHTED BREAKDOWN OF MAJOR CATEGORIES - PHASES 1 AND 2 (Cont.)

Construction/Demolition Materials			**9.31%**
	Demolition Wood Waste	0.22%	
	Drywall	0.54%	
	Stumps and Slash	0.22%	
	Inert Demolition Materials	1.39%	
	Cedar Shingles	2.30%	
	Asphalt Shingles	2.37%	
	Other C/D Wastes	2.27%	
Textiles			**3.25%**
	Clothing	1.35%	
	Other Textiles	1.90%	
Rubber			**0.21%**
	Vehicle Tires	0.00%	
	Other Rubber Products	0.21%	
Composite Products			**6.60%**
	Disposable Diapers	2.41%	
	Furniture	0.56%	
	Electronics	0.76%	
	Other	2.87%	
Hazardous Wastes			**0.38%**
	Paints	0.05%	
	Household Batteries	0.02%	
	Oils	0.00%	
	Oil Filters	0.02%	
	Sharps	0.01%	
	Other	0.28%	
Other			**7.58%**
	Other (fines, dirt, ceramics, etc.)	7.58%	
TOTAL		**100.00**	**100.00**

3.5 Total, Residential, Commercial and Apartment Waste Streams - 56 Categories

Table 3.10 provides the comparison between the total waste stream and the residential, commercial and apartment waste streams for phase 1. The categories are listed in decreasing order for the total waste stream.

Table 3.11 details the comparison between the total waste stream and the relative percentages in the residential and commercial waste streams for phase 2. The order of categories is the same as the order used in Table 3.10.

TABLE 3.10- TOTAL , RESIDENTIAL , COMMERCIAL & APARTMENTS - 56 SECONDARY CATEGORIES - PHASE 1

CATEGORY	TOTAL %	RESIDENCES %	COMM'L %	APTMT %
Food waste	15.19	14.36	23.98	38.72
Other paper	10.55	12.52	9.07	14.61
Other (fines, dirt, ceramics)	9.32	8.71	8.05	1.47
Yard waste	6.06	7.75	3.61	0.00
Film plastic	5.88	7.45	6.74	4.80
Other plastic	5.35	4.72	6.47	6.57
Other composite products	3.34	2.18	5.37	0.59
Disposable diapers	2.81	4.42	2.63	8.23
Asphalt shingles	2.79	2.29	0.00	0.00
Other clean wood	2.78	0.14	3.13	0.00
Boxboard	2.77	4.07	2.40	4.31
Other glass food containers	2.06	3.08	1.74	3.04
Corrugated cardboard	1.97	1.71	2.66	0.49
Newsprint	1.93	1.64	1.50	6.67
Other textiles	1.88	1.40	2.60	0.00
Clean dimensional lumber	1.87	0.00	0.29	0.00
Ferrous food & beverage containers	1.72	2.44	1.86	2.06
Coated cardboard	1.71	0.25	5.57	1.37
Clothing	1.64	2.61	1.31	0.88
Cedar shingles	1.58	0.00	0.00	0.00
Other ferrous metals - not food & beverage	1.52	1.11	1.08	1.57
Other construction and demolition	1.30	0.59	0.16	0.00
Milk cartons	1.26	2.26	0.61	1.18
Magazines	1.07	0.90	0.51	0.00
Electronics	1.04	1.27	0.82	0.00
Plastic food containers	0.99	1.62	0.70	0.59
White paper	0.92	1.14	0.49	0.00
HDPE bottles	0.91	1.56	0.56	1.18
Inert demolition materials	0.91	1.06	1.74	0.00
Contaminated and treated wood	0.83	0.19	0.38	0.00
Other paperboard	0.71	1.11	0.54	0.00
Drywall	0.59	0.26	0.48	0.00
PET bottles	0.50	0.78	0.32	0.20
Other glass	0.45	0.27	0.53	0.20
Other putrescible	0.42	1.15	0.06	0.00
Aluminum beverage cans	0.42	0.64	0.27	0.29
Furniture	0.40	0.00	0.58	0.00
Stumps and slash	0.37	0.00	0.13	0.00
Demolition wood waste	0.30	0.00	0.15	0.00
Deposit container glass	0.26	0.43	0.23	0.00
Other rubber products	0.26	0.09	0.00	0.00
Other mostly ferrous materials	0.24	0.25	0.16	0.00
Sawdust	0.23	0.00	0.00	0.00
Aluminum foil and plates	0.23	0.49	0.13	0.69
Telephone books	0.18	0.40	0.15	0.00
Aerosol cans	0.16	0.35	0.07	0.29
Other hazardous wastes	0.14	0.22	0.03	0.00
Pallets, skids	0.09	0.00	0.00	0.00
Paints	0.03	0.00	0.10	0.00
Household batteries	0.03	0.03	0.01	0.00
Oil filters	0.03	0.07	0.00	0.00
Sharps	0.01	0.02	0.03	0.00
Other mostly non-ferrous	0.00	0.00	0.00	0.00
Other 100% non-ferrous	0.00	0.00	0.00	0.00
Vehicle tires	0.00	0.00	0.00	0.00
Oils	0.00	0.00	0.00	0.00
TOTAL	100.00	100.00	100.00	100.00

TABLE 3.11 - TOTAL , RESIDENTIAL & COMMERCIAL - 56 SECONDARY CATEGORIES - PHASE 2

CATEGORY	TOTAL %	RESIDENCES %	COMMERCIAL %
Food waste	21.11	28.58	26.17
Other paper	9.31	9.97	10.10
Other (fines, dirt, ceramics)	5.21	6.73	3.90
Yard waste	9.24	9.98	9.88
Film plastic	3.75	4.52	3.34
Other plastic	8.39	8.41	7.10
Other composite products	2.24	1.54	2.29
Disposable diapers	1.86	3.52	0.44
Asphalt shingles	4.36	0.00	0.00
Other clean wood	3.61	0.59	2.51
Boxboard	1.97	3.10	1.93
Other glass food containers	1.33	1.53	1.44
Corrugated cardboard	2.15	1.34	2.98
Newsprint	2.79	2.51	1.35
Other textiles	1.93	1.48	1.92
Clean dimensional lumber	0.30	0.17	0.15
Ferrous food & beverage containers	1.00	1.72	0.70
Coated cardboard	0.50	0.06	2.51
Clothing	0.96	1.30	0.17
Cedar shingles	1.63	0.00	0.00
Other ferrous metals - not food & beverage	0.56	0.21	0.33
Other construction and demolition	3.61	1.23	1.36
Milk cartons	0.92	1.56	0.81
Magazines	0.51	0.48	0.54
Electronics	0.38	0.16	0.26
Plastic food containers	0.52	0.67	0.38
White paper	0.90	1.05	1.86
HDPE bottles	0.55	0.65	0.53
Inert demolition materials	1.13	0.48	6.54
Contaminated and treated wood	0.48	0.28	0.05
Other paperboard	0.37	0.03	0.38
Drywall	0.46	0.25	0.45
PET bottles	0.32	0.43	0.50
Other glass	0.62	0.77	0.32
Other putrescible	1.28	2.64	0.14
Aluminum beverage cans	0.21	0.19	0.47
Furniture	0.77	0.00	3.37
Stumps and slash	0.00	0.00	0.00
Demolition wood waste	0.12	0.01	0.15
Deposit container glass	0.11	0.10	0.35
Other rubber products	0.13	0.02	0.03
Other mostly ferrous materials	0.45	0.48	0.60
Sawdust	0.36	0.00	0.00
Aluminum foil and plates	0.22	0.42	0.07
Telephone books	0.22	0.02	0.29
Aerosol cans	0.03	0.06	0.02
Other hazardous wastes	0.49	0.23	0.48
Pallets, skids	0.22	0.00	0.00
Paints	0.07	0.17	0.09
Household batteries	0.01	0.02	0.02
Oil filters	0.02	0.01	0.00
Sharps	0.01	0.02	0.00
Other mostly non-ferrous	0.21	0.19	0.56
Other 100% non-ferrous	0.10	0.12	0.17
Vehicle tires	0.00	0.00	0.00
Oils	0.00	0.00	0.00
TOTAL	100.00	100.00	100.00

Probably the most notable numbers in tables 3.10 and 3.11 are those showing the large increase in residential food wastes in phase 2. This may be partially attributable to the rainy weather which made some of the wastes very wet and to the efficiency of the crew. This efficiency shows up in the reduction in the "other" category in phase 2 because the crew were able to sort a large proportion of the fine materials into specific categories, one of which was food wastes. In general the rankings (order by decreasing percentage are fairly consistent when taking into account the source of the wastes.

