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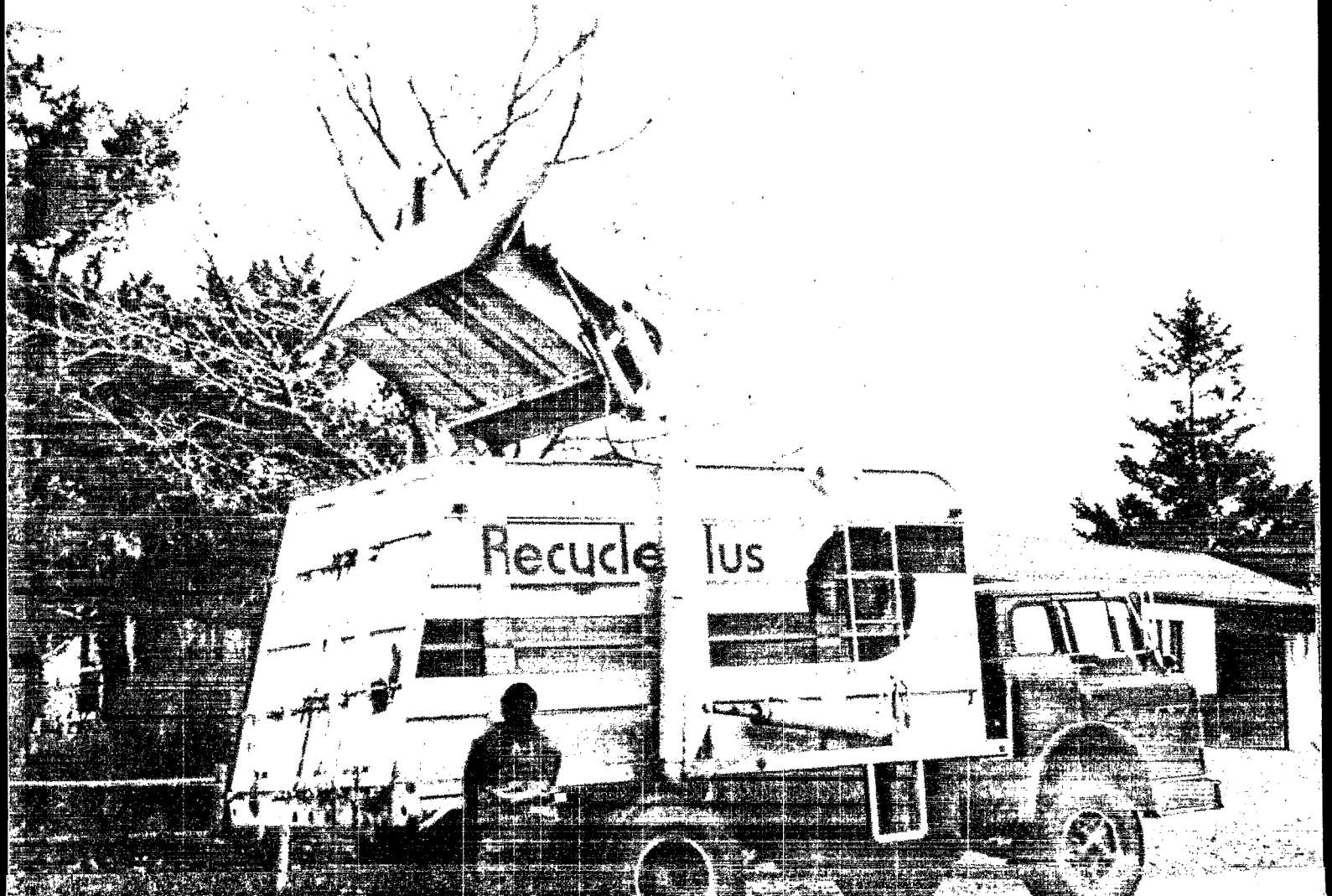
Multimaterial Source Separation in Marblehead and Somerville, Massachusetts

Composition of Source-Separated Materials and Refuse

Volume III



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MULTIMATERIAL SOURCE SEPARATION

IN MARBLEHEAD AND SOMERVILLE, MASSACHUSETTS

Composition of Source-Separated Materials and Refuse

Volume III

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MULTIMATERIAL SOURCE SEPARATION REPORT SERIES

This volume is one in a series of reports about the demonstration of multimaterial source separation in Marblehead and Somerville, Massachusetts. The series presents the key results of demonstration programs initiated and funded by the U.S. Environmental Protection Agency in 1975. Intended to provide local governments and the interested public with useful information for planning, implementing, and operating their own source separation programs, the reports in the series cover a range of issues related to source separation. The reports are:

The Community Awareness Program in Marblehead and Somerville, Massachusetts (SW-551)

Collection and Marketing (SW-822)

Composition of Source-Separated Materials and Refuse (SW-823)

Energy Use and Savings from Source-Separated Materials and Other Solid Waste Management Alternatives for Marblehead (SW-824)

Citizen Attitudes toward Source Separation (SW-825)

Any suggestions, comments, or questions should be directed to the Resource Recovery Branch (WH-563), Office of Solid Waste, U.S. Environmental Protection Agency, Washington, D.C. 20460.

Resource Planning Associates, Inc. conducted the studies and prepared this series under contract no. 68-01-3964.

Acknowledgements

From October 1977 to October 1978, Resource Planning Associates, Inc. (RPA) conducted an extensive program of field sampling and analysis to determine the composition of source-separated materials and refuse in Somerville and Marblehead, Massachusetts.

It would be extremely difficult to acknowledge the great number of people who contributed to the success of this complex study. However, we would like to thank the following people for their help: Mr. Raymond Reed, Marblehead Board of Health; Mr. Ugaletto, Commissioner, Somerville Department of Public Works; Mr. John Clement, MATCON Recycling; Mr. David Grebow, Environmental and Education Services; Dr. Allan Molvar, Clevepak Corporation (subcontractors to RPA for the field sampling and moisture analysis, respectively); and Ms. Penelope Hansen and Mr. Stephen E. Howard, U.S. Environmental Protection Agency.

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Contract No. 68-01-3964

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Introduction

Early in 1976, the U.S. Environmental Protection Agency (EPA) awarded 3-year grants to the communities of Marblehead and Somerville, Massachusetts, to demonstrate the source separation of paper, cans, and glass by residents. For the first 2 years of the grants, the communities commissioned Resource Planning Associates, Inc. (RPA), to assist them in designing and implementing their programs. For the third grant year, EPA engaged RPA to assess the results of the two programs and to study the characteristics of the communities' residential waste streams.

Marblehead and Somerville were selected for the demonstrations for several reasons. First, Marblehead had conducted a relatively successful municipal curbside source-separation program for several years before the start of the new program; Somerville had no previous source-separation experience. Second, Marblehead is an affluent suburban community in the Boston metropolitan area with a population of 23,000; Somerville is an urban community adjacent to Boston with a population of 90,000. Marblehead's median income is much higher and its population density much lower than Somerville's.

Both source-separation programs implemented under the EPA grants were designed to collect paper, glass, and metals at curbside using specially designed compartmentalized collection vehicles, but some specific requirements of the programs differed. Marblehead residents were asked to separate materials into three categories and to place their materials at curbside on different days than their refuse. Somerville residents were asked to separate materials into two categories and to place their materials at curbside on the same day as their refuse.

EPA has commissioned RPA to conduct studies and to prepare a series of reports about the two demonstration programs. The reports concern the collection and marketing of source-separated materials, citizen attitudes toward source separation, the composition of

the source-separated materials and refuse, the energy requirements of source separation vs. other solid-waste management alternatives, and the community awareness programs developed to encourage participation in the source-separation programs.

This report presents the results of our study of the composition of the source-separated materials and refuse. The study was conducted during the third year of the demonstration programs, from fall 1977 to summer 1978. In each season, we collected and analyzed samples of source-separated materials and refuse during one week. We then analyzed the samples in terms of categories of materials that can be sold most readily, and at a higher price than mixed materials, to reprocessing plants.* We separated beverage containers from nonbeverage glass and cans in order to assess the potential impact of beverage container legislation on source-separation programs. In all, 14 recoverable components were studied:

- Newsprint
- Magazines
- Corrugated paper
- Other paper
- Clear glass beverage containers
- Green glass beverage containers
- Brown glass beverage containers
- Other clear glass
- Other green glass
- Other brown glass
- Ferrous beverage containers
- Other ferrous
- Nonferrous beverage containers
- Other nonferrous

* An intermediate materials processor further separates materials from the two or three categories separated by residents; a reprocessor in nearby Salem, Massachusetts provides this service for Somerville and Marblehead.

The composition study was conducted to develop three sets of data on source-separated materials and refuse:

- Relative percentages of the 14 recoverable components in the source-separated, refuse, and total residential waste streams
- Recovery rates, or the percentage of each component that is source-separated
- Moisture content and heat content of the source-separated materials and refuse.

The results of these three analyses are presented in the three chapters of this report. The averages of the four seasonal analyses and seasonal trends are described in each chapter. The appendixes provide general background information on the programs and detailed data from the composition study: Appendix A provides demographic data on the two communities and describes their source-separation programs; Appendix B describes our methodologies for sampling and data analysis; Appendix C provides data from the samples taken in each of the four seasons; and Appendix D presents laboratory data on the moisture content of the components.

1 COMPONENT ANALYSIS

An important aspect of our study was to analyze the components of source-separated materials and refuse to determine the amounts of various recoverable components in the Marblehead and Somerville residential waste streams, and to provide information that a variety of other communities can use in planning, designing, or implementing their programs. We studied three streams of waste for this analysis: total residential waste, or the combination of source-separated materials and refuse; source-separated materials; and refuse, or the residential solid waste remaining after source separation. We analyzed the percentages of recoverable components in each stream, determined how the percentages varied seasonally, and how the percentages varied among each sample within the seasons.

We found that recoverable materials constitute more than half of the total residential waste streams in both communities. Newsprint and glass were the major components in the source-separated stream. Other paper was the major recoverable component in the refuse stream.

We also found that the seasonal fluctuations in the component percentages were relatively minor, although some components changed more than others. The fluctuations do not reveal any significant seasonal trends in the percentages of recoverable materials in the waste streams. However, an analysis conducted over 2 or 3 years would be more conclusive.

The percentages of some recoverable components were more consistent than others from sample to sample. Newsprint, glass beverage containers, and other glass varied least among both the source-separated and refuse samples.

COMPONENT PERCENTAGES

The percentages of recoverable components in the total residential, source-separated, and refuse streams differed between Marblehead and Somerville. The total residential waste streams of the two communities were composed of different percentages of various recoverable components, and the composition of source-separated materials and refuse also differed between the communities. There are several reasons for these differences:

- The two communities have different socioeconomic characteristics, and the products and materials they consume and discard are different.
- A much higher percentage of Marblehead residents participated in the source-separation programs than did Somerville residents.
- Marblehead residents source-separated materials into three categories, Somerville residents into two.
- The collection of source-separated materials and refuse was on the same day in Somerville, and on different days in Marblehead.

We analyzed the composition of total residential waste, source-separated materials, and refuse in terms of component percentages by weight (see Exhibit 1.a for a summary of the component percentages of these streams).

Component Percentages in the Total Residential Waste Stream

We analyzed the average component percentages of the two communities' total residential waste streams, and made the following comparisons:

- Recoverable materials constituted more than half of the residential waste stream of both communities; about 60 percent of Marblehead's and 56 percent of Somerville's residential waste were recoverable materials.

Exhibit 1.a

Average Composition of Total Residential Waste, Source-Separated Materials, and Refuse
(Percent by Weight)

Component	Total Residential Waste		Source-Separated Materials		Refuse	
	Marblehead Four Seasons	Somerville Fall, Spring and Summer	Marblehead Four Seasons	Somerville Fall and Spring	Marblehead Four Seasons	Somerville Fall and Spring
Paper	37.7	30.3	50.6	60.9	33.7	30.3
Glass beverage containers	9.0	11.6	20.6	18.6	5.3	8.5
Other glass	8.6	7.5	19.7	11.3	5.1	7.7
Ferrous beverage containers	0.7	1.7	1.2	1.1	0.5	1.5
Other ferrous	3.6	4.5	5.7	5.0	3.0	3.7
Nonferrous beverage containers	0.2	0.3	0.5	0.2	0.1	0.4
Other nonferrous	0.4	0.5	0.2	0.1	0.5	0.6
Remaining waste	39.7	43.6	1.5	2.9	51.8	47.1
Total*	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Component	Total Residential Waste		Source-Separated Materials		Refuse	
	Marblehead Winter, Spring and Summer	Somerville Spring and Summer	Marblehead Winter, Spring and Summer	Somerville Spring	Marblehead Winter, Spring and Summer	Somerville Spring
Paper						
Newsprint	15.1	9.5**	41.9	51.5***	6.4	9.0**
Magazines	2.5	1.3	4.3	0.5	2.0	1.0
Corrugated	1.5	0.9	1.2	2.3	1.8	0.5
Other paper	19.6	19.2	2.2	3.5	23.0	19.6
Other glass						
Clear	5.9	6.2	13.2	7.2	3.6	6.7
Green	2.5	1.1	6.2	3.3	1.3	1.8
Brown	0.7	0.6	1.5	1.3	0.5	0.5
Glass beverage containers						
Clear	4.4	8.6	12.3	8.8	1.9	6.4
Green	3.4	2.6	7.1	5.0	2.2	3.3
Brown	1.6	2.9	1.9	6.2	1.5	1.4

SOURCE: Resource Planning Associates, Inc.

* May not add to 100.0 due to rounding.
** Average for fall, spring and summer.
*** Average for fall and spring.

- Marblehead had about 5 percent more newsprint and 7 percent more total paper in its total residential waste than Somerville.
- Other paper was found more than any other individual recoverable component, at about 19 percent in each community.
- The total amounts of glass beverage containers in both communities were similar; however, Somerville had more clear and brown glass beverage containers and Marblehead had more green glass containers.
- The percentages of other glass components and ferrous and nonferrous materials were similar between the two communities.
- Beverage containers made up about 14 percent of Somerville's and about 10 percent of Marblehead's total residential waste.

Component Percentages in the Source-Separated Materials Stream

Although Marblehead had significantly more paper in its total waste stream than Somerville, Marblehead had substantially more glass and metals than Somerville in its source-separated stream. Marblehead had about 10 percent less paper than Somerville in its source-separated stream, primarily because it had over 8 percent more other glass. Other findings about the recoverable components in the communities' source-separated streams are:

- Over 80 percent of the source-separated paper was newsprint in both communities.
- About 5 percent of the source-separated materials in both communities was other ferrous; other ferrous made up 60 percent of the source-separated metals.
- Less than 1 percent of the source-separated materials was nonferrous.

- Clear glass constituted over 25 percent of the source-separated stream in Marblehead and 16 percent in Somerville.
- Almost half of the source-separated glass and metals was beverage containers in Marblehead (47 percent); for Somerville, about 54 percent of the glass and metals was beverage containers.