3.6 Construction and Demolition Wastes

Table 3.12 shows the breakdown of the construction and demolition wastes sampled. These are listed in decreasing order for the phase 1 percentages. Categories for which no weights were recorded have not been included.

TABLE 3.12 - PERCENTAGE BREAKDOWNS OF THE CONSTRUCTION AND DEMOLITION WASTES CATEGORIES

CATEGORY	PHASE 1 PER CENT	PHASE 2 PER CENT
Asphalt shingles	47.69	47.68
Cedar shingles	38.77	17.86
Other construction and demolition	6.94	14.53
Other paper	1.73	0.00
Boxboard	1.33	0.00
Contaminated and treated wood	1.20	0.00
Corrugated cardboard	0.99	3.02
Film plastic	0.99	0.29
Other ferrous metals - not food & beverage	0.26	2.52
HDPE bottles	0.10	0.00
Other clean wood	0.00	10.08
Pallets	0.00	1.57
Other plastic	0.00	1.33
Other composite materials	0.00	1.12
TOTAL	100.00	100.00

3.7 Estimated Percentages of the Waste Stream

It is difficult to provide a clear picture of the percentages attributable to commercial, residential and construction and demolition wastes because many of the loads (40 out of 105 in phase 1 and 62 out of 116 in phase 2) were mixed commercial and residential. In addition, commercial loads could include apartment wastes because these are frequently collected by the front loading trucks serving commercial customers. Whether or not a particular load was "pure" residential or commercial or what the load proportion was, was based upon the driver's answer to the question of what proportion of the load was residential and what was commercial. In addition, no breakdown of the proportion of commercial and residential waste going into the bins near the gate was available. On top of this, the

only data regarding the proportion of waste delivered during the sampling period by each of the vehicles sampled are the sample weights. As will be shown in Chapter 4, this is not a perfectly accurate assumption.

Assuming that the information provided by drivers is correct and assuming that the waste from the bins was 75% residential and assuming that the sample weights are an accurate reflection of the actual incoming weights, the breakdown of the waste stream into the three major categories is shown in Table 3.13. Because the number of "pure" commercial and "pure" residential loads was greater in phase 1 than in phase 2, Table 3.13 is based upon phase 1 results only.

TABLE 3.13 - WASTE STREAM PROPORTIONS

Category	Per Cent of the Waste Stream
Residential	50.4
Commercial	45.8
Construction and Demolition	3.8
TOTAL	100.0

3.8 Comparison With 1990 Waste Stream Analysis

Table 3.14 shows the comparison between the waste stream analysis done for the CRD in 1990 and the analysis done this year. Because the analyses were done slightly differently, some of the categories are not exactly the same. The major categories are the same and provide a reasonable picture of changes that have taken place over the past 6 years. Explanatory notes are provided at the end of Table 3.14 for those items that are different from the 1996 items.

TABLE 3.14 - COMPARISON WITH 1990 WASTE STREAM

CATEGORY	1990 PER CENT	1996 PER CENT
Food waste	9.10	17.69
Other paper	11.56	10.03
Other (fines, dirt, ceramics)	9.60	7.56
Yard waste	10.49	7.40
Other plastic	6.39	6.64
Film plastic	4.07	4.97
Asphalt shingles	1.98	2.37
Other clean wood	4.01	1.66
Other composite products	0.25	2.87
Boxboard	5.70	2.43
Disposable diapers	1.20	2.41
Newsprint	1.65	2.30
Other construction and demolition	0.54	2.27
Corrugated cardboard	9.15	2.05
Other textiles	0.00 [a]	1.90
Other glass food containers	0.00 [b]	1.75
Cedar shingles	0.00 [c]	2.30
Ferrous food & beverage containers	1.10	1.41
Clothing	1.57	1.35
Clean dimensional lumber	0.00 [d]	1.20
Coated cardboard	0.10	1.20
Milk cartons	1.17	1.12
Other ferrous metals - not food & beverage	4.89	1.12
Inert demolition materials	0.53	1.39
White paper	0.33	0.91
Magazines	0.42	0.83
Plastic food containers	0.19	0.79
Other putrescible	0.00 [e]	0.75
Electronics	0.00 [f]	0.76
HDPE bottles	0.10	0.76
Contaminated and treated wood	3.55	0.68
Other paperboard	0.37	0.57
Furniture	0.39	0.56
Drywall	2.41	0.54
Other glass	0.39	0.53
PET bottles	0.05	0.43
Aluminum beverage cans	0.24	0.33
Other mostly ferrous materials	0.05	0.33
Other hazardous wastes	1.90	0.28
Sawdust	0.00 [g]	1.76
Aluminum foil and plates	0.00 [h]	0.23
Demolition wood waste	0.00 [i]	0.22
Stumps and slash	0.00 [j]	0.22
Other rubber products	0.97	0.21
Deposit container glass	2.52	0.20
Telephone books	0.00 [k]	0.19
Pallets, skids	0.00 [l]	0.15
Aerosol cans	0.00 [m]	0.10
Other mostly non-ferrous	0.00 [n]	0.09
Paints	0.00	0.05
Other 100% non-ferrous	0.81	0.09
Oil filters	0.00 [o]	0.02
Household batteries	0.00 [p]	0.02
Sharps	0.00 [q]	0.01
Vehicle tires	0.26	0.00
Oils	0.00 [r]	0.00
TOTAL	100.00	100.00

Notes to Table 3.14

[a] Other textiles - included with clothing.
[b] Other glass food containers - included with deposit glass.
[c] Cedar shingles - included with other clean wood.
[d] Clean dimensional lumber - included with other clean wood.
[e] Other putrescibles - included with other.
[f] Electronics - included with other.
[g] Sawdust - included with other.
[h] Aluminum foil, plates - included with other non-ferrous.
[i] Demolition wood - included with other clean wood.
[j] Stumps, slash - included with yard waste.
[k] Telephone books - included with other paper.
[l] Pallets, skids - not included.
[m] Aerosol cans - included with other non-ferrous.
[n] Other mostly non-ferrous - included with other non-ferrous.
[o] Oil filters - included with other hazardous.
[p] Household batteries- included with other hazardous.
[q] Sharps - included with other hazardous.
[r] Oils - included with other hazardous.

Care must be exercised when comparing percentages between different years because the total must always equal 100%, so when one category decreases, others must increase. There do appear to be some categories where fairly substantial declines have occurred. In order of decreasing reductions the categories are tires (100%), deposit container glass (92%), miscellaneous non-ferrous metals (89%), other hazardous wastes (85%), contaminated wood (81%), other rubber (78%), drywall (78%), corrugated cardboard (78%), other ferrous metals (77%), boxboard (57%) and yard wastes (29%). The reduction in the wood category may be partially attributable to differences in the sorting (e.g. cedar shingles in 1990 could have been included in either the clean wood or the contaminated or treated wood categories depending upon whether or not the shingles were treated, painted or untreated). Yard waste differences could be partly attributable to seasonality and weather conditions (e.g. the fall sort in 1996 was during a very wet period which could result in less yard and garden activity but a severe windstorm in the fall could have increased the amount of blown down branches and trees). Decreases in other rubber could be due to some rubber products being supplanted by plastics. One must also look at the statistical variations in these categories as well as at the number of annual tonnes when drawing conclusions about the effectiveness of reduction programs.

Of the increases in major categories food waste is by far the most significant with a 94% increase. The quantities of construction and demolition materials appear to have increased by about 71%.

CHAPTER 4 - CONFIDENCE IN THE RESULTS

4.1 Statistical Evaluation

Appendix A is comprised of a discussion of the results of the statistical analysis and a series of four tables showing the various statistics for the total waste stream, the residential waste stream, the commercial waste stream and the mixed commercial and residential waste stream for phase 1. The apartment sample was a single sample so that a statistical analysis does not apply. The construction and demolition samples were comprised of 7 trucks carrying only roofing materials and one truck carrying demolition wastes. The trucks carrying roofing materials comprised either or both asphalt shingles and cedar shingles. Application of statistics to these would have no meaning.

From the statistical discussion and tables, it is abundantly clear that most of the categories do not follow a normal (bell shaped) distribution. Intuitively, one would expect samples drawn from the residential sector to be relatively consistent because most people tend to buy and dispose of similar things. For the commercial sector, one would expect greater variability which is best illustrated by a conceptual example. One of the commercial trucks was reported to contain only wastes from the hospital, while another contained only wastes from BC Ferries and a third contained wastes from a supermarket. There is no reason to expect that the contents of these three vehicles would be the same or even close to the same. Significant variability is therefore to be expected in commercial trucks. Because of the variability in commercial loads, some of this will carry over into loads comprising mixed residential and commercial refuse. In general, wastes comprising the lower percentages have greater Chi-square values thus indicating greater deviation from a normal distribution. Application of the often used approach of calculating a mean and applying a confidence interval of +/- two standard deviations (i.e. the range within which 95% of the measurements fall) is not valid when the statistics show other than a normal distribution. This is abundantly clear when looking at the data in Tables 1 through 4 in Appendix A. Here, in a large number of cases, subtracting 2 standard deviations from the mean results in negative values, which is impossible. The means and standard deviations have been calculated and are shown in Tables 1 through 4 in Appendix A, but are not being used to report confidence limits in this report.