Beverage containers represented a significant percentage of source-separated materials in Somerville and Marblehead; they are a large percentage of the recoverable materials in many communities. Some citizens and local officials are therefore concerned about the effect of beverage container legislation, which would outlaw no-deposit, no-return bottles, on potential revenues from source-separation programs. Removing beverage containers from the source-separated stream would reduce the amount of marketable materials in the stream. However, if the need for collection equipment, labor, or collection frequency is reduced correspondingly, beverage container legislation may not substantially decrease the net revenues from source-separation programs.

Component Percentages in the Refuse Stream

There were more recoverable materials in Somerville's refuse stream than Marblehead's; 60 percent of Somerville's refuse stream was recoverable materials, compared to 48 percent for Marblehead. Marblehead had less newsprint and more other paper in its refuse than did Somerville. Paper constituted over 30 percent of the refuse in both communities, and other paper was the largest paper category.

Because Marblehead's residents source-separated more than Somerville's, there were less recoverable glass and metals left in its refuse than in Somerville's. The difference was much greater for clear glass than for the colored glass and metal components.

SEASONAL VARIATION OF THE COMPONENTS

The percentages of recoverable components in the total residential waste, source-separated, and refuse streams fluctuated seasonally. However, the fluctuations generally did not show patterns or trends, with one exception: There were less glass and metals and more paper in the fall and spring than in the winter and summer in the source-separated stream. This is because there were more glass and metals available from the total residential waste stream in those seasons.

We analyzed seasonal component variation only for Marblehead; data were not available for Somerville in the winter and summer because its program was interrupted. Our results are based on samples taken over 3 days in Marblehead during each season.

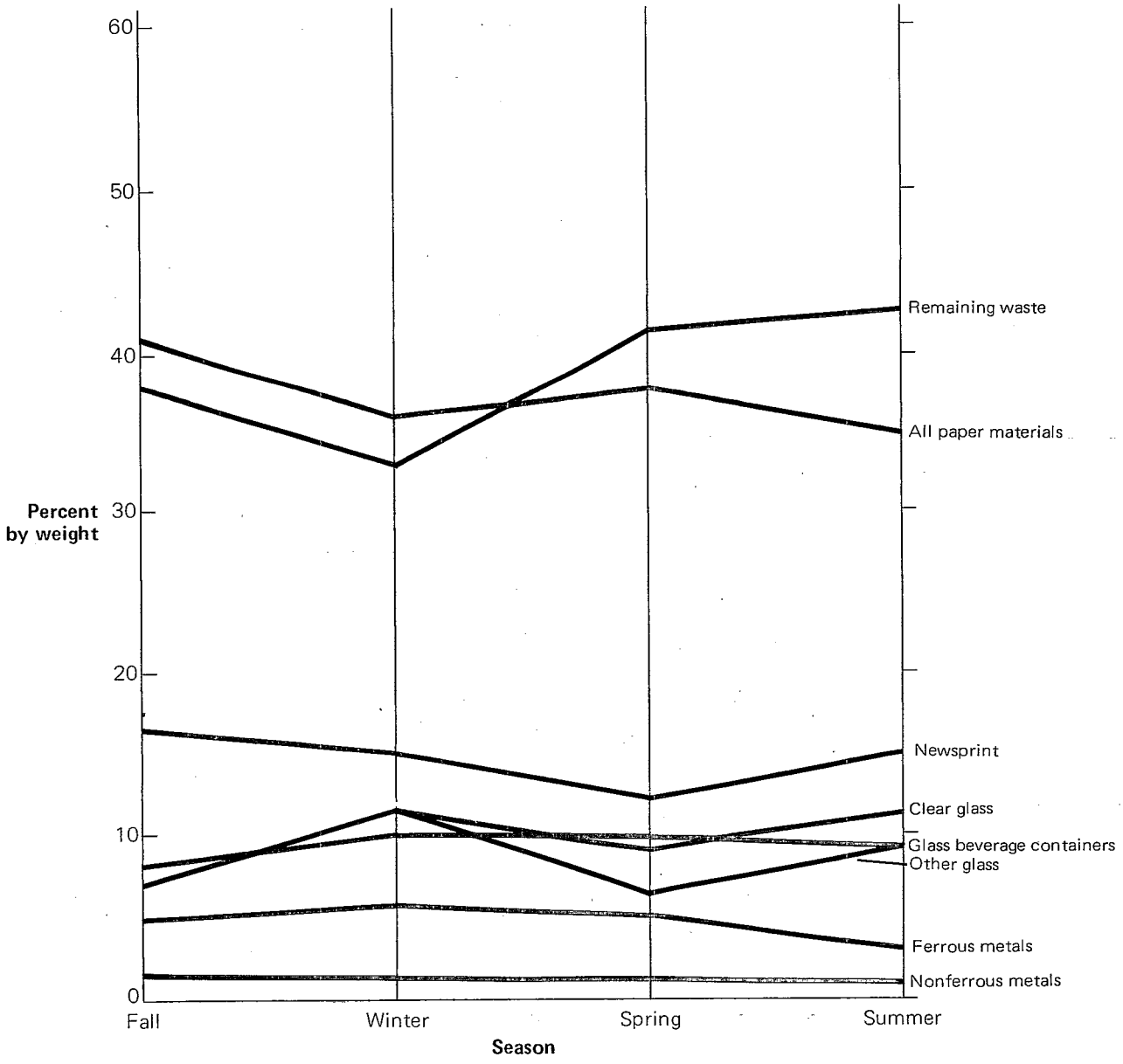
The percentages of recoverable materials were generally less variable than remaining waste in Marblehead's total residential waste stream; almost all of the recoverable components varied only a few percentage points in the total waste stream over the four seasons (see Exhibit 1.b). Glass beverage containers and ferrous and nonferrous metals were very consistent seasonally.

Some components were more variable than others in the source-separated stream. Metals, newsprint, and clear glass were relatively consistent seasonally (see Exhibit 1.c). Glass beverage containers in the source-separated stream fluctuated from season to season, paralleling the seasonal fluctuations of other glass. Ferrous and nonferrous materials were most consistent seasonally. All paper materials varied more seasonally in the source-separated stream than in the total residential waste stream.

Paper materials in refuse varied in patterns similar to paper in the total residential waste stream (see Exhibit 1.d). The other recoverable components in the refuse stream varied slightly and followed no particular pattern.

Exhibit 1.b

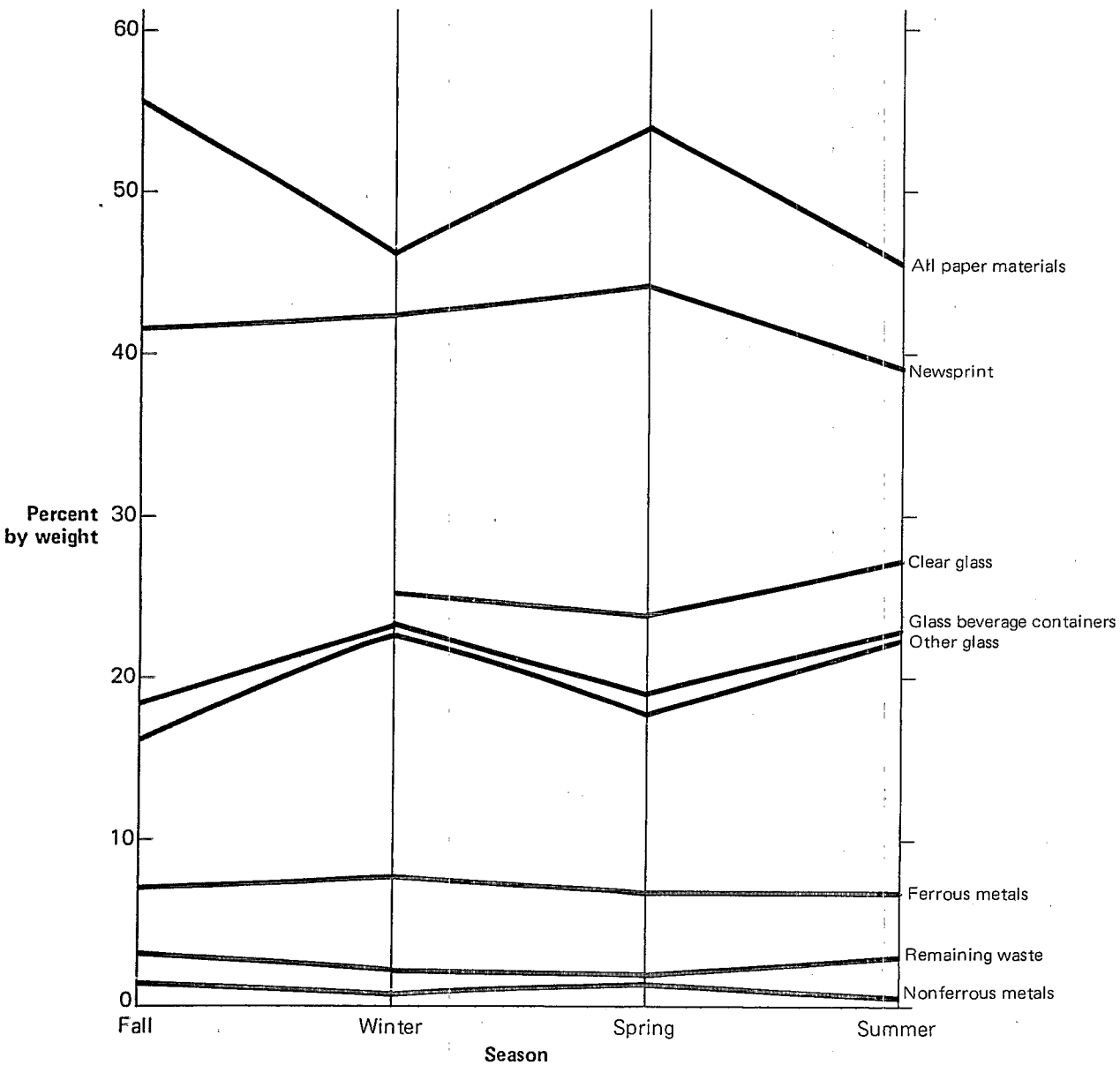
Seasonal Variation of the Composition of Total Residential Waste, Marblehead



SOURCE: Resource Planning Associates, Inc.

Exhibit 1.c

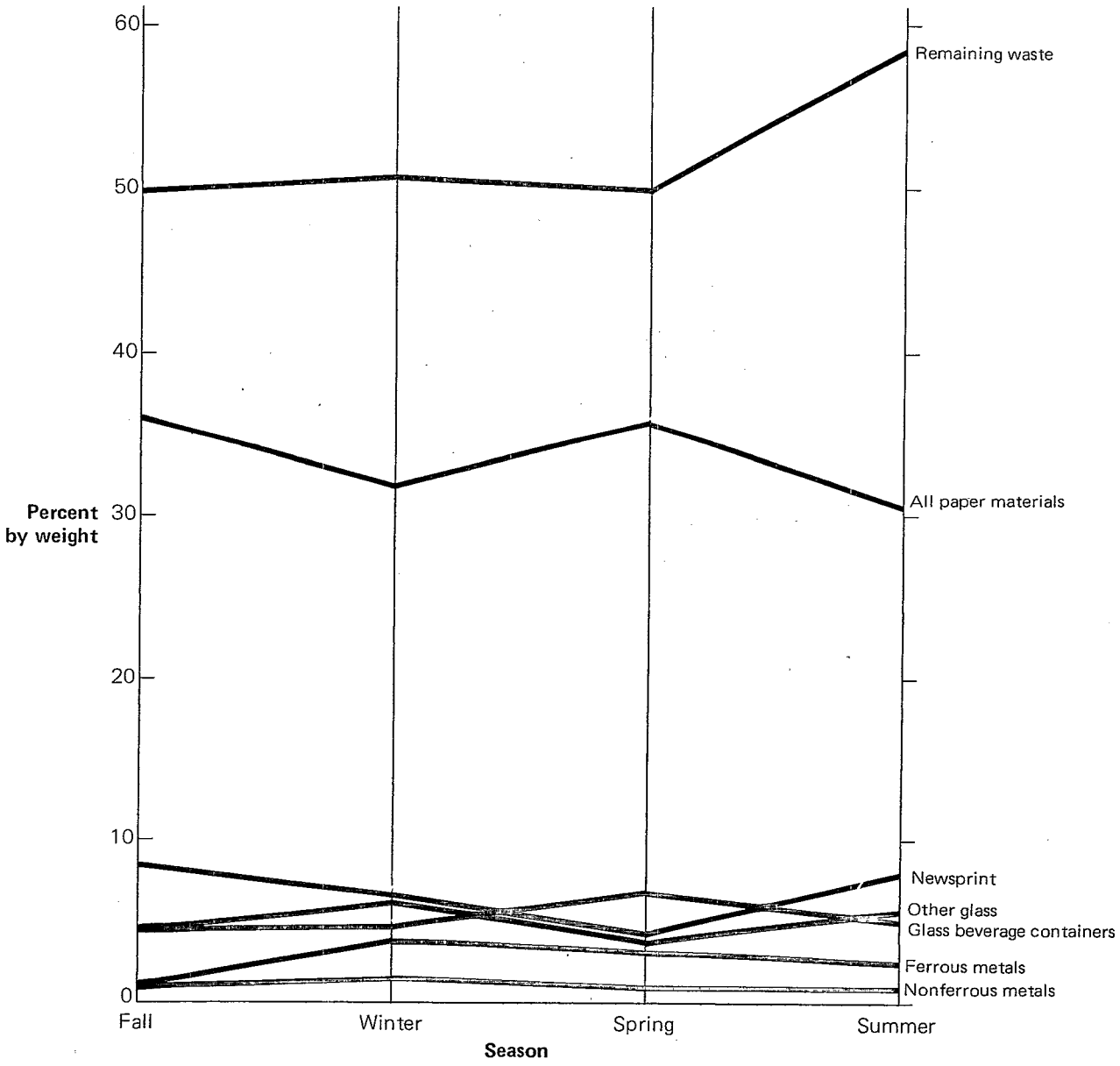
Seasonal Variation of the Composition of Source-Separated Materials, Marblehead



SOURCE: Resource Planning Associates, Inc.

Exhibit 1.d

Seasonal Variation of the Composition of Refuse, Marblehead



SOURCE: Resource Planning Associates, Inc.

COMPONENT VARIABILITY WITHIN SAMPLES

We examined the component percentages among the samples to determine which components varied the most. To quantify variability, we used a coefficient of variation, defined as the standard deviation divided by the mean (see Appendix B for a detailed discussion of the coefficient of variation). The components with the lowest coefficients were those that varied least among the samples. Components with the highest coefficients varied most from sample to sample (see Exhibits 1.e and 1.f).