Even for those categories to which the test for a normal distribution is positive, care must be taken. For example, for the plastic category in commercial refuse the mean is 15.1 % and the standard deviation is 4.6% and the chi-square statistic indicates normality. The results might therefore be reported as plastics being 15.1% of the waste stream +/- 9.2%, 95% of the time. This cannot be taken to mean that a sample from any truck carrying commercial refuse will produce this result.

As pointed out in the statisticians report in Appendix A, a larger number of samples could help to lead to a more normal distribution of the sample data but, especially for those categories where the percentage is close to zero, this is not likely to occur.

In addition, where percentages are close to zero and where the unit weight of the items is small, (e.g. sharps {hypodermic needles} and household batteries), the smallest scale reading (0.25 lb.) on the beam scale that was used could have a distorting effect. For example, if three size AA batteries were obtained in a sample, the actual weight would be 0.15 lb. This would have been recorded as 0.25 lb. - an error of 66.7%. With hypodermic syringes the potential error due to this scale effect would be greater because of the small weight of an individual syringe. Due consideration must therefore be given to this weigh scale factor when interpreting the results for items where weights are a very low percentage of the total.

Given the preceding information, achieving a goal of "a profile of the Hartland landfill solid waste stream within an accuracy of +/- 5% at a 95% confidence level" is not likely to occur no matter how many samples are taken. It is also apparent that for those categories for which the test indicates a normal distribution, an increase in the number of samples will result in a reduction in the size of the confidence limits. There is some point therefore, where a trade-off between sampling costs and improved confidence limits (but likely never reaching the +/- 5% at a 95% confidence level goal for all 16 categories) will occur. Without a detailed analysis it is impossible to make a definite statement about where this trade-off point would be. The intuitive feeling held by the consultant and the statistician is that doubling the number of samples would not result in a large improvement in the statistics and that the number of samples would have to be increased five or ten-fold to produce an appreciable change in the confidence limits results.

Appendix A also includes statistical calculations and a discussion of the phase 2 results. As had been expected, increasing the sample size did not have any appreciable effect on the variability of the results. From a statistical point of view, there is no particular difference between the results in phase 1 and phase 2. The statistical comparison of the ranking of the results in the two phases (the categories by decreasing order of percentage) shows a very high correlation coefficient which by showing that the sampling procedures were consistent gives credence to the results.

A further perspective on the adequacy of the procedures used and the results obtained is provided in the following sections.

4.2 Adequacy of Sampling Procedure - Phase 1

As discussed in Chapter 2, the sample design was based on weight but the samples were taken based on volume. Table 4.1 shows the relationship between the percentage to be sampled based on the program design and the actual amount sampled.

TABLE 4.1 - SAMPLE DESIGN AND ACTUAL SAMPLE PERCENTAGES - PHASE 1

Company	Design percentage to be sampled	Percentage actually sampled	Per Cent difference
BFI	29.02	27.21	- 6.2
Laidlaw	15.33	15.26	- 0.5
Bins	13.15	15.22	15.7
Alpine	8.70	9.33	7.2
Saanich	8.55	7.96	- 6.9
Victoria	5.68	5.99	5.5
Ron's	4.26	2.41	- 43.4
H & L	2.91	3.01	3.4
Oak Bay	2.15	1.63	- 24.2
Esquimalt	1.28	1.91	49.2
Parker Johnston	1.25	1.10	- 12.0
Tim Jopp	1.19	1.87	57.1
Roofing companies	1.18	1.93	63.6
McNutt	1.18	1.38	16.9
Sooke	1.14	0.63	- 44.7
Brother's Transit	0.65	0.00	- 100.0
Ladah	0.52	1.38	165.0
Cubbon	0.51	0.54	5.9
Armour	0.51	0.69	35.3
Top Line	0.42	0.00	- 100.0
Goodwill	0.42	0.55	30.9
Total	100.00	100.00	

As expected, the general trend is for the amount of error to increase with smaller sample sizes. That is, plus or minus errors in estimating weights will tend to even out with a greater number of samples being taken. From the Table, 80.43% of the total weight sampled was within 15.7% of the design sample weight.

As discussed in Chapter 2, the sample sizes were determined based on the tonnage received at the landfill during the month of February, 1996. Table 4.2 shows the percentages used for the program design and the actual quantities delivered by the carrier.

TABLE 4.2 - SAMPLE DESIGN AND ACTUAL DELIVERIES - PHASE 1

Company	Design percentage to be sampled	Percentage delivered during sampling period	Percentage difference
BFI	29.02	28.09	- 3.2
Laidlaw	15.33	15.12	- 1.4
Bins	13.15	14.40	9.5
Alpine	8.70	9.00	3.4
Saanich	8.55	9.13	6.8
Victoria	5.68	6.24	9.9
Ron's	4.26	5.24	23.0
H & L	2.91	2.02	- 30.5
Oak Bay	2.15	2.14	- 0.5
Esquimalt	1.28	1.50	17.2
Parker Johnston	1.25	0.70	- 44.0
Tim Jopp	1.19	1.10	- 7.6
Roofing companies	1.18	1.37	16.1
McNutt	1.18	0.99	- 16.1
Sooke	1.14	1.26	10.5
Brother's Transit	0.65	0.32	- 50.8
Ladah	0.52	0.53	1.9
Cubbon	0.51	0.26	- 49.0
Armour	0.51	0.01	- 98.0
Top Line	0.42	0.13	- 69.0
Goodwill	0.42	0.45	7.1
Total	100.00	100.00	

As anticipated, the trend is for the percentage differences to increase with smaller sample sizes. That is, the larger companies like BFI, Laidlaw, the bins and Alpine are more consistent in their deliveries than are the smaller more infrequent customers. From the Table, 80.43% of the total weight delivered is within 9.9% of the design sample weight.

Table 4.3 combines the results from Tables 4.1 and 4.2 and relates the sample percentages to the percentage delivered during the sampling period.

TABLE 4.3 - ACTUAL DELIVERIES AND ACTUAL SAMPLES - PHASE 1

Company	Percentage delivered	Percentage actually sampled	Per Cent difference
BFI	28.09	27.21	- 3.1
Laidlaw	15.12	15.26	0.9
Bins	14.40	15.22	5.7
Alpine	9.00	9.33	9.7
Saanich	9.13	7.96	- 12.8
Victoria	6.24	5.99	- 4.0
Ron's	5.24	2.41	- 54.0
H & L	2.02	3.01	49.0
Oak Bay	2.14	1.63	- 23.8
Esquimalt	1.50	1.91	27.3
Parker Johnston	0.70	1.10	57.1
Tim Jopp	1.10	1.87	70.0
Roofing companies	1.37	1.93	40.9
McNutt	0.99	1.38	39.4
Sooke	1.26	0.63	- 50.0
Brother's Transit	0.65	0.00	-100.0
Ladah	0.53	1.38	160.4
Cubbon	0.26	0.54	108.0
Armour	0.01	0.69	6800.0
Top Line	0.13	0.00	- 100.0
Goodwill	0.45	0.55	22.2
Total	100.00	100.00	

Similar to the two preceding tables, the percentage differences increase with smaller sample sizes. 80.97% of the total sample percentage was within 12.8% of the percentage delivered.

4.3 Adequacy of Sampling Procedure - Phase 2

The sample design percentages and percentages delivered during the sampling period for phase 2 are presented in Table 4.4.

TABLE 4.4 - ACTUAL DELIVERIES AND ACTUAL SAMPLES - PHASE 2

Company	Percentage delivered	Percentage actually sampled	Per Cent difference
BFI	26.87	31.38	25.7
Regent Recycling	13.22	10.60	- 19.8
Alpine	8.82	7.49	- 15.1
Bins	8.60	8.73	1.5
Saanich	8.43	6.22	- 26.2
Laidlaw	5.91	7.58	28.3
Victoria	5.74	5.43	- 5.4
Ron's	5.44	5.81	6.8
Oak Bay	2.17	1.30	- 40.1
Top Line	1.87	0.46	- 75.4
H & L	1.77	1.52	- 14.1
Roofing companies	1.55	1.66	7.1
Tim Jopp	1.50	0.92	- 38.7
Esquimalt	1.33	1.23	- 7.5
Sooke	1.24	1.31	5.6
Parker Johnston	1.19	2.59	117.6
Brother's Transit	1.04	1.12	7.7
Sidney	1.03	1.28	24.3
McNutt	0.85	1.87	120.0
Ladah	0.45	0.30	- 33.34
Cubbon	0.38	0.37	- 2.6
Salvation Army	0.36	0.37	-2.8
Universal Sheet Metal	0.24	0.46	91.7
Total	100.00	100.00	

It can be seen that the results in phase 2 are not a good as those from the phase 1 sort. In phase 2, 83.24% of the total weight sampled was within 28.3% of the design. A significant contributor to this decrease in accuracy between the two phases is attributed to weather. In phase 2, the garbage tended to be very wet due to the amount of rain received. This made visual estimating difficult.

It would be possible to reduce the percentage differences in Table 4.1 to zero by weighing the sample prior to sorting. This would require putting the load from the front end loader on a large scale, then adding or subtracting material until the correct weight was achieved and then loading the material into the loader bucket and delivering it to the sorting table. Because there is no way to predict how much a given customer will deliver in the future, altering the per cent differences in Table 4.2 is not possible. The percentage differences in Table 4.2 are therefore the minimum to be expected. Comparing the first six categories in Tables 4.2 and 4.3 (80.43% or 81.98% of the total) shows that the totals of the absolute percentage differences are very close. Therefore weighing the samples prior to sorting would not likely achieve any improvement for these first six customers. Without going into a detailed cost analysis it is not possible to say whether or not the extra time needed to pre-weigh the samples would compensate for the reduced number of samples that would

be taken in this procedure, given the constraints of a fixed crew size and fixed sampling period.

4.4 Comparison With Another Recent Study

In March 1994, a waste stream analysis was prepared for the incinerator facility in Ferndale Washington. The sample size in Ferndale was 0.32% of the received waste stream compared with 0.077% for phase 1 of the CRD study. This incinerator receives wastes from the Bellingham area north to the Canadian border and includes urban and rural communities with curbside recycle programs in place. Table 4.5 provides a comparison for the 16 primary waste categories for phase 1 only because both phase 1 and the Ferndale study were conducted in the spring. The weighted total percentages for the CRD study are included in brackets for reference.

TABLE 4.5 - TOTAL WASTE STREAM - 16 PRIMARY CATEGORIES - COMPARISON WITH ANOTHER STUDY

CATEGORY	PHASE 1 - THIS STUDY %		FERNDALE STUDY %
Food waste	15.19	(17.69)	14.78
Paper	14.65	(14.26)	12.95
Plastic	13.63	(13.59)	11.97
Other	9.74	(8.36)	15.39 [a]
Paperboard	8.42	(7.37)	14.91 [b]
Construction and demolition	7.84	(9.31)	3.58
Composite materials	7.59	(6.60)	6.08
Yard wastes	6.06	(7.40)	1.14 [c]
Wood and wood products	5.80	(5.45)	4.22
Textiles	3.52	(3.25)	2.30
Ferrous metals	3.48	(2.86)	4.79
Glass	2.77	(2.48)	3.81
Non-ferrous metals	0.81	(0.79)	1.56
Rubber	0.26	(0.21)	0.56
Hazardous wastes	0.24	(0.38)	1.96
TOTAL	100.00	(100.00)	100.00

Notes to Table 4.5

[a] In the Ferndale study, sorting fines were classified as less than 3", whereas in the CRD, sorting fines were less than 2". In both cases sorting fines were included in the "Other" category. In Ferndale sorting fines accounted for 12.39%. "Other Putrescible Wastes" in the CRD study have been included in the "Other" category in Table 4.4.

[b] In Ferndale, "Paperboard" included magazines and telephone books which were in "Paper" for CRD.

[c] In Ferndale, "Yard Wastes" were minimal because it was still very cold and snowy.

Because the data in Table 4.5 come from two areas in the Pacific Northwest, both of which have rural and semi-rural population and which have extensive recycle programs, the Ferndale data are considered to provide support to the relative proportions in the CRD waste stream analysis.

4.5 Conclusions

The literature search clearly supported that the sample weight chosen was appropriate for most of the categories selected. The approach of using a judgmental sampling procedure was also supported by the literature reviewed. The discussion in Section 4.2 regarding Tables 4.1, 4.2, 4.3 and 4.4 indicates that the volumetric sampling approach was reasonable, certainly for the majority of the samples taken.

The results of the statistical analysis led the statistician to conclude that the sample design based upon stratification by sector was appropriate.

A comparison was made between solid waste analyses in two areas in Table 4.5. The two areas are within the same climate zone and each have active recycling programs and a mix of urban and rural population. Both analyses were conducted in the spring although the Ferndale study was done in March when it was still too cold for all but the most avid gardeners. Taking into account the notes to Table 4.4, the table shows a reasonable consistency between the two studies. The trend from highest to lowest percentages is also reasonably consistent.

Given the constraints of time, crew size and budget and considering the results and factors outlined in this chapter, it is felt that one can have a reasonable degree of confidence in the results for the major categories having relatively high percentages. Reliance on the percentages for the categories, especially the 56 secondary categories, having very low values should be done with considerable care. For the 16 primary categories, variability, as measured by the coefficient of variation, was least in the residential loads, second least in the mixed loads and greatest in the commercial loads As might be expected, the combination of all types of loads resulted in a variability falling between the lowest (residential) and the highest (commercial).

It seems likely that weather conditions may have contributed to some differences between phases 1 and 2. Garbage generally appeared to be much wetter during the high rainfall during phase 2. It was also felt that high winds during phase 2 may have caused an increase in tree branches due to blow-down. These factors may have contributed to the generally greater variability of the results in phase 2 of the study.

CHAPTER 5- CONCLUSIONS

No evidence was produced during the sampling to indicate that there were any single businesses contributing substantial quantities to the waste stream. The cut-off point for this determination is the minimum sample size which was equivalent to about 1400 tonnes per year.

Phase 2 results may have been influenced by the wet weather during the sampling period which may have resulted in increased weights in some categories.

No conclusions are drawn about the apartment sample in phase 1 because it was a single sample.

Only one conclusion is drawn about the demolition and construction samples and that is that the amount of construction and demolition refuse arriving at the Hartland Avenue landfill is relatively small. In phase 1, only one load (not including the specific loads from roofers), was characterized as construction and demolition (C & D) waste. This load was about 0.5% of the total sample weight. In phase 2, a total of 11 loads were called C & D. Of these 11 however, seven loads were composed of roofing materials, so that only four loads would be classified as C & D if roofing materials were not included. These four loads comprised about 4.3% of the sample weights. When the contribution from roofers is included the percentage rises to about 11.3%.

The food wastes from commercial establishments is a relatively high percentage when compared to that from residences. Because most commercial food wastes are from a limited number of sources (compared with residential food wastes) this seems to provide a reasonable potential for reduction with composting. Based on the one sample from apartments, food wastes from apartments is also a high percentage of the apartment waste stream.

While reductions have occurred in several categories since 1990, food wastes have increased to a substantial percentage of the waste stream (approximately double the 1990 percentage).

Statistically, there is no reason to accept the hypothesis that there is a difference between the phase 1 and phase 2 results. This is because the results do not follow a normal distribution and because there is significant statistical variance in the percentages for the individual categories, part of which may have had to do with wet conditions in phase 2..

In spite of the statistical variances, the results are consistent between the two phases and consistent with other waste stream analyses.

It seems clear that the percentage of compostable materials as measured by the (1) food waste, (2) yard waste and, (3) a proportion of the "other" category (the sorting fines) as well as possibly the paper and wood categories is a significant proportion of the residual waste stream some of which has not been strongly affected by the existing comprehensive Regional District solid waste reduction programs.

APPENDIX A

STATISTICS

Statistical Appendix

Tables 1 through 4 set out statistical results for the waste composition sampling study conducted in the Spring of 1996. The key data to focus on in these tables are the coefficients of variation shown in the fourth column. The coefficient of variation is calculated as the ratio of the standard deviation and the mean of the sample data and is expressed in percentage terms. It summarizes the degree of variability in the sample data.

For all sectors and for all waste categories, the estimated coefficients of variation are very high relative to the level required to place a narrow range on the values of the waste proportions. The lowest estimated coefficient of variation (30.84%) is for plastics in the commercial sector, but even this is considerably above that which is required to achieve a level of accuracy of $\pm$ 5% in the composition estimates. To achieve this latter level of accuracy, one would need to bring the coefficients of variation down to about 2-3%. A larger number of samples could help to lower the coefficients of variation, but this is not bound to occur. For example, adding sample data for the composition analysis to be done in the Fall of 1996, while adding to the total number of samples, could introduce a further source of variability related to seasonal factors. Similarly, Table 4 (which summarizes the statistical results for the total of 105 samples) indicates that increasing the sample numbers by pooling data for the different sectors will not necessarily lead to less variability. In fact, a comparison of the estimated coefficients of variation in Table 4 with those in the earlier tables shows that, in this instance, the variability is generally higher in the total sample.