For both refuse and source-separated materials, the components that had the lowest average coefficients of variation were newsprint, other glass, glass beverage containers, other ferrous, and other paper. Of these components, newsprint and both glass components had the lowest coefficients. Nonferrous materials, magazines, and corrugated paper had the highest coefficients. However, these components made up only a small percentage of the refuse or source-separated materials streams, and their variability had only a minor impact on the percentages (and variability) of other components.

The coefficients for newsprint, glass beverage containers, and other glass were relatively consistent in source-separated materials and refuse. Remaining waste was the most consistent component in refuse.

Exhibit 1.e

Coefficients of Variation, Marblehead
(Percent)

Component	Source-Separated Materials					Refuse				
	Fall	Winter	Spring	Summer	Average	Fall	Winter	Spring	Summer	Average
Newsprint	7.7	21.2	15.9	23.4	17.0	29.5	24.0	10.1	14.8	19.6
Magazines	–	72.6	86.9	84.8	81.4	–	60.4	37.8	84.9	61.0
Corrugated	–	0	83.9	37.8	40.6	–	67.1	59.0	87.8	71.3
Other paper*	26.4	40.9	73.2	15.6	39.0	19.1	12.4	23.3	15.1	17.5
Glass beverage containers	8.0	29.5	5.8	13.3	14.1	59.0	31.8	53.6	63.2	51.9
Other glass	44.2	16.2	22.9	23.2	26.6	23.1	29.4	28.7	10.4	22.9
Ferrous beverage containers	60.6	54.1	76.5	19.5	52.7	68.0	17.4	56.3	53.5	48.8
Other ferrous	27.8	26.4	43.8	16.0	28.5	41.1	17.2	25.1	62.7	36.5
Nonferrous beverage containers	26.3	74.6	75.0	67.0	60.7	138.3	45.3	100.0	133.0	104.1
Other nonferrous	93.5	74.3	67.9	68.7	76.1	16.3	28.3	63.6	36.3	36.1
Remaining waste	48.1	73.8	30.5	30.9	45.8	11.9	12.0	16.2	10.1	12.5

SOURCE: Resource Planning Associates, Inc.

*For the fall season, "other paper" included magazines and corrugated paper.

Exhibit 1.f

Coefficients of Variation, Somerville
(Percent)

	Source-Separated Materials			Refuse		
Component	**Fall**	**Spring**	**Average**	**Fall**	**Spring**	**Average**
Newsprint	16.8	17.9	17.3	10.0	11.3	10.6
Magazines	—	127.4	127.4	—	33.8	33.6
Corrugated	—	69.2	69.4	—	67.2	67.2
Other paper*	8.0	70.2	39.1	10.0	3.5	6.7
Glass beverage containers	39.5	18.0	28.7	25.2	8.1	16.6
Other glass	22.1	51.5	36.8	21.2	17.1	19.1
Ferrous beverage containers	86.4	69.3	77.8	51.5	85.5	68.5
Other ferrous	17.5	15.2	16.3	5.0	19.4	12.2
Nonferrous beverage containers	114.5	126.0	120.2	200.0	17.3	108.6
Other nonferrous	117.2	147.0	132.1	16.7	71.9	44.3
Remaining waste	76.8	66.0	71.4	4.3	8.4	6.3

SOURCE: Resource Planning Associates, Inc.

*For the fall season, "other paper" included magazines and corrugated paper.

2 RECOVERY RATES

The recovery rate for each recoverable component is the percentage of the component that is source-separated from the total amount of the component available in the residential waste stream. Our composition study focused on recovery rates in Marblehead and Somerville to determine (1) which materials residents find easiest and most difficult to source-separate, and (2) which materials could be recovered in larger quantities if they received more emphasis in public education programs. We were also interested in identifying differences in recovery rates between the two communities, determining how differences in the structure of the two programs affected recovery rates, and analyzing seasonal variations in recovery rates.

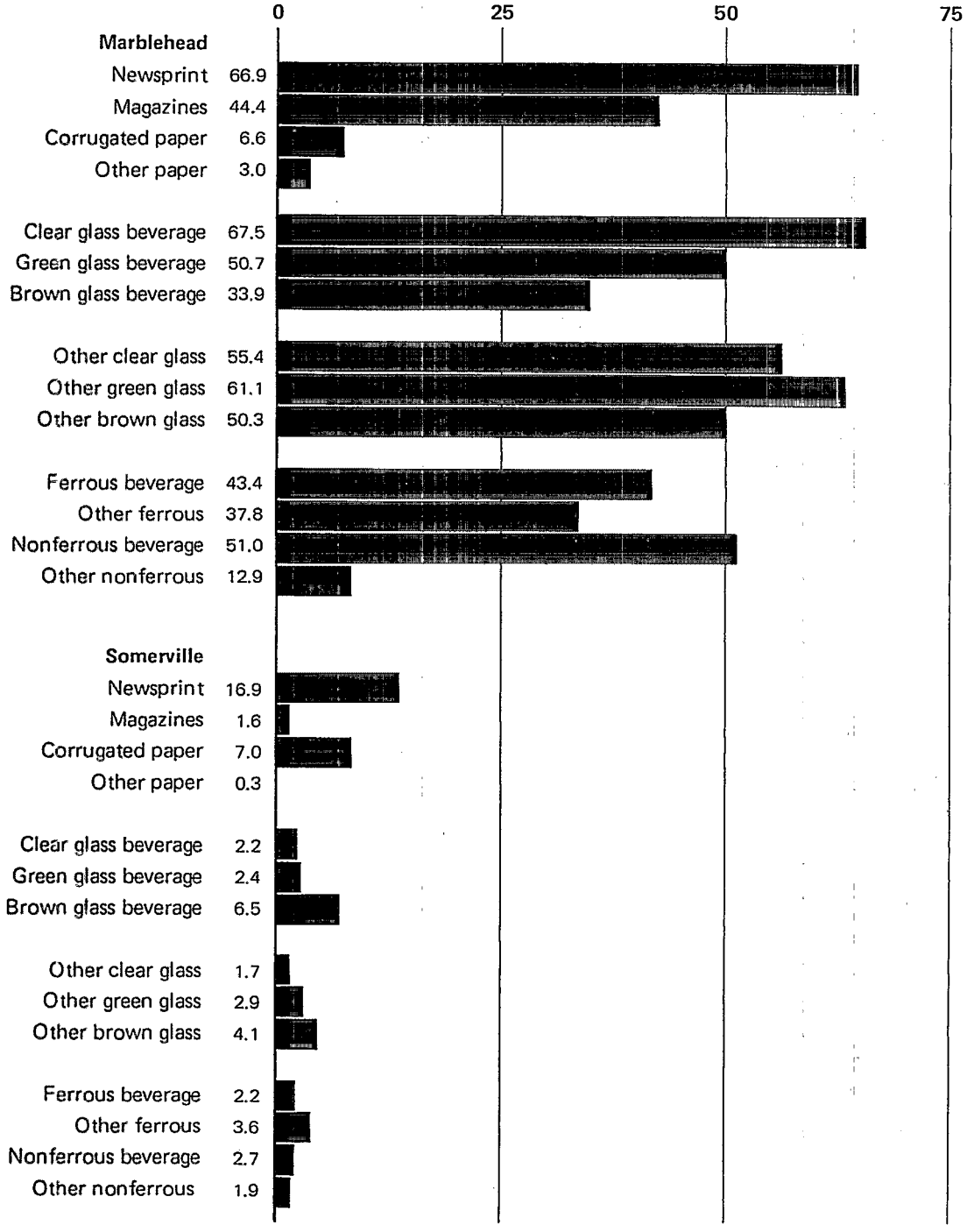
Marblehead residents recovered about 25 percent of their total solid waste during our study; Somerville residents recovered less than 5 percent. In Marblehead, we found that residents source-separated newsprint and clear glass more than any other components; over 65 percent of the available newsprint and clear glass was recovered. Newsprint, corrugated paper, and brown glass were recovered more than other components in Somerville. (See Exhibit 2.a for recovery rates for each community by component.)

Marblehead residents were not asked to source-separate corrugated paper or cardboard; however, on the average for the year, 6 percent was recovered. Residents were asked to recycle junk mail, telephone books, envelopes, paper bags, and other flat paper, but only 3 percent of these materials and a small percentage of milk cartons and paper wrappings were recovered.

Somerville residents were asked to source-separate cardboard; on the average for the year, 7 percent was recovered. Residents of Somerville were also asked

Exhibit 2.a

Average Recovery Rates
(Percent)



SOURCE: Resource Planning Associates, Inc.

to recycle envelopes, letters, telephone books, and paper bags, but less than 1 percent of such material was collected.

More than half of all glass was recovered through source separation in Marblehead, with the exception of brown glass beverage containers. In Somerville, brown glass beverage containers were recovered at a rate of 6.5 percent, higher than the rate for any other glass or metal component. In addition, colored glass had higher recovery rates than clear glass in Somerville. The opposite was true for Marblehead, where clear glass was recovered most. Because clear glass is more marketable and generally has a higher value than mixed colored glass, Marblehead required its residents to separate clear glass from colored. On the other hand, Somerville's program had only a single category for glass, which appears to have encouraged the source separation of colored glass.

Other metal components (ferrous and nonferrous) were generally recovered at a lower rate than glass and newsprint in both communities. The other nonferrous component had the lowest average recovery rate of metal components in both communities. Nonferrous beverage containers were recovered slightly more than ferrous beverage containers; nonferrous containers were recovered at a 50-percent rate in Marblehead. The higher rate may result from labeling found on many aluminum cans that encourages recycling. Other nonferrous materials, such as aluminum trays and foil, were recovered at a much lower rate than other metals in Marblehead and at a slightly lower rate in Somerville.

We found recovery rates to be more variable from season to season than the component percentages in either source-separated materials or refuse (see Exhibits 2.b and 2.c for the seasonal recovery rates for the two communities). For example, the recovery rates for newsprint varied by 15.8 percent, magazines by 24, glass beverage containers by 15.6, ferrous beverage containers by 17.9, and nonferrous beverage containers by 26.8. All other materials stayed within a 15-percent range from season to season. Although the different paper components varied significantly, total paper varied only 2.6 percent.

Exhibit 2.b

Seasonal Recovery Rates, Marblehead (Percent)

Component	Fall	Winter	Spring	Summer	Average
Paper					
Newsprint	60.0	68.0	75.8	63.7	66.9
Magazines	—	40.0	34.4	58.9	44.4
Corrugated	—	0	5.6	14.3	6.6
Other paper	13.0*	2.6	2.8	3.5	3.0**
Subtotal	**32.0**	**32.9**	**30.4**	**33.0**	**32.1**
Glass beverage containers					
Clear	—	75.5	61.6	65.4	67.5
Green	—	51.5	46.5	54.1	50.7
Brown	—	36.4	10.7	54.6	33.9
Subtotal	**55.0**	**59.7**	**44.7**	**60.3**	**54.9**
Other glass					
Clear	—	47.3	63.3	55.5	55.4
Green	—	56.9	56.4	70.1	61.1
Brown	—	52.8	51.8	46.2	50.3
Subtotal	**54.0**	**50.8**	**60.5**	**58.7**	**56.0**
Ferrous beverage containers	**43.0**	**34.6**	**43.7**	**52.5**	**43.4**
Other ferrous	**36.0**	**39.8**	**34.9**	**40.5**	**37.8**
Nonferrous beverage containers	**50.0**	**36.4**	**63.2**	**54.5**	**51.0**
Other nonferrous	**0**	**8.7**	**23.1**	**20.0**	**12.9**
Remaining waste	**1.0**	**0.8**	**0.6**	**1.1**	**0.9**
Total	**24.0**	**25.4**	**22.1**	**24.7**	**24.0**

SOURCE: Resource Planning Associates, Inc.

*Includes magazines and corrugated paper.
**Average does not include fall season.

Exhibit 2.c

Seasonal Recovery Rates, Somerville
(Percent)

Component	Fall	Spring	Summer	Average
Paper				
Newsprint	21.0	17.5	12.3	16.9
Magazines	—	1.8	1.3	1.6
Corrugated	—	13.5	0.5	7.0
Other paper	3.0*	0.4	0.3	0.3**
Subtotal	**9.0**	**6.5**	**3.4**	**6.3**
Glass beverage containers				
Clear	—	4.4	0	2.2
Green	—	4.8	0	2.4
Brown	—	13.0	0	6.5
Subtotal	**13.0**	**5.7**	**0**	**6.2**
Other glass				
Clear	—	3.5	0	1.7
Green	—	5.8	0	2.9
Brown	—	8.2	0	4.1
Subtotal	**8.0**	**4.2**	**0**	**3.1**
Ferrous beverage containers	**5.0**	**1.7**	**0**	**2.2**
Other ferrous	**6.0**	**4.7**	**0**	**3.6**
Nonferrous beverage containers	**7.0**	**1.0**	**0**	**2.7**
Other nonferrous	**5.0**	**0.6**	**0**	**1.9**
Remaining waste	**0**	**0.1**	**0**	**0**
Total	**5.0**	**3.3**	**1.0**	**3.1**

SOURCE: Resource Planning Associates, Inc.

*Includes magazines and corrugated paper.
**Average does not include fall season.

The seasonal data did not indicate a trend in recovery rates from season to season. However, the spring season had both the highest and lowest recovery rates for individual components in Marblehead. Newsprint had the highest recovery rate in the spring of any component in any season (75.8 percent), although total paper had a lower rate in the spring than in the other seasons. Glass beverage containers were recovered less in the spring, but other glass components were generally recovered more. Spring also had the lowest total recovery rate of 22.1 percent.

For Somerville, recovery rates generally decreased from the highest in the fall to lowest in the summer. (The Somerville recycling program was discontinued during the winter months and the program did not include glass and metals after the spring.) Interrupting the program in the winter apparently decreased the spring recovery rates.

3 MOISTURE AND HEAT CONTENT

Many community officials and resource-recovery plant operators are concerned about the effect of source separation on the heat content of refuse. During our composition study, we performed a preliminary analysis of the moisture content and heat content of Somerville's and Marblehead's source-separated materials and refuse to determine the effect of source separation on energy recovery.

We measured the moisture content of source-separated materials and refuse, and then computed the heat content from the moisture content. (Appendix B presents the methodologies we followed in detail.) It appears that source separation has two divergent effects on the heat content of the refuse delivered to energy-recovery plants. The heat content per pound of refuse increases when noncombustibles such as glass and metal are removed by source separation. But combustibles, mostly the paper components, are also removed from refuse, which lowers the total heat content available to energy-recovery plants on a daily basis. However, an energy-recovery facility can replace the heat content lost because of source separation by burning waste from another community.

MOISTURE CONTENT

We conducted moisture content analyses on source-separated materials and refuse during each of our four seasonal component analyses. We then averaged the moisture data from Marblehead and Somerville to provide a general characterization of the moisture content of urban solid waste (see Exhibit 3.a).