The fifth column in the tables shows chi-square test statistics of the distribution of the sample data for each waste category. The chi-square statistic gives a means to determine if the sample data appears normally distributed. It compares the shape of the actual sample distribution with that which would occur if the sample were normally distributed.[1]

For many, but not all of the waste categories, the chi-square statistics are very high relative to that required to indicate a normal distribution. Where the sample data do not appear to follow a normal distribution, errors would be introduced by applying the standard approach of calculating confidence intervals using the sample mean $\pm$ two standard deviations. A larger number of samples could help lead to a more normal distribution in the sample data, but for many of the minor waste categories, the proximity of the sample means to zero will likely continue to be problematic (since the waste proportion is actually a binomial variable with a lower bound of zero).

It is important to note that even if it were possible to estimate confidence intervals for the individual waste components with some precision (i.e., with narrow confidence intervals), this precision would apply to the total waste stream only (e.g., proportion of paperboard in the total waste stream for the residential sector) not to the waste stream delivered by

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[1] For example, in a normal distribution, one-eighth of the sample data (12.5th percentile) would have values less than the mean minus 1.15 times the standard deviation. The 12.5th percentile for the actual sample data might be less than or greater than this latter value, and the chi-square statistic measures the significance of these types of differences.

any particular vehicle or operator. Clearly, any particular vehicle arrival could involve a waste composition considerably outside the confidence interval for the associated total waste stream (potentially, any individual waste category could have a proportion between zero and 100% for any particular arrival).

Two final points emerging from the Spring 1996 composition study are worthy of highlight:

1) The generally lower coefficients of variation observed in Tables 1 through 3, as compared with Table 4, indicate that a sample design based on stratification by sector appears to be a good approach to reducing sample variability.
2) Across all sectors, plastics are consistently estimated with the highest level of precision and the distribution of this component appears fairly normal.

TABLE 1

Key Statistics for Solid Waste Stream Composition Study,
Capital Regional District, Spring 1996
Sector: RESIDENTIAL Sample Size: 32

Primary Waste Category	Mean (μ)	Standard Deviation (σ)	Coefficient of Variation (σ/μ)	Chi-Square Statistic[a] (χ^2)
Paper	0.169	0.102	60.45%	12.0
Paperboard Products	0.091	0.064	70.26%	13.0
Plastics	0.169	0.055	32.44%	6.5
Glass	0.037	0.033	88.39%	18.5
Ferrous Metals	0.038	0.028	73.85%	13.5
Non-ferrous Metals	0.014	0.011	78.30%	15.0
Yard Wastes	0.078	0.084	107.42%	13.0
Food Waste	0.135	0.081	60.21%	4.5
Other Organic Waste	0.010	0.021	221.22%	116.5
Wood and Wood Products	0.004	0.013	308.25%	166.5
Construction/Demolition Materials	0.029	0.108	370.34%	149.0
Textiles	0.045	0.059	132.54%	19.0
Rubber	0.001	0.004	365.00%	165.5
Composite Products	0.084	0.054	64.60%	3.0
Hazardous Wastes	0.004	0.009	251.47%	128.5
Other	0.093	0.059	63.05%	24.0

[a] Degrees of freedom for the chi-square statistic for the Residential sector are 5, reflecting the division of the sample frequencies into 8 percentile ranges. Degrees of freedom are calculated as the number of percentile ranges, minus 1, minus the number of estimated distribution parameters, μ and σ. The critical value of the chi-square test for normality at (.99, 5) is 15.09. A chi-square statistic greater than this critical value indicates that the hypothesis that the sample values have a normal distribution can be rejected.

TABLE 2

Key Statistics for Solid Waste Stream Composition Study, Capital Regional District, Spring 1996
Sector: COMMERCIAL Sample Size: 25

Primary Waste Category	Mean (μ)	Standard Deviation (σ)	Coefficient of Variation (σ/μ)	Chi-Square Statistic[a] (χ^2)
Paper	0.112	0.081	72.08%	2.0
Paperboard Products	0.112	0.103	91.74%	5.2
Plastics	0.151	0.046	30.84%	1.6
Glass	0.025	0.026	104.13%	2.4
Ferrous Metals	0.033	0.044	132.44%	32.4
Non-ferrous Metals	0.005	0.004	93.08%	2.8
Yard Wastes	0.033	0.058	176.28%	26.8
Food Waste	0.221	0.191	86.34%	5.2
Other Organic Waste	0.001	0.003	500.00%	90.4
Wood and Wood Products	0.038	0.063	168.52%	31.8
Construction/Demolition Materials	0.032	0.102	315.45%	56.8
Textiles	0.043	0.086	200.31%	43.2
Rubber	0.000	0.000	#n/a	90.4
Composite Products	0.114	0.164	143.60%	26.4
Hazardous Wastes	0.002	0.006	326.95%	51.2
Other	0.079	0.070	89.75%	3.2

[a] Degrees of freedom for the chi-square statistic for the Commercial sector are 2, reflecting the division of the sample frequencies into 5 percentile ranges. Degrees of freedom are calculated as the number of percentile ranges, minus 1, minus the number of estimated distribution parameters, μ and σ. The critical value of the chi-square test for normality at (.99, 2) is 9.21. A chi-square statistic greater than this critical value indicates that the hypothesis that the sample values have a normal distribution can be rejected.

TABLE 3

Key Statistics for Solid Waste Stream Composition Study,
Capital Regional District, Spring 1996
Sector: MIXED OR OTHER Sample Size: 40

Primary Waste Category	Mean (μ)	Standard Deviation (σ)	Coefficient of Variation (σ/μ)	Chi-Square Statistic (χ^2)[a]
Paper	0.165	0.111	67.54%	26.4
Paperboard Products	0.067	0.047	69.99%	21.2
Plastics	0.121	0.052	43.04%	16.4
Glass	0.022	0.022	98.39%	15.2
Ferrous Metals	0.038	0.039	102.42%	21.2
Non-ferrous Metals	0.006	0.006	92.11%	20.0
Yard Wastes	0.075	0.085	112.77%	26.4
Food Waste	0.118	0.102	87.11%	18.4
Other Organic Waste	0.003	0.013	438.72%	220.8
Wood and Wood Products	0.129	0.187	144.34%	31.2
Construction/Demolition Materials	0.073	0.140	191.49%	106.0
Textiles	0.034	0.035	103.83%	37.2
Rubber	0.006	0.016	250.42%	181.6
Composite Products	0.066	0.053	81.03%	21.2
Hazardous Wastes	0.003	0.007	217.58%	116.4
Other	0.074	0.057	76.28%	7.6

[a] Degrees of freedom for the chi-square statistic for the Mixed or Other sector are 5, reflecting the division of the sample frequencies into 8 percentile ranges. Degrees of freedom are calculated as the number of percentile ranges, minus 1, minus the number of estimated distribution parameters, μ and σ. The critical value of the chi-square test for normality at (.99, 5) is 15.09. A chi-square statistic greater than this critical value indicates that the hypothesis that the sample values have a normal distribution can be rejected.

TABLE 4

Key Statistics for Solid Waste Stream Composition Study, Capital Regional District, Spring 1996
Sector: ALL Sample Size: 105[a]

Primary Waste Category	Mean (μ)	Standard Deviation (σ)	Coefficient of Variation (σ/μ)	Chi-Square Statistic (χ^2)[b]
Paper	0.142	0.105	73.70%	13.4
Paperboard Products	0.081	0.073	90.16%	34.1
Plastics	0.136	0.064	46.61%	5.6
Glass	0.027	0.027	101.21%	43.9
Ferrous Metals	0.034	0.037	106.81%	50.3
Non-ferrous Metals	0.008	0.009	110.88%	42.7
Yard Wastes	0.059	0.076	128.40%	146.3
Food Waste	0.141	0.131	92.92%	51.5
Other Organic Waste	0.004	0.014	344.67%	672.4
Wood and Wood Products	0.051	0.117	228.23%	371.3
Construction/Demolition Materials	0.109	0.266	243.51%	482.5
Textiles	0.036	0.058	158.73%	140.2
Rubber	0.002	0.009	413.15%	757.8
Composite Products	0.079	0.099	125.21%	96.2
Hazardous Wastes	0.003	0.007	278.63%	467.1
Other	0.088	0.077	87.61%	43.9

[a] Includes 8 samples of Construction and Demolition Waste.

[b] Degrees of freedom for the chi-square statistic for the All sector (total waste stream) are 7, reflecting the division of the sample frequencies into 10 percentile ranges. Degrees of freedom are calculated as the number of percentile ranges, minus 1, minus the number of estimated distribution parameters, μ and σ. The critical value of the chi-square test for normality at (.99, 7) is 18.48. A chi-square statistic greater than this critical value indicates that the hypothesis that the sample values have a normal distribution can be rejected.

Statistical Appendix II

Table 5 sets out summary statistics for the waste composition sampling study conducted in the Fall of 1996. The table includes sample data for all sectors (residential, commercial, mixed and construction/demolition), with a sample size of 116. It corresponds to Table 4 found in the Statistical Appendix to the report on the Spring, 1996 sampling study.[1]

Again, the key data to focus on in this table are the coefficients of variation shown in the fourth column. The coefficient of variation is calculated as the ratio of the standard deviation and the mean of the sample data and is expressed in percentage terms. It summarizes the degree of variability in the sample data.

For all waste categories, the estimated coefficients of variation continue to be very high relative to the level required to place a narrow range on the values of the waste proportions. The lowest estimated coefficient of variation (69.56%) is for paper, which is considerably above that which is required to achieve a level of accuracy of ± 5% in the composition estimates.

In some circumstances, collecting a larger number of samples can help to lower the coefficients of variation. However, it appears in this case that adding the sample data from the Fall survey to that previously obtained in the Spring survey does not substantially reduce the observed variability in the data. Table 6 shows the coefficients of variation for the pooled survey data for the four largest waste categories observed in each of the seasonal surveys (i.e.. paper, plastics, food waste and construction/demolition materials). It is apparent, from a comparison of the coefficients of variation in this table with those in Table 4 (Spring survey) and Table 5 (Fall survey), that the variability of the waste composition estimates are not substantially reduced as a result of the larger sample size. Indeed, in the case of plastics, the coefficient of variation is substantially higher in the pooled sample than in the sample for the Spring survey only. It appears likely that the Fall survey data contain additional sources of variability related to seasonal and other factors. Higher moisture levels affecting the Fall sampling study have been cited as one probable source of additional variability.

Two final points should be made with respect to the data collected in the Spring and Fall surveys:

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[1] Since it was apparent from the Spring survey that the waste composition fractions calculated for each of the individual samples are generally not normally distributed, the chi-squared statistic is omitted from this table.

1) On account of the high variability observed in the sample data, it is not possible for meaningful hypotheses to be tested about seasonal differences in the data. For example, it is not possible, based on the calculated standard deviations of the yard waste composition fraction, to reject the hypothesis that the higher fraction of yard waste observed in the Fall (8.3% vs. 5.9% in the Spring) was simply the result of statistical variation rather than systematic seasonal factors.

2) In the two sets of survey data, there is a high correlation between the ordering of the primary waste categories in terms of their relative contributions to the total waste stream. Waste categories which contributed a high percentage of the total waste stream in the Spring survey continued to contribute a high percentage in the Fall survey. Despite some relative reordering of the categories in the two surveys (e.g., paper, which was the most important contributor in the Spring survey fell to the fourth largest contributor in the Fall), it is apparent that a close correlation exists between the two orderings. To confirm this, a rank correlation coefficient was calculated for the two orderings and shows a very high correlation coefficient of +0.96.

TABLE 5

Key Statistics for Solid Waste Stream Composition Study,
Capital Regional District, Fall 1996
Sector: ALL Sample Size: 116

Primary Waste Category	Mean (μ)	Standard Deviation (Í)	Coefficient of Variation (Í/μ)
Paper	0.138	0.096	69.56%
Paperboard Products	0.063	0.060	94.95%
Plastics	0.143	0.115	80.62%
Glass	0.022	0.024	109.91%
Ferrous Metals	0.020	0.027	136.61%
Non-ferrous Metals	0.008	0.015	177.78%
Yard Wastes	0.083	0.120	145.63%
Food Waste	0.195	0.157	80.61%
Other Organic Waste	0.012	0.025	207.53%
Wood & Wood Prod's	0.046	0.112	242.40%
Construction/Demo	0.140	0.303	215.39%
Textiles	0.026	0.043	162.98%
Rubber	0.002	0.007	399.08%
Composite Products	0.055	0.099	181.04%
Hazardous Wastes	0.006	0.015	232.71%
Other	0.059	0.109	184.23%

TABLE 6

Comparision of Coefficients of Variation For Individual and Pooled Samples, Solid Waste Stream Composition Study, Capital Regional District, Spring and Fall 1996

Primary Waste Category	CV in Spring survey	CV in Fall survey	CV for pooled sample
Paper	73.70%	69.56%	71.50%
Plastics	46.61%	80.62%	67.30%
Food Waste	92.92%	80.61%	87.10%
Construction/Demo	243.51%	215.39%	227.30%

* CV denotes Coefficient of Variation.

APPENDIX B

DATA SHEETS

CAPITAL REGIONAL DISTRICT - WASTE STREAM ANALYSIS - DAILY LOG

Date _____ Sample No. ____ Number of staff sorting ___ Garbage hauler _____

Vehicle type _____ Vehicle I. D. # _____ Type of garbage _____

********* REMEMBER TO SUBTRACT TARE WEIGHT OF CONTAINER ********

Newspaper								
Magazines								
White paper (computer, bond)								
Telephone books, MLS directories								
Other paper								
Corrugated cardboard (OCC)								
Coated or waxed OCC								
Boxboard								
Milk Cartons & Tetra-Paks								
Other paperboard								
PET bottles (Type 1)								
HDPE bottles (Type 2)								
Plastic food containers								
Film plastic (sheet, bags)								
Film plastic (sheet, bags)								
Other plastic								
Deposit container glass								
Other food & beverage conts.								
Other glass								
Ferrous metal food & beverage cans								
Other 100% ferrous metal objects								
Other mostly ferrous metal objects								
Non-ferrous aluminum beverage cans								
Non-ferrous aluminum foil, pie plates								
Non ferrous aerosol cans								
Other 100% non-ferrous objects								
Other mostly non-ferrous objects								
Garden & yard wastes								
Garden & yard wastes								
Food wastes								
Other putrescible								
SUB TOTAL								

SUB TOTAL CARRIED FORWARD								
Pallets, skids								
Clean dimension lumber								
Contaminated, treated, painted wood								
Other wood								
Demolition wood waste								
Drywall								
Inert demolition materials								
Stumps, branches > 3" diam								
Other construction, demolition wastes								
Clothing								
Other textiles								
Vehicle tires								
Other rubber								
Disposable diapers								
Furniture								
Electronics (Computers, VCRs, etc)								
Other composite materials								
Paints								
Household batteries								
Oils								
Oil filters								
Sharps (needles)								
Other hazardous wastes								
Other (fines, dirt, ceramics, etc)								
TOTAL								

COMMENTS - Delays, unusual materials

Sample No. - continuous numbering from day 1.

Vehicle type - front loader, rear loader, side loader, roll-off, van, other.
Vehicle ID # - if available.
Type of garbage - Residential, commercial, construction/demolition, mixed (e.g. X % residential, Y % commercial)

Plastic food containers - hard plastics like margarine, yogurt, cream cheese, etc.
Other putrescibles - animal carcasses, fecal matter, etc.
Inert demolition materials - bricks, concrete, gravels, rubble, soil, asphalt.
Other hazardous - solvents, antifreeze, polishes, drain cleaners, acids, medical, insecticides, glue.

APPENDIX C

SORTING CATEGORY SHEETS

CAPITAL REGIONAL DISTRICT - WASTE STREAM ANALYSIS

Garbage is to be separated into 53 different categories. Because 53 categories is too many for easy sorting, we will separate first into 34 primary categories and then do a separate sort for 6 of the primary categories. The sort is listed as follows.