Exhibit 3.a

Average Moisture Content of Source-Separated Materials and Refuse (Percent H_2O)

Component	Source-Separated Materials	Refuse
Newsprint	6.4	13.0
Other paper	6.1	18.1
Glass beverage containers	0.0	0.0
Other glass	1.0	0.1
Ferrous beverage containers	1.9	6.6
Other ferrous	2.1	2.8
Nonferrous beverage containers	1.8	0.6
Other nonferrous	0.9	12.8
Remaining waste	12.8	23.7
All components	4.2	17.2

SOURCE: Resource Planning Associates, Inc.

The composite moisture content of refuse was 17 percent, more than 4 times the 4-percent composite content of source-separated materials. Newsprint, other paper, and remaining waste had the highest moisture content of all components.

The moisture content of newsprint, other paper, and remaining waste varied greatly from season to season. We studied the variability of the moisture content of these three components and the sum of all components over four seasons for the two communities (see Exhibit 3.b). The composite moisture content of source-separated materials is more consistent than that of refuse from season to season because of the more consistent composition of source-separated materials, and because cans and bottles are usually emptied before source separation.

HEAT CONTENT

After measuring the moisture content, we computed the heat content of source-separated materials and remaining refuse in two ways: heat content per pound and total heat content per day available to an energy-recovery facility.

We found that the heat content per pound of Marblehead's refuse was higher than Somerville's because there are less noncombustibles in Marblehead's refuse (see Exhibit 3.c). However, because Marblehead's source-separated material has less paper and more glass and metals than Somerville's, the heat content per pound of Marblehead's source-separated materials was significantly lower than Somerville's. Furthermore, the heat content per pound of source-separated materials of both communities was more consistent seasonally than the heat content of refuse, because the composition of source-separated materials is more seasonally consistent than refuse.

It appears that source separation can increase the heat content per pound of a community's solid waste if a significant amount of noncombustibles is removed. We found that the heat content per pound of Marblehead's refuse is considerably higher than the heat content of

Exhibit 3.b

Moisture Content for Four Seasons
(Percent H_2O)

	Source-Separated Materials				Refuse			
	Somerville		Marblehead		Somerville		Marblehead	
Component	Fall	Spring	Winter	Summer	Fall	Spring	Winter	Summer
Newsprint	6.0	6.6	9.2	3.9	21.8	14.0	7.8	8.6
Other paper	4.5	11.5	4.1	4.6	18.2	29.8	14.5	10.0
Remaining waste	17.2	—	3.2	18.1	22.9	30.9	22.9	18.2
All components	4.5	4.9	4.1	3.2	15.1	21.5	18.8	13.4

SOURCE: Resource Planning Associates, Inc.

Exhibit 3.c

Heat Content for Four Seasons
(Btu/lb)

	Somerville		Marblehead	
	Fall	**Spring**	**Winter**	**Summer**
Source-Separated Materials	4,911	4,813	3,661	3,717
Refuse	4,704	3,981	4,734	5,254

SOURCE: Resource Planning Associates, Inc.

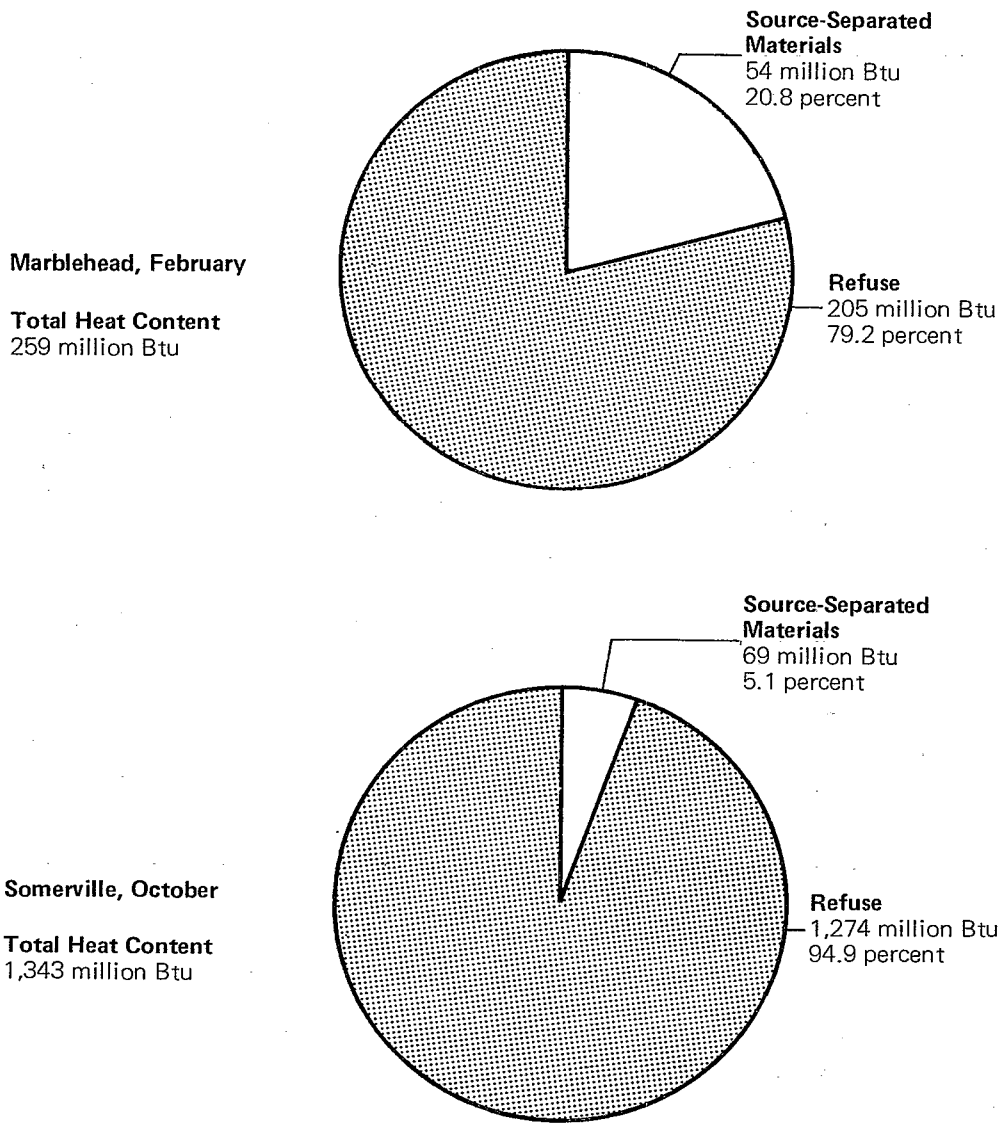
Marblehead's total residential waste stream. With source separation, there are proportionately fewer noncombustibles and more other paper in refuse. The heat content of refuse with source separation was about 4,950 Btu/lb, approximately 14 percent higher than the 4,340 Btu/lb for the total residential waste stream (without source separation).

The total heat content of refuse per day available for energy recovery is lowered by source separation because combustibles are removed. For the average solid-waste collection day in the fall season in Somerville, source separation removed about 5 percent of the heat content per day from the total residential waste stream (see Exhibit 3.d). For Marblehead in the winter season, source separation removed about 21 percent of the daily heat content of residential waste.

However, the increase in the heat content per pound of Marblehead's refuse offsets the decrease in heat content in the total residential waste stream caused by source separation. An energy recovery facility can easily replace the heat content removed by source separation by burning refuse from other communities. If the additional refuse is obtained from a community that does not source separate, the total heat content will increase slightly because of the higher Btu content per pound of Marblehead's refuse. If additional refuse is obtained from communities that do source separate, the increase in total heat content is even greater (see Exhibit 3.e).

Exhibit 3.d

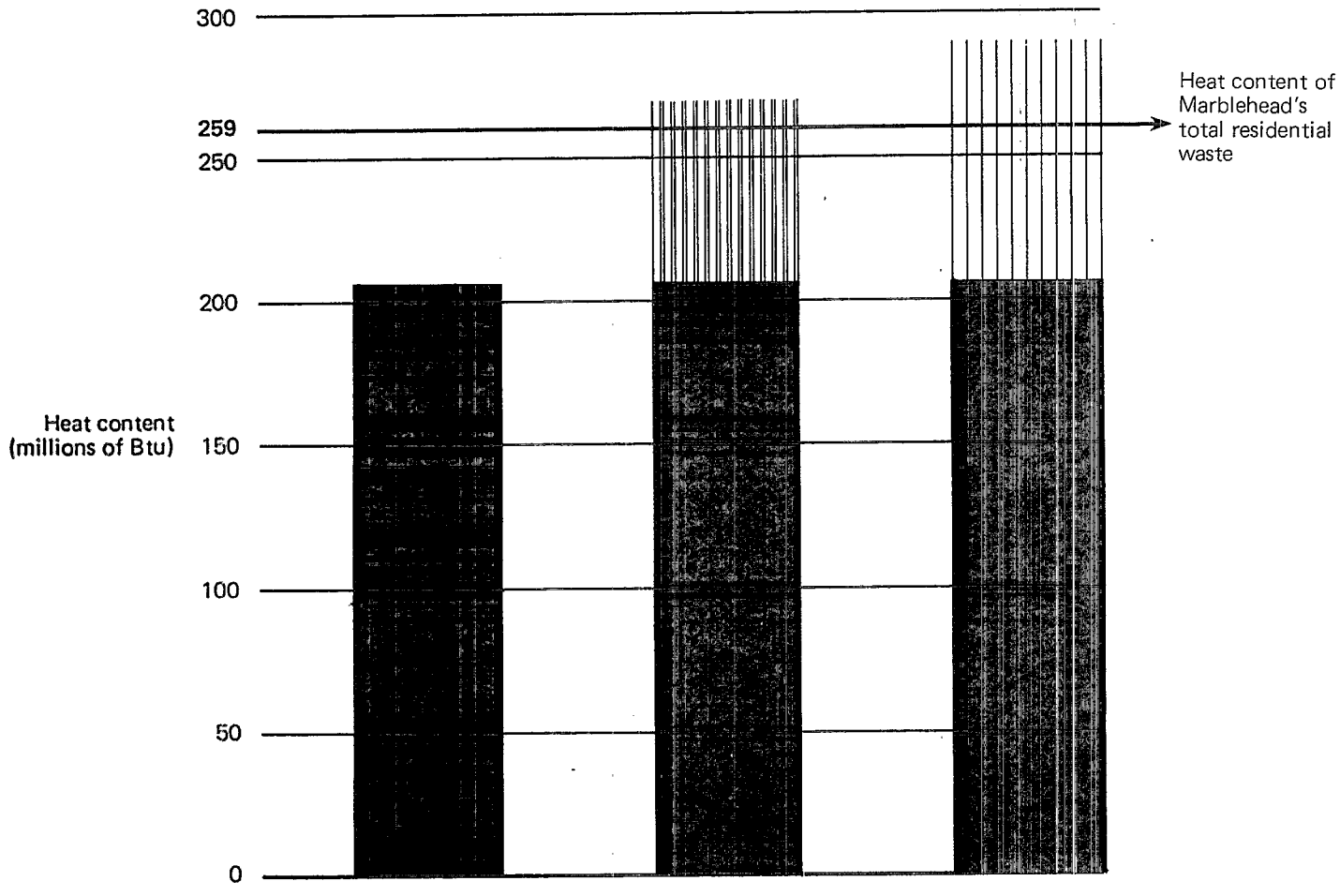
Average Heat Content Per Day of Refuse and Source-Separated Materials



SOURCE: Resource Planning Associates, Inc.

Exhibit 3.e

Heat Content Available to an Energy Recovery Facility



Key:

Marblehead's refuse.

Total residential waste from a community with the same heat content per pound as Marblehead's, without source separation.

Refuse from a community with the same heat content per pound as Marblehead's, with source separation.

SOURCE: Resource Planning Associates, Inc.

Appendix A

PROGRAM BACKGROUND

As part of its evaluation of different types of resource-recovery programs, EPA selected Somerville and Marblehead, Massachusetts for demonstration studies of source separation. This appendix provides demographic information about Marblehead and Somerville and describes how their source-separation programs operate.

DEMOGRAPHIC INFORMATION

Marblehead is an affluent suburban community in the Boston metropolitan area with a population of 23,000 and a density of 5,200 persons per square mile. Seventy percent of the families live in single-family homes. Fifteen percent of the families rent their homes or apartments, and 85 percent own their residences. The median income is $12,600 per year, and the median education level is 13.2 years.

Somerville is an urban community also within the Boston metropolitan area, with a population of 90,000 and a density of 22,600 persons per square mile, one of the highest in the nation. Single-family homes house 10 percent of the families in Somerville; most of the remaining people live in two- , three-, and four-family homes. Sixty-five percent of the families rent their homes or apartments, and 35 percent live in their own homes. The median income is $9,600 per year, and the median education level is 11.6 years.

Salient demographic characteristics of the communities and their source-separation programs can be summarized as follows:

	Somerville	Marblehead
Population	90,000	23,000
Land area (sq mile)	4	4.5
Population density (persons/sq mile)	22,600	5,200
Housing: Single-family	10%	70%
Multi-family	90%	30%
Median income (per year)	$9,600	$12,600
Median education (years)	11.6	13.2

PROGRAM DESCRIPTIONS

Although Marblehead has had an organized source-separation program since 1972, that program offered only monthly collection for each of four materials. One week paper was collected, the following week cans, the next week clear glass, and the fourth week green glass. During certain holidays, no materials were collected. The collection schedule was confusing and residents were required to carefully prepare materials by washing bottles, removing labels and rings, and so on. The publicity for the program was also limited.

On January 12, 1976, Marblehead initiated a new, substantially improved collection program: Recycle Plus. The new multi-materials program was preceded by extensive public education/public relations activities and offered a much better collection service.

Although source separation was mandatory in Marblehead under the old program, and still is, participation since January 12, 1976, has more than doubled. This indicates both the difficulty of enforcing source-separation legislation and the importance of good public relations to encourage voluntary participation.

In Marblehead, residents place three bundles -- flat paper, clear glass and cans, and colored glass and cans -- at the curb for collection on source-separation days, which are different than regular trash collection days. As in Somerville, no other preparation is necessary. Special crews with three-compartment trucks pick up the materials. In addition to the weekly collection of source-separation materials, Marblehead has open bins at the site of the former town landfill for residents who wish to bring their materials. The success of Recycle Plus helped the town to reduce the frequency of the remaining mixed-household-refuse collection from twice per week to once per week. The town also was able to reduce its mixed-refuse equipment and labor needs.

In Somerville, collection of source-separated materials began on December 1, 1975. At that time, Somerville's residents could put flat paper and a mixture of clear glass and cans at the curbside next to their regular refuse on the regular weekly collection day. In 1976, Somerville added colored glass to its glass and can mixture. No preparation was necessary except to sort waste into the source-separation categories. The paper and glass and can mixtures were then picked up by special town crews. Somerville is paid by the ton of source-separated materials delivered, based on the current secondary materials market. Participation in the program by Somerville residents is voluntary, and the major inducement to source separation has been a public education/public relations program.