PRIMARY SORT	SECONDARY SORT
1. NEWSPAPER	
2. MAGAZINES, TELEPHONE BOOKS AND MLS DIRECTORIES	1. Magazines 2. Tel books and MLS dir
3. WHITE PAPER (COMPUTER, BOND)	
4. OTHER PAPER	
5. CORRUGATED CARDBOARD (OCC)	
6. COATED OR WAXED OCC	
7. BOXBOARD, MILK CARTONS AND TETRA-PAKS	1. Milk cartons and Tetra-Paks 2. Boxboard
8. OTHER PAPERBOARD	
9. PET BOTTLES, HDPE BOTTLES AND PLASTIC FOOD CONTAINERS	1. PET bottles (Type 1) 2. HDPE bottles (Type 2) 3. Plastic food conts (Hard plastic)
10. FILM PLASTIC, PLASTIC BAGS	
11. OTHER PLASTIC	
12. DEPOSIT CONTAINER GLASS	
13. OTHER GLASS FOOD & BEVERAGE CONTS.	
14. OTHER GLASS	
15. FERROUS METALS	1. Ferrous metal food & bev cans 2. Other 100% ferrous metal objects 3. Other mostly ferrous metal objects
16. NON-FERROUS METALS	1. Non-ferrous alum beverage cans 2. Non-ferrous alum foil, pie plates 3. Non ferrous aerosol cans 4. Other 100% non-ferrous objects 5. Other mostly non-ferrous objects
17. GARDEN & YARD WASTES	
18. FOOD WASTES	

19. OTHER PUTRESCIBLE

20. CLEAN DIMENSION LUMBER

21. CONTAMINATED, TREATED, PAINTED WOOD

22. OTHER WOOD

23. DEMOLITION WOOD WASTE

24. DRYWALL

25. INERT DEMOLITION MATERIALS

26. OTHER CONSTRUCTION, DEMOLITION WASTES

27. CLOTHING

28. OTHER TEXTILES

29. RUBBER OTHER THAN VEHICLE TIRES

30. DISPOSABLE DIAPERS

31. ELECTRONICS (COMPUTERS, VCRS, ETC)

32. OTHER COMPOSITE MATERIALS

33. HAZARDOUS WASTES

    1. Paints
    2. Household batteries
    3. Oils
    4. Oil filters
    5. Sharps (needles)
    6. Other hazardous wastes

34. OTHER (FINES, DIRT, CERAMICS, ETC)

In addition to the above are four other categories which, because of their bulk, will probably not show up in the samples. If they do show up, they are to be kept separate and the weights entered into the daily log. The categories are:

1. Pallets, skids
2. Stumps and branches < 3"
3. Vehicle tires
4. Furniture

This gives a grand total of 53 different categories.

APPENDIX D

VEHICLES TO BE SAMPLED - PHASE 1

CAPITAL REGIONAL DISTRICT - SAMPLING SCHEDULE

Company	Equip No.	Arrival Frequency	Usual Time	No. of sample	Sample Size cu. m	Sample Taken
Alpine	1-330	7/mo	10-12 AM	1	0.6	Whenever
	111	Daily	11-12 AM	4	1.2	1/week
	1111	3/mo	9-12 AM	1	0.4	Whenever
	2-330	Daily	11-12 AM	1	1.2	Whenever
	3-330	Daily	8-9 AM	1	1.2	Whenever
	4-330	1/2 days	10-12 AM	1	1.2	Whenever
	5-330	1/2 days	9-12AM	1	0.6	Whenever
Armour Sheet Metal	1125-480 1030-480 1025-480	1/wk	Variable	1	0.6	Whenever from one vehicle
Brothers Transit	1140-1550	2/wk	Variable	1	0.6	Whenever from largest load
BFI-Front Loaders	501	Daily	Noon	1	0.5	Whenever
	608	Daily	2-3 PM	1	0.5	Whenever
	650	Daily	3-4 PM	1	0.7	Whenever
	927	2/day	Variable	4	1.2	1/week
	929	2/day	9AM, 1PM	5	1.2	5/4 wks
	930	1.5/day	Noon, 4PM	3	1.2	3/4 wks
	931	2/day	9AM, 2PM	4	1.2	1/week
BFI Roll-off	1001-1700	2/day	9 AM, Noon	4	1.2	1/week
	416-3	2/wk	Variable	1	0.5	Whenever
	416-66	2/wk	Variable	1	0.6	Whenever
	421	2/day	9 AM, Noon	1	1.2	Whenever
Cubbon Indust	4-2385	1/day	Variable	1	0.6	Whenever
Laidlaw Roll-off	160	2/day	Variable, AM	2	1.2	2 wks apart
	161	2/day	Variable, AM	2	1.2	2 wks apart
	348	1/day	Variable, AM	1	1.0	Whenever
	75	1/day	Variable, AM	1	1.0	Whenever
Laidlaw res	223	1/day	11AM-1PM	1	0.7	Whenever
Laidlaw Front End	2036	2/day	8 AM, Noon	4	1.2	1/ week
	473	2/day	10 AM, 1 PM	4	1.2	1/week
Esquimalt	119-3000	1/2 days	3 PM	1	1.0	Whenever
	98-3000	1/2 days	3 PM	1	0.3	Whenever
Goodwill	8-4000	1/day	Variable	1	0.5	Whenever
H & L Disp	27-4400	2/wk	Variable	1	0.8	Whenever
	30-4400	2/day	Variable	2	1.2	2 wks apart
PAGE TOTAL				60		

CAPITAL REGIONAL DISTRICT - SAMPLING SCHEDULE

Company	Equip No.	Arrival Frequency	Usual Time	No. of sample	Sample Size cu. m	Sample Taken
Ladah Holding	3-4943	2/wk	730 AM	1	1.2	Whenever
MacNutt	1135 1135-4950 1111-4950	2/wk	Variable	1	1.2	Whenever from one truck only
Oak Bay	111-7200	1/wk	Variable	1	0.6	Whenever
	41-7200	1/2day	2-3 PM	1	0.8	Whenever
	70-7200	1/wk	2-3 PM	1	0.4	Whenever
Parker	1630	3/wk	Variable	1	0.6	Whenever
Johnston	1640	2/wk	Variable	1	0.4	Whenever
Rons	12-8800	1/day	Variable	2	1.2	2 wk apart
Disposal	4-8800	1/day	3-4 PM	1	0.8	Whenever
	6-8800	1/day	3-4 PM	1	0.8	Whenever
Saanich	509	4/wk	2 PM	1	0.3	Whenever
	510	1/day	2-3 PM	1	0.4	Whenever
	558	4/wk	2-3 PM	1	1.0	Whenever
	559	2/wk	2-3 PM	1	1.0	Whenever
	560	1/wk	7AM, 2PM	2	1.2	2 wk apart
	561	1/day	2 PM	1	1.2	Whenever
	562	1/day	2 PM	1	1.2	Whenever
	563	1/day	2 PM	1	1.2	Whenever
Sidney	17-9205	4/wk	1-2 PM	1	0.8	Whenever
Sooke	9-9456	1/wk	Variable	1	0.8	Whenever
Top Line	1140-9510 1130-9510	1/wk	Variable	1	0.5	From either truck
Tim Jopp	1-9511	2/wk	Variable	1	0.6	Whenever
	2-9511	3/wk	Variable	1	0.8	Whenever
	3-9511	2/wk	Variable	1	0.3	Whenever
PAGE TOTAL				26		

CAPITAL REGIONAL DISTRICT - SAMPLING SCHEDULE

Company	Equip No.	Arrival Frequency	Usual Time	No. of sample	Sample Size cu. m	Sample Taken
Victoria	348-347	2/wk	Variable	1	1.2	Spread
	348-350	2/wk	Variable	1	1.2	over
	351-347	2/wk	Variable	1	1.1	four
	351-350	2/wk	Variable	2	1.2	weeks
Bins				11	1.2	3/wk
PAGE TOTAL				16		

Roofers - Try to get one small sample (0.3 cu m) from each of the following roofers (List under residential):

Rain Coast	Twice/week	Usually afternoons
Square Deal	Once/week	Usually mornings
Southport	Twice/week	Variable

In addition to the above, we will be arranging to get one load from BFI of strictly apartment wastes. Take a 1.2 cu m sample from this unit.

This gives a grand total of 106 samples.

CRD - WASTE STREAM ANALYSIS - SUGGESTED WEEKS FOR SAMPLES

WEEK 1

Alpine 111
Alpine 1111
Armour - 1 of 3 trucks
BFI 927
BFI 929
BFI 930
BFI 931
BFI 1001-1700
BFI 416-3
Esquimalt 119-3000
H & L 30-4400
Laidlaw 160
Laidlaw 2036
Laidlaw 473
Parker Johnston 1640
Rons Disposal 12-8800
Saanich 560
Victoria 351-350
Victoria 348-347
1 roofer
2 bins

WEEK 2

Alpine 111
Alpine 1-330
Alpine 5-330
BFI 927
BFI 929
BFI 930
BFI 931
BFI 1001-1700
Laidlaw 2036
Laidlaw 473
Laidlaw 161
Oak Bay 111-7200
Saanich 559
Tim Jopp 1-9511
MacNutt 1 0f 3 trucks
Top Line 1 of 2 trucks
Victoria 348-350
Victoria 351-350
One lawn and garden
One roofer
3 bins

WEEK 3

Alpine 111
Alpine 4-330
BFI 927
BFI 929
BFI 929
BFI 931
BFI 1001-1700
Brothers transit 1140-1550
Cubbon 4-2385
Esquimalt 98-3000
H & L 27-4400
Ladah 3-4943
Laidlaw 160
Laidlaw 348
Laidlaw 223
Laidlaw 2056
Laidlaw 473
Oak Bay 70-7200
Sooke 9-9456
Rons Disposal 4-8800
Saanich 510
Saanich 560
Saanich 561
Tim Jopp 3-9511
Victoria 351-347
1 roofer
3 bins

WEEK 4

Alpine 111
Alpine 2-330
Alpine 3-330
BFI 501
BFI 608
BFI 650
BFI 927
BFI 929
BFI 930
BFI 931
BFI 1001-1700
BFI 416-66
BFI 421
Goodwill 8-4000
H & L 30-4400
Laidlaw 161
Laidlaw 75
Laidlaw 2056
Laidlaw 473
Oak Bay 41-7200
Parker Johnston 1630
Rons Disposal 6-8800
Saanich 509
Saanich 562
Saanich 563
Saanich 558
Victoria 351-350
Tim Jopp 2-9511
1 roofer
3 bins

APPENDIX E

VEHICLES TO BE SAMPLED - PHASE 2

CAPITAL REGIONAL DISTRICT - SAMPLING INFORMATION

Company	Equip No.	Arrival Frequency	Usual Time	No. of samples	Sample Size cu. m	Sample Taken
Alpine	111	Daily	Variable	5	0.9	5/4 weeks
	1111	2/wk	Variable	1	0.9	Whenever
	2-330	2/wk	Variable	1	0.6	Whenever
	3-330	Daily	Morning	1	0.9	Whenever
	4-330	Daily	Before 2 PM	1	0.9	Whenever
Brothers Transit	Different	Daily	Variable	2	0.5	Whenever from large loads
BFI-Front Loaders	701	4/wk	Noon	1	0.5	Whenever
	808	4/wk	Variable	1	0.5	Whenever
	850	3/wk	Variable	1	0.6	Whenever
	927	4/wk	Variable	2	0.7	Whenever
	929	3/day	Variable	6	0.9	6/4 wks
	930	2/day	Noon, 4 PM	3	0.9	3/4 wks
	931	3/day	Variable	6	0.9	6/4 wks
	932	3/day	Variable	5	0.9	5/4 wks
	934	1.5/wk	Variable	1	0.5	Whenever
BFI	1001-1170	1/day	Mornings	2	0.9	1/2 wks
Roll-off	416	2/day	Variable	2	0.9	Whenever
Cubbon Indust	4-2385	1/day	Variable	1	0.4	Whenever
Laidlaw	161	2/day	Variable, AM	2	0.9	2 wks apart
Roll-off	348	1/day	Variable, AM	1	0.9	Whenever
	646	1/day	Variable, AM	1	0.6	Whenever
Laidlaw res	223	1/day	11 AM - 1 PM	1	0.7	Whenever
Laidlaw	343	2/day	Variable	3	0.8	3/4 wks
Front End	473	3/wk	Mornings	2	0.6	2/4 wks
Esquimalt	119- 3000	4/wk	3 PM	1	1.0	Whenever
H & L Disp	30-4400	1/day	Variable	2	0.5	2 wks apart
	32-4400	4/wk	Variable	1	0.5	Whenever
Ladah Holding	4-4943	2/wk	730 AM	1	0.5	Whenever
MacNutt	Different Numbers	2/wk	Variable	1	0.9	Whenever from one truck only
Oak Bay	111-7200	2/wk	Mornings	1	0.9	Whenever
	41-7200	2/wk	1-3 PM	1	0.6	Whenever
	70-7200	2/wk	2-3 PM	1	0.6	Whenever
PAGE TOTAL				61		

CAPITAL REGIONAL DISTRICT - SAMPLING INFORMATION

Company	Equip No.	Arrival Frequency	Usual Time	No. of samples	Sample Size cu. m	Sample Taken
Parker Johnston	1640	2/wk	Variable	2	0.9	2 wk apart
Regent Recycling	Different numbers	2/day	Variable	11	0.9	3 per week
Rons Disposal	12-8800	1/day	Variable	3	0.9	3/4 wk
	16-8800	1/day	Variable	1	0.9	Whenever
	6-8800	4/wk	Variable	1	0.9	Whenever
	14-8800	4/wk	Variable	1	0.5	Whenever
Saanich	556	6/4 wk	1-3 PM	1	0.5	Whenever
	559	1/day	1-3 PM	2	0.5	2 wk apart
	560	1/day	1-3 PM	2	0.6	2 wk apart
	561	1/day	1-3 PM	1	1.1	Whenever
	562	1/day	1-3 PM	2	0.5	2 wk apart
	563	1/day	1-3 PM	1	1.0	Whenever
Salvation Army	417-9300	1/day	Early AM	1	0.4	Whenever
Sidney	17-9205	1/day	Variable	1	0.9	Whenever
Sooke	Varying	1/day	Variable	2	0.6	2 wks apart
Top Line	Varying	1/day	Variable	2	0.6	2 wks apart
Tim Jopp	Varying	2/wk	Variable	1	1.0	Whenever
Universal Sheet Metal	Varying	3/wk	Variable	1	0.5	Whenever
Victoria	Varying	2/day	Variable	6	0.9	Spread over 4 weeks
Bins				10	0.9	Spread over 4 weeks
PAGE TOTAL				52		

CAPITAL REGIONAL DISTRICT - SAMPLING INFORMATION

Roofers - Get one small sample (0.4 cu m) from each of the following roofers (Enter in the construction and demolition category):

Haley	Almost daily	Variable times
Rain Coast	Three/week	Variable times
Square Deal	Three/week	Variable times
Victoria Roofing & Insulation	Three/week	Usually mornings

You may not need to collect a sample from the roofers. for example if the load is evenly split between asphalt shingles and cedar shingles, simply enter the weight of a 0.2 cu m sample for each (i. e. 44 lb each).

This gives a grand total of 117 samples.

The estimated conversion between sample size and weight is as follows:

0.9 cu m	221 lb
0.8 cu m	196 lb
0.7 cu m	171 lb
0.6 cu m	133 lb
0.5 cu m	110 lb
0.4 cu m	88 lb

CRD - WASTE STREAM ANALYSIS - SUGGESTED WEEKS FOR SAMPLES

WEEK 1

Alpine 111
Alpine 1111
BFI 929
BFI 931
BFI 932
BFI 934
Brothers Transit
Esquimalt 119-3000
H & L 30-4400
Laidlaw 343
Laidlaw 646
Parker Johnston 1640
Regent Recycling
1 roofer
Regent Recycling
Rons Disposal 12-8800
Saanich 556
Saanich 560
Universal Sheet Metal
Victoria
1 bin

WEEK 2

Alpine 111
Alpine 2-330
BFI 416
BFI 927
BFI 929
BFI 930
BFI 931
BFI 931
BFI 932
BFI 1001-1700
Laidlaw 161
Laidlaw 343
Laidlaw 473
Oak Bay 111-7200
Rons Disposal 12-8800
Rons Disposal 16-8800
Saanich 559
Saanich 562
Sooke
1 bin
MacNutt
Top Line
Victoria
1 roofer
Tim Jopp
Regent Recycling
Regent Recycling
Regent Recycling
1 bin
1 bin

WEEK 3

Alpine 111
Alpine 111
Alpine 4-330
BFI 929
BFI 929
BFI 930
BFI 931
BFI 932
Cubbon 4-2385
1 roofer
1 bin
Brothers Transit
H & L 32-4400
Ladah 4-4943
Laidlaw 223
Laidlaw 348
Oak Bay 70-2700
Parker Johnston 1640
Regent Recycling
Regent Recycling
1 bin
1 bin
Regent Recycling
Rons Disposal 12-8800
Rons Disposal 14-8800
Saanich 560
Saanich 561
Saanich 563
Salvation Army
Sidney 17-9205
Victoria
Victoria

WEEK 4

Alpine 111
Alpine 3-330
BFI 416
BFI 701
BFI 808
BFI 850
BFI 927
BFI 929
BFI 929
BFI 930
BFI 931
BFI 931
BFI 932
BFI 932
BFI 1001-1170
H & L 30-4400
Laidlaw 161
Laidlaw 343
Laidlaw 473
Oak Bay 41-2700
Regent Recycling
Regent Recycling
Regent Recycling
Rons Disposal 6-8800
Saanich 559
Saanich 562
Sooke
Top Line
Victoria
Victoria
1 bin
1 bin
1 bin
1 roofer