Somerville suspended its source-separation program for the winter early in December 1976, as a result of collection problems caused by severe weather. The program was again suspended during the winter of 1977-1978.

The political leadership in Somerville changed in January 1977, and it was not until April 24, 1977, that

Somerville was able to resume the source-separation program.

On May 10, 1978, Somerville was notified by the company that buys its glass and cans that it would no longer buy colored mixed glass or cans mixed with glass. The last load of glass and cans left Somerville May 13, and there have been no collections of these materials since then. Paper collections are continuing as usual.

Salient features of the two programs can be summarized as follows:

	Somerville	Marblehead
Program name	"Somerville Saves"	"Recycle Plus"
Materials collected	Flat paper Cans and mixed glass	Flat paper Cans and clear glass Cans and colored glass
Recyclables collection frequency	Weekly	Weekly
Refuse collection frequency	Weekly	Weekly
Recycling crews	Two 3-man crews, one 4-man crew	Two 3-man crews
Refuse crew	Nine 3-man crews	Four 3-man crews
Collection vehicles	Compartmentalized trucks with rear-loading hydraulic buckets; 2 compartments	Compartmentalized trucks with rear-loading hydraulic buckets; 3 compartments
Disposal cost per ton	$9.40	$18.95

Appendix B

COMPOSITION ANALYSIS METHODOLOGIES

The Marblehead and Somerville studies represent the first seasonal composition analysis of the recoverable components in refuse and source-separated materials. Therefore, a review of the methodologies used for our waste composition study is important. We have generally followed a consistent approach to our analysis over four seasons, except that we increased the number of recoverable sample components from 8 to 14 after the fall season's analysis. This appendix describes our methodology for sampling and for analyzing data.

SAMPLING METHODOLOGY

The sampling methodology we used for our component analysis consisted of two steps: collecting samples and sorting samples. This approach could be applied to composition studies in most communities.

Collecting Samples

Before our component analysis began, we decided to take twice as many samples of refuse and source-separated materials in Marblehead as in Somerville. Our efforts were more concentrated in Marblehead because its source-separation program was much more successful and because we knew that Somerville's program would be suspended for the winter, disrupting our seasonal analysis. We collected two samples from each of eight representative areas in Marblehead and from four areas in Somerville. The sampling areas are geographically dispersed and cover the range of social and economic

characteristics of each community. One of the two samples was refuse, the other was source-separated materials. Therefore, 16 samples were collected in Marblehead and 8 in Somerville for each season. In Marblehead, we collected samples that varied from 145 to 547 pounds for refuse, and 83 to 580 pounds for source-separated materials. Samples in Somerville ranged from 267 to 368 pounds for refuse and 153 to 425 pounds for source-separated materials. We collected samples for one week (Monday through Friday) in each season. Samples were collected in Marblehead on Monday, Wednesday, and Friday, and on Tuesday and Thursday in Somerville.

We documented weather conditions for three days before and for each day we sampled (see Exhibit B.a). This was to account for the effect excess moisture may have had on the weight or heat content of the samples, since some residents stored their waste out of doors uncovered. Little or no rain or snow fell during any of the sample periods, and no snow melted during the winter period. It is unlikely that these conditions could have increased the weight or moisture content of the refuse or source-separated material samples.

The number of housing units per sample ranged from 3 to 13 units for refuse, and 4 to 20 for source-separated materials, and sampling was conducted just before the normal municipal waste was collected by the town/city crews. Source-separated materials were collected from every house in the sample area until a sample, estimated to be between 250 and 300 pounds, was accumulated. Slightly smaller samples of recovered materials were taken in Somerville because fewer residents participated in the source-separation program.

The sampling crew consisted of a driver/recorder and at least three collectors who would later sort the samples. The driver was responsible for knowing the collection route. The driver was also responsible for completing collection forms and noting all deviations in the sample (such as changes in address or route) and materials that were not collected.

Collectors took only refuse and source-separated materials that were placed at the curbside. During the refuse

Exhibit B.a

Weather Conditions During Sampling Periods

Season	Date	Temperature (°F)	Precipitation (Inches)
Fall	October 21	—	Traces of rain
	October 22	—	0
	October 23	—	0
	October 24	37	0
	October 25	49	0
	October 26	57	0.13
	October 27	62	Traces of rain
	October 28	69	0
Winter	January 27	—	0
	January 28	—	0
	January 29	—	0
	January 30	29	0
	January 31	—	0
	February 1	30	0
	February 2	—	0
	February 3	21	0
	February 20	—	0
	February 21	—	0
	February 22	—	0
	February 23	38	0
Spring	May 5	49	0.34*
	May 6	53	0
	May 7	60	0
	May 8	62	Traces of rain
	May 9	59	0.25*
	May 10	62	Traces of rain
	May 11	59	0
	May 12	63	0
Summer	July 14	74	0
	July 15	68	0.12
	July 16	66	0
	July 17	65	0.27*
	July 18	71	0.02
	July 19	78	0
	July 20	80	0
	July 21	81	0

SOURCE: National Weather Bureau; Logan International Airport.

* After sampling.

collection, if a previously selected house did not have trash out, refuse was taken from the next house and the deviation from collection procedures was noted on the data collection sheet. Refuse items that were large or were clearly not routine -- furniture, large appliances, bundles of wood, tires -- were left at the curbside and noted on the collection forms. These items were described and their approximate size noted. Yard wastes, with the exception of large prunings, were collected as refuse. When exceptionally large quantities of yard wastes were found, some bags were left and the number left was noted on the data form.

The collection vehicle was a 14-foot U-Haul truck with an overhang above the cab. The interior floor area was 7 feet by 11 feet. This area was divided into four sections, each measuring 3-1/2 feet by 5-1/2 feet. The partition was constructed from pine board and pressboard. A single 1-by-12-inch pine board, cut to a length of 11 feet, was placed in the center of the truck. Three notches were cut into the board in the back, middle, and front. Crosspieces, measuring 1-by-12 inches by 7 feet, were notched and fitted at each of these points. The sides of each section were pieces of 3-foot pressboard. All pieces could be removed, which made sorting quick and relatively simple. The floor of the truck was covered with plastic drop cloths before the partition pieces were installed. After the boards were in place, four separate drop cloths were placed in each section. All additional materials were stored in the overhang of the truck, where they were easily accessible.

Sorting Samples

The samples were taken to the municipal garage for sorting. The garage floor directly behind the truck was covered with plastic drop cloths, and one sample at a time was removed from the truck for sorting and weigning. The best method was to remove the rear partition in the truck and wrap the drop cloth around the sample and slide it onto the floor. After this was done, the following items were used in the sorting and weighing: 15 32-gallon plastic barrels, work gloves, No. 10 clear plastic barrel liners, a 100-pound Homs dial scale with an extended platform, tags, twist-ties,

2 snow shovels, 2 push brooms, and 4 magnets. The barrels were clearly labeled, one for each of the 14 components and remaining waste. The barrels were arranged in a semicircle behind the sample. The scale was placed off to one side of the truck with the brooms, shovels, liners, ties, and tags. Two magnets were attached to each side of the truck near the work space. Each barrel was lined with a No. 10 clear plastic trash liner. Clear plastic liners were used to enable easy identification of the samples after they were removed from the barrels.

Large, easily identifed objects were sorted first. Magnets were used to determine ferrous materials. All questionable materials (such as composites) or materials difficult to separate (such as bags of extremely wet refuse) were set aside.

For any glass, metal, or plastic container that held other materials, the contents were removed and appropriately sorted. In cases where the contents were food remains or liquids, the materials were shaken out into the remaining waste barrel. Removable container tops were sorted separately from the container. Only beer, ale, and carbonated soft-drink containers were placed in the beverage container bins (ferrous, nonferrous, and glass). Mirrors and plate glass cannot be recycled and were placed in the remaining waste barrel. Glass was sorted into colors: clear, green, and brown.

After all the large and easily identified objects were sorted, the remaining materials were then separated. Composites that were more than 75 percent by weight of any designated component were placed into the appropriate barrel; for example, cardboard/metal juice cans were sorted into the other paper category. The work crew attempted to separate all items larger than a cigarette pack. All materials left behind were placed in the remaining waste barrel.

After the sample was completely sorted, the plastic barrel liners were closed with the ties and tagged with the sample number, category, and date. The contents of the barrels were then weighed.

One crew member recorded all final weights in each category and the total sample weight. This person was also responsible for filling out the sorting forms, making final decisions on questionable items being sorted, checking the sample for any contamination, and making general reference notes.

DATA ANALYSIS METHODOLOGY

Our analysis methodology for interpreting data derived from our component analysis includes three parts: determining recovery rates, measuring component variability, and analyzing moisture and heat content. The methodology can be used in developing city and regional solid-waste management policies.

Determining Recovery Rates

Recovery rates are one way to measure the success of a multimaterial source-separation program. The recovery rate is defined as the percentage of a recoverable material that is actually recovered from the total amount of that material in the waste stream. Recovery rates indicate the recoverable materials that residents find easiest or most difficult to source-separate, and what materials could be recovered in larger quantities.

To compute recovery rates, we first performed a component analysis for the combined streams of refuse and source-separated materials. We factored the component percentages against the total weights of refuse and source-separated materials reported for the month in which our seasonal analysis took place.

For each component, we determined what percent of the combined streams was recovered material. For example, of the 113.2 tons of newsprint discarded by Marblehead residents in July, 72.1 tons were recovered. This gives us a recovery rate of 63.7 percent for newsprint.

Measuring Component Variability

To determine the significance of our component analysis, we measured the amount that each component varied from sample to sample. Component fractions that show the least variability among a group of samples are statistically more significant than component fractions that have a high variability. However, an established value for acceptable variability for waste composition is not available. Therefore, we can only show which component fractions varied more than others, without drawing conclusions on the significance of the fractions.

To measure how the percentages of each component varied among the individual samples, we calculated the coefficient of variation (CV), defined as the standard deviation divided by the mean for each component. However, since the component percentages for the samples are small (less than 20 percent) and there are a small number of samples, the actual statistical distribution is skewed from a "normal curve." Therefore, to compute the CV, a transformation of the data to counter skewness is appropriate. We used an arcsin transformation as follows*:

$$\overline{Y} = 2 \arcsin \overline{X}$$

Where $\overline{X}$ is the mean of the component percentages in each sample and $\overline{Y}$ is the transformed mean.

The CVs were computed for 11 components (beverage containers were not separated by color). High CV values represent component percentages that vary widely from sample to sample; low values represent percentages that are less variable.

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* U.S. Department of Health, Education and Welfare, Public Health Service, Analysis of Solid Waste Composition, 1969.

Analyzing Moisture and Heat Content

Our methodology for the moisture and heat content analysis was designed to provide preliminary data on whether the moisture content of recovered materials and refuse differs, and to find out if source separation affects the heating value of residential waste. A more rigorous sampling program would be required to accurately quantify typical values for moisture and heat content.

After dividing samples into their 15 components, we combined like sample components (e.g., two refuse samples of newsprint) and mixed them by hand to obtain a homogeneous mixture. A representative sample of about 10 pounds was taken from the combined samples, placed in plastic bags, and delivered to a laboratory for analysis. In the laboratory, each moisture sample was shredded, crushed, and mixed to increase homogeneity and then dried in an oven. The percent of moisture in the sample was then derived by the weight loss of H_2O. The results of this analysis for four seasons are included in Appendix D.

The heating value, in Btu/lb, was computed for refuse and recovered material sample components, using the moisture analysis results and the known heating values of those components in typical municipal waste (see Exhibit B.b).

Exhibit B.b

Heat Content of Refuse With and Without Source Separation

Component	With Source Separation			Without Source Separation	
	Heating* Value (Btu/lb)	Percentage† of Total Refuse	Contribution to Heat Content (Btu/lb)	Percentage†† of Total Refuse	Contribution to Heat Content (Btu/lb)
Newsprint	7,215	6.4	461	24.6	1,775
Other paper**	5,890	26.8	1,579	17.7	1,042
Glass beverage containers	82	5.3	4	13.1	11
Other glass	82	5.1	4	12.4	10
Ferrous beverage containers	688	0.5	3	0.9	6
Other ferrous	716	3.0	21	4.4	31
Nonferrous beverage containers	732	0.1	1	0.3	2
Other nonferrous	642	0.5	3	0.3	2
Remaining waste	5,544	51.8	2,872	26.3	1,458
Composite		100.0	4,948	100.0	4,337

SOURCE: Resource Planning Associates, Inc.

* Heating value was computed using known heating values for each component and the average moisture content found from our sampling, see Exhibit 3.a and Appendix B.
** "Other paper" includes magazines and corrugated paper.
† Average composition of Marblehead's refuse, see Exhibit 1.a.
†† Average composition of Marblehead's combined refuse and source-separated materials, see Exhibit 1.a.

Appendix C

COMPONENT ANALYSIS SAMPLE DATA

Exhibit C.a

Composition of Source-Separated Materials
(Percent)

Component	Marblehead					Somerville			
	Fall	Winter	Spring	Summer	Average	Fall	Spring	Summer	Average*
Paper									
Newsprint	41.9	42.3	44.0	39.6	41.9	46.8	56.5	91.5	51.6
Magazines	–	2.5	7.2	3.1	4.3	–	0.5	2.3	0.5
Corrugated	–	0.0	0.3	1.3	1.2	–	2.3	0.7	2.3
Other paper	13.4	1.8	2.6	2.2	2.2**	13.7	2.0	5.0	3.5**
Subtotal	**55.3**	**46.6**	**54.1**	**46.2**	**50.6**	**60.5**	**61.3**	**99.5**	**60.9**
Glass beverage									
Clear	–	11.8	11.8	13.3	12.3	–	8.8	–	8.8
Green	–	8.7	6.1	6.5	7.1	–	5.0	–	5.0
Brown	–	1.7	1.1	2.9	1.9	–	6.2	–	6.2
Subtotal	**18.7**	**22.2**	**19.0**	**22.7**	**20.6**	**17.3**	**20.0**	**–**	**13.6**
Other glass									
Clear	–	13.1	12.7	13.7	13.2	–	7.2	–	7.2
Green	–	7.4	4.1	7.1	6.2	–	3.3	–	3.3
Brown	–	1.6	1.5	1.3	1.5	–	1.3	–	1.3
Subtotal	**16.3**	**22.1**	**18.3**	**22.1**	**19.7**	**10.9**	**11.8**	**–**	**11.3**
Ferrous beverage containers	**1.0**	**0.8**	**1.1**	**1.7**	**1.2**	**1.3**	**0.9**	**–**	**1.1**
Other ferrous	**6.1**	**6.6**	**5.5**	**4.8**	**5.7**	**5.5**	**4.5**	**–**	**5.0**
Nonferrous beverage containers	**0.7**	**0.3**	**0.6**	**0.3**	**0.5**	**0.3**	**0.1**	**–**	**0.2**
Other nonferrous	**0.2**	**0.2**	**0.3**	**0.2**	**0.2**	**0.2**	**0.1**	**–**	**0.1**
Remaining waste	**1.7**	**1.2**	**1.1**	**2.0**	**1.5**	**4.0**	**1.3**	**0.5**	**2.9**
Total	**100.0**	**100.0**	**100.0**	**100.0**	**–**	**100.0**	**100.0**	**100.0**	**–**

SOURCE: Resource Planning Associates, Inc.

*Glass and metals were not recovered for the summer, therefore, the averages were taken from fall and spring data only.

**Average does not include fall season.

Exhibit C.b

Composition of Refuse
(Percent)

Component	Marblehead					Somerville			
	Fall	Winter	Spring	Summer	Average	Fall	Spring	Summer	Average*
Paper									
Newsprint	8.7	6.8	4.0	7.4	6.4	9.0	9.0	6.3	9.0
Magazines	–	1.3	3.9	0.7	2.0	–	1.0	1.7	1.0
Corrugated	–	1.3	1.5	2.6	1.8	–	0.5	1.3	0.5
Other paper	27.5	23.1	25.9	20.1	23.0**	21.6	19.6	17.6	18.6**
Subtotal	**36.2**	**32.5**	**35.3**	**30.8**	**33.7**	**30.6**	**30.1**	**26.9**	**30.3**
Glass beverage containers									
Clear	–	1.3	2.1	2.3	1.9	–	6.4	10.9	6.4
Green	–	2.8	2.0	1.8	2.2	–	3.3	1.7	3.3
Brown	–	1.0	2.6	0.8	1.5	–	1.4	4.4	1.4
Subtotal	**4.6**	**5.1**	**6.7**	**4.9**	**5.3**	**5.9**	**11.1**	**17.0**	**8.5**
Other glass									
Clear	–	5.0	2.1	3.6	3.6	–	6.7	5.8	6.7
Green	–	1.9	0.9	1.0	1.3	–	1.8	0.5	1.8
Brown	–	0.5	0.4	0.5	0.5	–	0.5	0.7	0.5
Subtotal	**4.4**	**7.4**	**3.4**	**5.1**	**5.1**	**6.4**	**9.0**	**7.0**	**7.7**
Ferrous beverage containers	**0.7**	**0.5**	**0.4**	**0.5**	**0.5**	**1.3**	**1.7**	**2.1**	**1.5**
Other ferrous	**3.3**	**3.4**	**2.9**	**2.3**	**3.0**	**4.6**	**3.1**	**5.9**	**3.8**
Nonferrous beverage containers	**0.2**	**0.2**	**0.1**	**0.1**	**0.1**	**0.5**	**0.3**	**0.2**	**0.4**
Other nonferrous	**0.7**	**0.6**	**0.3**	**0.3**	**0.5**	**0.7**	**0.5**	**0.3**	**0.6**
Remaining waste	**49.9**	**50.3**	**50.9**	**56.0**	**51.8**	**50.0**	**44.2**	**40.6**	**47.1**
Total	**100.0**	**100.0**	**100.0**	**100.0**	**–**	**100.0**	**100.0**	**100.0**	**–**

SOURCE: Resource Planning Associates, Inc.

*Glass and metals were not recovered in the summer, therefore, the averages were taken from fall and spring data only.

**Average does not include the fall season.

Exhibit C.c

Composition of Combined Refuse and Source-Separated Materials

Component	Marblehead					Somerville			
	Fall (Oct)	Winter (Feb)	Spring (May)	Winter (Jul)	Average	Fall (Oct)	Spring (May)	Summer (Jul)	Average
Paper									
Newsprint	16.5	15.8	12.9	15.3	15.1	10.9	10.5	7.1	9.5
Magazines	–	1.6	4.6	1.3	2.5	–	1.0	1.7	1.3
Corrugated	–	1.0	1.2	2.3	1.5	–	0.6	1.3	0.9
Other paper	24.1*	17.7	20.7	15.7	19.6**	21.2*	19.0	17.5	19.2**
Subtotal	**40.6**	**36.1**	**39.4**	**34.6**	**37.7**	**32.1**	**31.1**	**27.6**	**30.3**
Glass beverage containers									
Clear	–	4.0	4.2	5.0	4.4	–	6.5	10.8	8.6
Green	–	4.3	2.9	3.0	3.4	–	3.4	1.7	2.9
Brown	–	1.2	2.3	1.3	1.6	–	1.5	4.4	2.9
Subtotal	**8.0**	**9.5**	**9.4**	**9.3**	**9.0**	**6.5**	**11.4**	**16.9**	**11.6**
Other glass									
Clear	–	7.0	4.5	6.1	5.9	–	6.7	5.7	6.2
Green	–	3.3	1.6	2.5	2.5	–	1.8	0.5	1.1
Brown	–	0.8	0.6	0.7	0.7	–	0.5	0.7	0.6
Subtotal	**7.1**	**11.1**	**6.7**	**9.3**	**8.6**	**6.6**	**9.0**	**6.9**	**7.5**
Ferrous beverage containers	**1.0**	**0.6**	**0.6**	**0.8**	**0.7**	**1.0**	**1.8**	**2.1**	**1.7**
Other ferrous	**4.0**	**4.2**	**3.5**	**2.9**	**3.6**	**4.6**	**3.1**	**5.8**	**4.5**
Nonferrous beverage containers	**0.3**	**0.2**	**0.2**	**0.1**	**0.2**	**0.5**	**0.3**	**0.2**	**0.3**
Other nonferrous	**0.6**	**0.5**	**0.3**	**0.3**	**0.4**	**0.7**	**0.5**	**0.3**	**0.5**
Remaining waste	**38.4**	**39.8**	**39.9**	**42.7**	**39.7**	**48.0**	**42.8**	**40.2**	**43.6**
Total	**100.0**	**100.0**	**100.0**	**100.0**	–	**100.0**	**100.0**	**100.0**	–

SOURCE: Resource Planning Associates, Inc.

* Includes magazines and corrugated.
** Average does not include the fall season.

Exhibit C.d

Refuse, Fall Season, Somerville

Sample No.	1		2		3		4	
Housing Units Sampled	10		5		3		4	
	Lb	Percent	Lb	Percent	Lb	Percent	Lb	Percent
Paper								
Newsprint	25	9.4	42	11.0	24	8.3	19	6.8
Magazines					3	1.0	0	0
Corrugated					5	1.7	38	13.7
Other paper					42	14.4	32	11.5
Subtotal	**93**	**34.9**	**117**	**30.6**	**74**	**25.4**	**89**	**32.0**
Glass beverage containers								
Clear								
Green								
Brown								
Subtotal	**10**	**3.7**	**27**	**7.0**	**26**	**8.9**	**9**	**3.2**
Other glass								
Clear								
Green								
Brown								
Subtotal	**28**	**10.5**	**17**	**4.4**	**21**	**7.3**	**12**	**4.3**
Ferrous beverage containers	**1**	**0.4**	**5**	**1.3**	**9**	**3.1**	**1**	**0.4**
Other ferrous	**10**	**3.7**	**21**	**5.5**	**12**	**4.1**	**13**	**4.7**
Nonferrous beverage containers	**0**	**0**	**6**	**1.6**	**0**	**0**	**0**	**0**
Other nonferrous	**3**	**1.1**	**2**	**0.5**	**2**	**0.7**	**2**	**0.7**
Remaining waste	**122**	**45.7**	**188**	**49.1**	**147**	**50.5**	**152**	**54.7**
Total	**267**	**100.0**	**383**	**100.0**	**291**	**100.0**	**278**	**100.0**

SOURCE: Resource Planning Associates, Inc.

Exhibit C.e

Source-Separated Materials, Fall Season, Somerville

Sample No.	5		6		7		8	
Housing Units Sampled	*		*		20		14	
	Lb	Percent	Lb	Percent	Lb	Percent	Lb	Percent
Paper								
Newsprint	197	46.4	106	31.5	179	61.3	155	50.3
Magazines					27	9.3	8	2 6
Corrugated					3	1.0	26	8.5
Other paper					10	3.4	9	2.9
Subtotal	246	57.9	160	47.6	219	75.0	198	64.3
Glass beverage containers								
Clear								
Green								
Brown								
Subtotal	57	13.4	69	20.5	41	14.1	68	22.0
Other glass								
Clear								
Green								
Brown								
Subtotal	68	16.0	35	10.4	19	6.5	26	8.4
Ferrous beverage containers	7	1.6	10	3.0	0	0	1	0.3
Other ferrous	28	6.6	23	6.8	10	3.4	14	4.5
Nonferrous beverage containers	2	0.5	1	0.3	1	0.3	0	0
Other nonferrous	2	0.5	1	0.3	0	0	0	0
Remaining waste	15	3.6	37	11.0	2	0.7	1	0.3
Total	425	100.0	336	100.0	292	100.0	308	100.0

SOURCE: Resource Planning Associates, Inc.

* The number of housing units sampled was not recorded.

Exhibit C.f

Refuse, Fall Season, Marblehead

Sample No.	1		2		3		4	
Housing Units Sampled	3		5		7		5	
	Lb	Percent	Lb	Percent	Lb	Percent	Lb	Percent
Paper								
Newsprint	19	8.7	7	4.8	33	19.0	23	13.3
Magazines								
Corrugated								
Other paper								
Subtotal	41	18.8	36	24.8	64	36.8	40	23.1
Glass beverage containers								
Clear								
Green								
Brown								
Subtotal	29	13.3	3	2.1	0	0	14	8.1
Other glass								
Clear								
Green								
Brown								
Subtotal	16	7.3	7	4.8	7	4.0	6	3.2
Ferrous beverage containers	2	0.9	1	0.7	0	0	3	1.7
Other ferrous	7	3.2	14	9.7	11	6.3	2	1.2
Nonferrous beverage containers	1	0.5	0	0	0	0	0	0
Other nonferrous	1	0.5	1	0.7	1	0.6	1	0.6
Remaining waste	102	46.8	76	52.4	58	33.3	84	48.8
Total	218	100.0	145	100.0	174	100.0	173	100.0

SOURCE: Resource Planning Associates, Inc.

Exhibit C.f (continued)

Refuse, Fall Season, Marblehead

Sample No. Housing Units Sampled	5 8 Lb	Percent	6 6 Lb	Percent	7 7 Lb	Percent	8 5 Lb	Percent
Paper								
Newsprint	17	9.0	9	4.3	7	4.1	19	7.5
Magazines								
Corrugated	5	2.7	46	21.8	3	1.8	0	0
Other paper	45	23.9	46	21.8	55	32.2	41	16.2
Subtotal	**67**	**35.6**	**101**	**47.9**	**65**	**38.1**	**60**	**23.7**
Glass beverage containers								
Clear								
Green								
Brown								
Subtotal	**9**	**4.8**	**3**	**1.4**	**5**	**2.9**	**7**	**2.8**
Other glass								
Clear								
Green								
Brown								
Subtotal	**9**	**4.8**	**7**	**3.3**	**6**	**3.5**	**9**	**3.6**
Ferrous beverage containers	**1**	**0.5**	**1**	**0.5**	**0**	**0**	**3**	**1.2**
Other ferrous	**3**	**1.6**	**4**	**1.9**	**3**	**1.8**	**6**	**2.4**
Nonferrous beverage containers	**0**	**0**	**1**	**0.5**	**0**	**0**	**1**	**0.4**
Other nonferrous	**1**	**0.5**	**2**	**1.0**	**2**	**1.2**	**2**	**0.8**
Remaining waste	**98**	**52.2**	**92**	**43.6**	**90**	**52.6**	**165**	**65.2**
Total	**188**	**100.0**	**211**	**100.0**	**171**	**100.0**	**253**	**100.0**

SOURCE: Resource Planning Associates, Inc.

Exhibit C.g

Source-Separated Materials, Fall Season, Marblehead

Sample No. Housing Units Sampled	9 8 Lb	Percent	10 12 Lb	Percent	11 6 Lb	Percent	12* Lb	Percent
Paper								
Newsprint	134	46.8	101	37.4	136	45.6		
Magazines								
Corrugated								
Other paper								
Subtotal	**153**	**53.4**	**147**	**54.4**	**164**	**55.0**		
Glass beverage containers								
Clear								
Green								
Brown								
Subtotal	**63**	**22.0**	**49**	**18.2**	**62**	**20.8**		
Other glass								
Clear								
Green								
Brown								
Subtotal	**63**	**22.0**	**40**	**14.8**	**28**	**9.4**		
Ferrous beverage containers	**0**	**0**	**5**	**1.9**	**1**	**0.3**		
Other ferrous	**5**	**1.8**	**23**	**8.5**	**35**	**11.7**		
Nonferrous beverage containers	**1**	**0.4**	**3**	**1.1**	**1**	**0.3**		
Other nonferrous	**0**	**0**	**1**	**0.4**	**0**	**0**		
Remaining waste	**1**	**0.4**	**2**	**0.7**	**7**	**2.4**		
Total	**286**	**100.0**	**270**	**100.0**	**298**	**100.0**		

SOURCE: Resource Planning Associates, Inc.

* Sample not taken due to scheduling error.

Exhibit C.g (continued)

Source-Separated Materials, Fall Season, Marblehead

Sample No. Housing Units Sampled	13 *		14 *		15 *		16 *	
	Lb	Percent	Lb	Percent	Lb	Percent	Lb	Percent
Paper								
Newsprint	116	43.3	99	32.6	102	39.8	129	45.7
Magazines	25	9.8	14	4.6	59	23.1	15	5.3
Corrugated	0	0	21	6.9	0	0	0	0
Other paper	6	2.3	6	2.0	11	4.3	12	4.3
Subtotal	**147**	**55.4**	**140**	**46.1**	**172**	**67.2**	**146**	**55.3**
Glass beverage containers								
Clear	18	7.0	20	6.6	21	8.2	35	12.4
Green	15	5.9	29	9.5	9	2.5	9	3.2
Brown	8	3.1	15	4.9	9	2.5	3	1.1
Subtotal	**41**	**16.0**	**64**	**21.0**	**39**	**15.2**	**47**	**16.7**
Other glass								
Clear	30	11.7	53	17.4	16	6.3	50	17.7
Green	5	2.0	16	5.3	2	0.8	9	3.2
Brown	0	0	6	2.0	1	0.4	0	0
Subtotal	**35**	**13.7**	**75**	**24.7**	**19**	**7.4**	**59**	**20.9**
Ferrous beverage containers	**6**	**2.3**	**5**	**1.6**	**1**	**0.8**	**1**	**0.4**
Other ferrous	**15**	**5.9**	**15**	**4.9**	**11**	**4.3**	**16**	**5.7**
Nonferrous beverage containers	**3**	**1.2**	**2**	**0.7**	**2**	**0.8**	**1**	**0.4**
Other nonferrous	**1**	**0.4**	**0**	**0**	**1**	**0.4**	**1**	**0.4**
Remaining waste	**8**	**3.1**	**3**	**1.0**	**11**	**4.3**	**1**	**0.4**
Total	**256**	**100.0**	**304**	**100.0**	**256**	**100.0**	**282**	**100.0**

SOURCE: Resource Planning Associates, Inc.

* The number of housing units sampled was not recorded.

Exhibit C.h

Refuse, Winter Season, Marblehead

Sample No.	1		2		3		4	
Housing Units Sampled	7		11		7		*	
	Lb	Percent	Lb	Percent	Lb	Percent	Lb	Percent
Paper								
Newsprint	21.0	6.0	5.0	2.8	6.0	2.8	14.0	7.3
Magazines	3.0	0.9	1.0	0.6	5.5	2.5	—	—
Corrugated	6.0	1.7	4.5	2.5	6.0	2.7	—	—
Other paper	52.0	14.9	37.5	20.7	44.0	20.1	44.5	23.0
Subtotal	**82.0**	**23.5**	**48.0**	**26.6**	**61.5**	**28.1**	**58.5**	**30.3**
Glass beverage containers								
Clear	6.0	1.7	1.0	0.6	0.5	0.2	0.6	0.3
Green	14.0	4.0	4.5	2.4	13.0	6.0	1.4	0.7
Brown	10.0	2.9	—	—	—	—	—	—
Subtotal	**30.0**	**8.6**	**5.5**	**3.0**	**13.5**	**6.2**	**2.0**	**1.0**
Other glass								
Clear	17.0	4.9	11.0	6.1	4.0	1.6	15.0	7.8
Green	5.0	1.4	5.0	2.7	0.5	0.2	4.0	2.1
Brown	4.5	1.3	0.5	0.3	—	—	4.5	2.3
Subtotal	**26.5**	**7.6**	**16.5**	**9.1**	**4.5**	**1.8**	**23.5**	**12.2**
Ferrous beverage containers	**2.5**	**0.7**	**1.0**	**0.5**	**1.0**	**0.5**	**1.5**	**0.8**
Other ferrous	**10.0**	**2.9**	**10.0**	**5.5**	**10.0**	**4.6**	**7.5**	**3.9**
Nonferrous beverage containers	**0.5**	**0.1**	**0.5**	**0.3**	**—**	**—**	**0.5**	**0.3**
Other nonferrous	**1.0**	**0.3**	**1.0**	**0.5**	**1.5**	**0.7**	**1.0**	**0.5**
Remaining waste	**196.0**	**56.3**	**99.0**	**54.5**	**127.0**	**58.1**	**98.5**	**51.0**
Total	**348.5**	**100.0**	**181.5**	**100.0**	**219.0**	**100.0**	**193.0**	**100.0**

SOURCE: Resource Planning Associates, Inc.

* The number of housing units sampled was not recorded.

Exhibit C.h (continued)

Refuse, Winter Season, Marblehead

Sample No.	5		6		7		8	
Housing Units Sampled	9		9		13		10	
	Lb	Percent	Lb	Percent	Lb	Percent	Lb	Percent
Paper								
Newsprint	31.0	11.2	16.0	6.1	28.0	9.5	23.0	6.4
Magazines	9.0	3.3	4.0	1.5	0.5	0.2	5.5	1.5
Corrugated	6.0	2.2	3.0	1.2	2.0	0.7	—	—
Other paper	82.5	29.8	73.0	28.0	83.0	28.3	75.5	21.1
Subtotal	**128.5**	**46.5**	**96.0**	**36.8**	**113.5**	**38.7**	**104.0**	**29.0**
Glass beverage containers								
Clear	—	—	3.5	1.3	10.5	3.6	5.0	1.4
Green	9.5	3.4	2.0	0.8	4.5	1.5	10.0	2.8
Brown	6.0	2.2	0.5	0.2	6.0	2.1	—	—
Subtotal	**15.5**	**5.6**	**6.0**	**2.3**	**21.0**	**7.2**	**15.0**	**4.2**
Other glass								
Clear	20.0	7.2	12.0	4.6	10.0	3.4	19.0	5.3
Green	17.5	6.3	2.5	1.0	2.0	0.7	4.0	1.1
Brown	0.5	0.2	—	—	—	—	—	—
Subtotal	**38.0**	**13.7**	**14.5**	**5.6**	**12.0**	**4.1**	**23.0**	**6.4**
Ferrous beverage containers	**1.0**	**0.4**	**2.0**	**0.8**	**1.0**	**0.3**	**1.5**	**0.4**
Other ferrous	**7.5**	**2.7**	**11.0**	**4.2**	**6.0**	**2.0**	**9.5**	**2.7**
Nonferrous beverage containers	**0.5**	**0.2**	**0.5**	**0.2**	**0.5**	**0.2**	**0.5**	**0.1**
Other nonferrous	**4.0**	**1.4**	**2.0**	**0.8**	**1.0**	**0.3**	**1.5**	**0.4**
Remaining waste	**81.5**	**29.5**	**128.5**	**49.3**	**138.5**	**47.2**	**203.5**	**56.8**
Total	**276.0**	**100.0**	**260.5**	**100.0**	**293.5**	**100.0**	**358.5**	**100.0**

SOURCE: Resource Planning Associates, Inc.

Exhibit C.i

Source-Separated Materials, Winter Season, Marblehead

Sample No.	9		10		11		12	
Housing Units Sampled	6		15		4		9	
	Lb	Percent	Lb	Percent	Lb	Percent	Lb	Percent
Paper								
Newsprint	188.0	70.5	129.5	35.2	44.0	47.1	104.0	36.9
Magazines	—	—	3.0	0.9	2.0	2.1	—	—
Corrugated	—	—	—	—	—	—	—	—
Other paper	0.5	0.2	4.5	1.2	5.0	5.3	3.0	1.1
Subtotal	**188.5**	**70.7**	**137.0**	**37.3**	**51.0**	**54.5**	**107.0**	**38.0**
Glass beverage containers								
Clear	10.0	3.8	44.0	12.0	7.5	8.0	51.0	18.1
Green	6.5	2.4	49.0	13.3	0.5	0.6	24.5	8.7
Brown	0.5	0.2	4.5	1.2	—	—	6.5	2.3
Subtotal	**17.0**	**6.4**	**97.5**	**26.5**	**8.0**	**8.6**	**82.0**	**29.1**
Other glass								
Clear	29.0	10.9	69.0	18.8	14.5	15.5	37.0	13.1
Green	22.0	8.2	27.5	7.5	—	—	12.0	4.3
Brown	0.5	0.2	3.0	0.8	1.5	1.6	10.5	3.7
Subtotal	**51.5**	**19.3**	**99.5**	**27.1**	**16.0**	**17.1**	**59.5**	**21.1**
Ferrous beverage containers	**1.0**	**0.4**	**4.5**	**1.2**	**—**	**—**	**2.5**	**0.9**
Other ferrous	**4.0**	**1.5**	**28.5**	**7.8**	**12.0**	**12.8**	**18.5**	**6.6**
Nonferrous beverage containers	**0.5**	**0.2**	**0.5**	**0.1**	**1.0**	**1.1**	**4.0**	**1.4**
Other nonferrous	**—**	**—**	**—**	**—**	**0.5**	**0.5**	**1.0**	**0.4**
Remaining waste	**4.0**	**1.5**	**—**	**—**	**5.0**	**5.4**	**7.0**	**2.5**
Total	**266.5**	**100.0**	**367.5**	**100.0**	**93.5**	**100.0**	**281.5**	**100.0**

SOURCE: Resource Planning Associates, Inc.

Exhibit C.i (continued)

Source-Separated Materials, Winter Season, Marblehead

Sample No.	13		14		15		16	
Housing Units Sampled	15		19		15		15	
	Lb	Percent	Lb	Percent	Lb	Percent	Lb	Percent
Paper								
Newsprint	116.0	27.4	129.5	34.3	266.5	61.1	151.5	35.7
Magazines	7.0	1.7	9.5	2.5	17.0	4.0	28.5	6.7
Corrugated	—	—	—	—	—	—	—	—
Other paper	6.5	1.5	12.5	3.3	8.5	1.9	8.5	2.0
Subtotal	**129.5**	**30.6**	**151.5**	**40.1**	**292.0**	**67.0**	**188.5**	**44.4**
Glass beverage containers								
Clear	84.5	19.9	31.0	8.2	43.5	10.0	44.0	10.4
Green	69.0	16.3	24.0	6.4	26.5	6.1	31.5	7.4
Brown	5.0	1.2	12.5	3.3	3.0	0.7	14.5	3.4
Subtotal	**158.5**	**37.4**	**67.5**	**17.9**	**73.0**	**16.8**	**90.0**	**21.2**
Other glass								
Clear	51.5	12.2	58.5	15.5	34.0	7.8	56.5	13.3
Green	29.0	6.8	59.0	15.6	6.5	1.5	41.0	9.7
Brown	15.5	3.7	1.0	0.3	7.5	1.7	4.0	0.9
Subtotal	**96.0**	**22.7**	**118.5**	**31.4**	**48.0**	**11.0**	**101.5**	**23.9**
Ferrous beverage containers	**4.5**	**1.1**	**3.5**	**1.0**	**0.5**	**0.1**	**4.0**	**1.0**
Other ferrous	**28.0**	**6.6**	**28.0**	**7.4**	**21.5**	**4.9**	**37.0**	**8.7**
Nonferrous beverage containers	**0.5**	**0.1**	**0.5**	**0.1**	—	—	**1.5**	**0.4**
Other nonferrous	**0.5**	**0.1**	**0.5**	**0.1**	**0.5**	**0.1**	**1.0**	**0.2**
Remaining waste	**6.0**	**1.4**	**7.5**	**2.0**	**0.5**	**0.1**	**1.0**	**0.2**
Total	**423.5**	**100.0**	**377.5**	**100.0**	**436.0**	**100.0**	**424.5**	**100.0**

SOURCE: Resource Planning Associates, Inc.

Exhibit C.j

Refuse, Spring Season, Marblehead

Sample No.	1		2		3		4	
Housing Units Sampled	7		10		9		11	
	Lb	Percent	Lb	Percent	Lb	Percent	Lb	Percent
Paper								
Newsprint	16.0	4.1	14.5	4.6	11.5	3.2	15.5	4.6
Magazines	15.5	4.0	10.5	3.3	0.5	0.1	12.5	3.8
Corrugated	6.0	1.5	1.0	0.3	16.0	4.5	—	—
Other	58.0	15.0	61.0	19.5	71.0	19.6	79.0	23.7
Subtotal	**95.5**	**24.6**	**87.0**	**27.7**	**99.0**	**27.4**	**107.0**	**32.1**
Glass beverage containers								
Clear	23.0	6.0	10.5	3.3	6.5	1.8	1.0	0.3
Green	7.5	1.9	0.5	0.2	22.0	6.0	3.0	0.9
Brown	10.0	2.6	1.0	0.3	38.5	10.7	—	—
Subtotal	**40.5**	**10.5**	**12.0**	**3.8**	**67.0**	**18.5**	**4.0**	**1.2**
Other glass								
Clear	10.5	2.7	8.0	2.6	12.0	3.3	10.0	3.0
Green	7.5	1.9	2.0	0.6	3.5	1.0	2.5	0.7
Brown	—	—	0.5	0.2	2.5	0.7	1.0	0.3
Subtotal	**18.0**	**4.6**	**10.5**	**3.4**	**18.0**	**5.0**	**13.5**	**4.0**
Ferrous beverage containers	**3.0**	**0.8**	**0.5**	**0.2**	**0.5**	**0.1**	**1.5**	**0.4**
Other ferrous	**22.0**	**5.7**	**7.0**	**2.2**	**12.5**	**3.5**	**7.5**	**2.3**
Nonferrous beverage containers	**—**	**—**	**—**	**—**	**0.5**	**0.1**	**0.5**	**0.1**
Other nonferrous	**0.5**	**0.1**	**1.0**	**0.3**	**0.5**	**0.1**	**1.0**	**0.3**
Remaining waste	**208.0**	**53.7**	**195.5**	**62.4**	**163.5**	**45.3**	**199.0**	**59.6**
Total	**387.5**	**100.0**	**313.5**	**100.0**	**361.5**	**100.0**	**334.0**	**100.0**

SOURCE: Resource Planning Associates, Inc.

Exhibit C.j (continued)

Refuse, Spring Season, Marblehead

Sample No.	5		6		7		8	
Housing Units Sampled	9		7		7		7	
	Lb	Percent	Lb	Percent	Lb	Percent	Lb	Percent
Paper								
Newsprint	13.0	4.8	12.0	5.2	19.0	3.4	11.5	3.0
Magazines	19.5	7.2	6.5	2.8	30.0	5.5	14.0	3.6
Corrugated	6.0	2.2	5.0	2.2	7.0	1.3	2.5	0.7
Other	103.5	38.3	66.0	28.6	239.5	43.8	56.5	14.7
Subtotal	**142.0**	**52.5**	**89.5**	**38.8**	**295.5**	**54.0**	**84.5**	**22.0**
Glass beverage containers								
Clear	4.5	1.7	—	—	11.5	2.1	2.5	0.6
Green	5.5	2.0	0.5	0.2	5.5	1.0	11.0	2.9
Brown	8.0	3.0	0.5	0.2	11.0	2.0	6.5	1.7
Subtotal	**18.0**	**6.7**	**0.5**	**0.2**	**28.0**	**5.1**	**20.0**	**5.2**
Other glass								
Clear	5.0	1.8	1.5	0.7	8.5	1.6	4.5	1.2
Green	5.5	2.1	—	—	1.5	0.3	2.0	0.5
Brown	5.0	1.8	—	—	—	—	3.5	0.9
Subtotal	**15.5**	**5.7**	**1.5**	**0.7**	**10.0**	**1.9**	**10.0**	**2.6**
Ferrous beverage containers	**0.5**	**0.2**	**1.5**	**0.7**	**—**	**—**	**3.0**	**0.8**
Other ferrous	**8.5**	**3.1**	**10.0**	**4.3**	**9.5**	**1.7**	**4.5**	**1.2**
Nonferrous beverage containers	**0.5**	**0.2**	**—**	**—**	**—**	**—**	**2.0**	**0.5**
Other nonferrous	**1.5**	**0.6**	**1.5**	**0.7**	**1.5**	**0.3**	**0.5**	**0.1**
Remaining waste	**84.0**	**31.0**	**126.0**	**54.6**	**202.5**	**37.0**	**260.5**	**67.6**
Total	**270.5**	**100.0**	**230.5**	**100.0**	**547.0**	**100.0**	**385.0**	**100.0**

SOURCE: Resource Planning Associates, Inc.

Exhibit C.k

Source-Separated Materials, Spring Season, Marblehead

Sample No.	9		10		11		12	
Housing Units Sampled	8		12		5		7	
	Lb	Percent	Lb	Percent	Lb	Percent	Lb	Percent
Paper								
Newsprint	80.5	25.8	127.5	44.8	25.0	30.1	65.0	35.4
Magazines	70.5	22.5	—	—	—	—	18.0	9.8
Corrugated	—	—	1.5	0.5	0.5	0.6	1.5	0.8
Other	5.5	1.8	5.5	2.0	15.0	18.1	4.5	2.5
Subtotal	**156.5**	**50.1**	**134.5**	**47.3**	**40.5**	**48.8**	**89.0**	**48.5**
Glass beverage containers								
Clear	25.0	8.0	38.0	13.3	14.0	16.9	25.0	13.6
Green	31.0	10.0	17.0	6.0	3.5	4.2	13.0	7.1
Brown	1.0	0.3	8.0	2.8	—	—	—	—
Subtotal	**57.0**	**18.3**	**63.0**	**22.1**	**17.5**	**21.1**	**38.0**	**20.7**
Other glass								
Clear	57.0	18.3	27.0	9.5	17.0	20.5	24.5	13.3
Green	12.5	4.0	20.0	7.0	—	—	6.0	3.3
Brown	4.0	1.2	7.0	2.5	—	—	1.5	0.8
Subtotal	**73.5**	**23.5**	**54.0**	**19.0**	**17.0**	**20.5**	**32.0**	**17.4**
Ferrous beverage containers	**2.5**	**0.8**	**0.4**	**1.4**	**7.5**	**9.0**	**4.0**	**2.2**
Other ferrous	**19.0**	**6.1**	**22.5**	**7.9**	**—**	**—**	**18.0**	**9.8**
Nonferrous beverage containers	**—**	**—**	**1.5**	**0.5**	**—**	**—**	**0.5**	**0.3**
Other nonferrous	**2.0**	**0.6**	**0.5**	**0.2**	**—**	**—**	**0.5**	**0.3**
Remaining waste	**2.0**	**0.6**	**4.5**	**1.6**	**0.5**	**0.6**	**1.5**	**0.8**
Total	**312.5**	**100.0**	**284.5**	**100.0**	**83.0**	**100.0**	**183.5**	**100.0**

SOURCE: Resource Planning Associates, Inc.

Exhibit C.k (continued)

Source-Separated Materials, Spring Season, Marblehead

Sample No.	13		14		15		16	
Housing Units Sampled	11		11		12		14	
	Lb	Percent	Lb	Percent	Lb	Percent	Lb	Percent
Paper								
Newsprint	145.0	52.5	144.5	38.4	311.0	56.6	267.0	46.0
Magazines	1.0	0.4	11.5	3.0	55.0	10.0	34.5	6.0
Corrugated	—	—	—	—	2.5	0.4	3.0	0.5
Other	—	—	17.0	4.5	12.5	2.3	8.0	1.4
Subtotal	**146.0**	**52.9**	**173.0**	**45.9**	**381.0**	**69.3**	**312.5**	**53.9**
Glass beverage containers								
Clear	27.5	10.0	43.5	11.6	88.0	15.9	51.5	8.9
Green	20.5	7.4	14.5	3.8	24.0	4.4	38.5	6.6
Brown	1.5	0.5	2.0	0.5	—	—	16.0	2.7
Subtotal	**49.5**	**17.9**	**60.0**	**15.9**	**112.0**	**20.3**	**106.0**	**18.2**
Other glass								
Clear	46.5	16.8	64.5	17.2	18.5	3.4	80.0	13.8
Green	11.0	4.0	34.0	9.0	2.0	0.4	22.5	3.9
Brown	4.5	1.6	6.0	1.6	3.5	0.6	14.5	2.5
Subtotal	**62.0**	**22.4**	**104.5**	**27.8**	**24.0**	**4.4**	**117.0**	**20.2**
Ferrous beverage containers	**1.0**	**0.4**	**7.0**	**1.9**	—	—	**3.0**	**0.5**
Other ferrous	**12.0**	**4.3**	**20.0**	**5.3**	**24.0**	**4.4**	**30.0**	**5.2**
Nonferrous beverage containers	**1.5**	**0.5**	**3.0**	**0.8**	**1.0**	**0.2**	**8.0**	**1.4**
Other nonferrous	—	—	**2.0**	**0.5**	**1.0**	**0.2**	**1.0**	**0.2**
Remaining waste	**4.5**	**1.6**	**7.0**	**1.9**	**6.5**	**1.2**	**2.5**	**0.4**
Total	**276.5**	**100.0**	**376.5**	**100.0**	**549.5**	**100.0**	**580.0**	**100.0**

SOURCE: Resource Planning Associates, Inc.

Exhibit C.I

Refuse, Spring Season, Somerville

Sample No.	1		2		3		4	
Housing Units Sampled	9		8		7		8	
	Lb	Percent	Lb	Percent	Lb	Percent	Lb	Percent
Paper								
Newsprint	22.5	7.0	37.0	10.1	21.5	7.3	37.0	10.9
Magazines	2.0	0.6	2.0	0.5	0.6	2.0	3.5	1.0
Corrugated	0.5	0.2	5.5	1.5	0.5	0.2	0.5	0.1
Other	60.0	18.8	68.5	18.8	62.0	21.2	68.0	20.0
Subtotal	**85.0**	**26.6**	**113.0**	**30.9**	**90.0**	**30.7**	**109.0**	**32.0**
Glass beverage containers								
Clear	8.0	2.5	31.0	8.5	22.0	7.5	23.0	6.7
Green	21.0	6.6	3.0	0.8	8.5	2.9	11.0	3.2
Brown	0.5	0.1	6.0	1.6	8.5	2.9	4.0	1.2
Subtotal	**29.5**	**9.2**	**40.0**	**10.9**	**39.0**	**13.3**	**38.0**	**11.1**
Other glass								
Clear	23.5	7.3	13.0	3.6	29.0	9.9	22.5	6.6
Green	9.5	3.0	5.0	1.4	5.0	1.7	4.5	1.3
Brown	2.5	0.8	2.5	0.7	2.0	0.7	0.5	0.2
Subtotal	**35.5**	**11.1**	**20.5**	**5.7**	**36.0**	**12.3**	**27.5**	**8.1**
Ferrous beverage containers	**1.5**	**0.5**	**10.5**	**2.9**	**9.0**	**3.1**	**2.0**	**0.6**
Other ferrous	**5.5**	**1.7**	**10.5**	**2.9**	**10.0**	**3.4**	**15.0**	**4.4**
Nonferrous beverage containers	**0.5**	**0.2**	**1.5**	**0.4**	**0.5**	**0.2**	**1.0**	**0.3**
Other nonferrous	—	—	**1.4**	**0.4**	**3.0**	**1.0**	**1.5**	**0.4**
Remaining waste	**162.5**	**50.7**	**168.0**	**45.9**	**105.5**	**36.0**	**146.5**	**43.1**
Total	**320.0**	**100.0**	**365.5**	**100.0**	**293.0**	**100.0**	**340.5**	**100.0**

SOURCE: Resource Planning Associates, Inc.

Exhibit C.m

Source-Separated Materials, Spring Season, Somerville

Sample No.	5		6		7		8	
Housing Units Sampled	12		12		12		6	
	Lb	Percent	Lb	Percent	Lb	Percent	Lb	Percent
Paper								
Newsprint	119.5	43.6	139.5	52.1	121.5	63.9	119.5	78.1
Magazines	—	—	1.0	0.4	3.0	1.6	—	—
Corrugated	8.0	2.9	10.0	3.7	2.5	1.3	—	—
Other	5.0	1.5	9.0	3.4	4.0	2.1	—	—
Subtotal	**132.5**	**48.3**	**159.5**	**59.6**	**131.0**	**68.9**	**119.5**	**78.1**
Glass beverage containers								
Clear	27.5	10.0	24.5	9.2	15.5	8.1	10.5	6.9
Green	15.5	5.7	22.0	8.2	3.0	1.6	3.5	2.3
Brown	15.5	5.7	18.0	6.7	19.5	10.3	2.0	1.3
Subtotal	**58.5**	**21.4**	**64.5**	**24.1**	**38.0**	**20.0**	**16.0**	**10.5**
Other glass								
Clear	35.5	13.0	21.0	7.9	—	—	7.5	4.9
Green	21.0	7.6	5.5	2.0	2.5	1.3	—	—
Brown	6.0	2.2	—	—	—	—	5.0	3.2
Subtotal	**62.5**	**22.8**	**26.5**	**9.9**	**2.5**	**1.3**	**12.5**	**8.1**
Ferrous beverage containers	**2.0**	**0.7**	**2.5**	**0.9**	**3.0**	**1.6**	—	—
Other ferrous	**13.0**	**4.7**	**10.0**	**3.8**	**12.0**	**6.3**	**5.0**	**3.3**
Nonferrous beverage containers	**0.5**	**0.2**	—	—	**0.5**	**0.3**	—	—
Other nonferrous	**1.0**	**0.4**	—	—	—	—	—	—
Remaining waste	**4.0**	**1.5**	**4.5**	**1.7**	**3.0**	**1.6**	—	—
Total	**274.0**	**100.0**	**267.5**	**100.0**	**190.0**	**100.0**	**153.0**	**100.0**

SOURCE: Resource Planning Associates, Inc.

Exhibit C. n

Refuse, Summer Season, Marblehead

Sample No.	1		2		3		4	
Housing Units Sampled	8		8		10		7	
	Lb	Percent	Lb	Percent	Lb	Percent	Lb	Percent
Paper								
Newsprint	23.0	8.2	12.0	4.5	13.0	5.4	25.0	8.2
Magazines	6.5	2.3	–	0	2.0	0.8	1.0	0.3
Corrugated	–	–	–	0	9.0	3.8	1.0	0.3
Other paper	44.0	15.7	38.5	14.6	51.5	21.6	66.5	21.6
Subtotal	**73.5**	**26.2**	**50.5**	**19.1**	**75.5**	**31.6**	**93.5**	**30.4**
Glass beverage containers								
Clear	6.5	2.3	4.5	1.7	3.5	1.5	11.0	3.6
Green	17.0	6.0	3.0	1.1	0.5	0.2	3.5	1.1
Brown	1.0	0.4	3.5	1.3	7.0	2.9	1.0	0.3
Subtotal	**24.5**	**8.7**	**11.0**	**4.1**	**11.0**	**4.6**	**15.5**	**5.0**
Other glass								
Clear	12.5	4.5	5.0	1.9	10.5	4.4	10.0	3.2
Green	1.5	0.5	5.0	1.9	–	–	3.0	1.0
Brown	1.5	0.5	–	–	–	–	5.5	1.8
Subtotal	**15.5**	**5.5**	**10.0**	**3.8**	**10.5**	**4.4**	**18.5**	**6.0**
Ferrous beverage containers	**1.5**	**0.5**	**0.5**	**0.2**	**1.0**	**0.4**	**2.5**	**0.8**
Other ferrous	**9.5**	**3.4**	**4.5**	**1.7**	**10.5**	**4.4**	**7.5**	**2.4**
Nonferrous beverage containers	–	–	–	–	–	–	**0.5**	**0.2**
Other nonferrous	**0.5**	**0.2**	**0.5**	**0.2**	**0.5**	**0.2**	**1.5**	**0.5**
Remaining waste	**156.0**	**55.5**	**187.5**	**70.9**	**130.0**	**54.4**	**168.5**	**54.7**
Total	**281.0**	**100.0**	**264.5**	**100.0**	**239.0**	**100.0**	**308.0**	**100.0**

SOURCE: Resource Planning Associates, Inc.

Exhibit C.n (continued)

Refuse, Summer Season, Marblehead

Sample No.	5		6		7		8	
Housing Units Sampled	8		7		8		10	
	Lb	Percent	Lb	Percent	Lb	Percent	Lb	Percent
Paper								
Newsprint	30.5	10.2	27.0	9.8	13.0	6.0	14.5	5.6
Magazines	–	–	0.5	0.2	5.0	2.3	1.0	0.4
Corrugated	27.0	9.1	7.5	2.7	10.0	4.6	1.5	0.6
Other paper	51.5	17.3	42.0	15.2	60.5	27.7	75.5	29.4
Subtotal	**109.0**	**36.6**	**77.0**	**27.9**	**88.5**	**40.6**	**92.5**	**36.0**
Glass beverage containers								
Clear	10.5	3.5	1.5	0.5	8.0	3.7	3.5	1.3
Green	2.5	0.8	3.5	1.3	8.0	3.7	1.0	0.4
Brown	0.5	0.2	4.0	1.5	–	–	–	–
Subtotal	**13.5**	**4.5**	**9.0**	**3.3**	**16.0**	**7.4**	**4.5**	**1.7**
Other glass								
Clear	10.0	3.4	6.0	2.2	13.0	6.0	9.5	3.7
Green	5.5	1.9	4.5	1.6	–	–	1.0	0.4
Brown	1.5	0.5	–	–	1.0	0.4	1.5	0.6
Subtotal	**17.0**	**5.8**	**10.5**	**3.8**	**14.0**	**6.4**	**12.0**	**4.7**
Ferrous beverage containers	**1.0**	**0.3**	**3.5**	**1.3**	**–**	**–**	**1.5**	**0.6**
Other ferrous	**3.0**	**1.0**	**3.0**	**1.1**	**6.0**	**2.7**	**5.0**	**1.9**
Nonferrous beverage containers	**–**	**–**	**1.0**	**0.3**	**–**	**–**	**0.5**	**0.2**
Other nonferrous	**0.5**	**0.2**	**0.5**	**0.2**	**2.0**	**0.9**	**1.0**	**0.4**
Remaining waste	**153.5**	**51.6**	**171.5**	**62.1**	**91.5**	**42.0**	**140.0**	**54.5**
Total	**297.5**	**100.0**	**276.0**	**100.0**	**218.0**	**100.0**	**257.0**	**100.0**

SOURCE: Resource Planning Associates, Inc.

Exhibit C.o

Source-Separated Materials, Summer Season, Marblehead

Sample No. Housing Units Sampled	9* Lb	Percent	10 14 Lb	Percent	11* Lb	Percent	12* Lb	Percent
Paper								
Newsprint	Collected by town		193.0	38.8	Collected by town		Collected by town	
Magazines			—	—				
Corrugated			5.5	1.1				
Other paper			9.0	1.8				
Subtotal			**207.5**	**41.7**				
Glass beverage containers								
Clear			88.5	17.8				
Green			39.5	7.9				
Brown			11.0	2.2				
Subtotal			**139.0**	**27.9**				
Other glass								
Clear			73.0	14.7				
Green			31.0	6.2				
Brown			3.0	0.6				
Subtotal			**107.0**	**21.5**				
Ferrous beverage containers			**6.5**	**1.3**				
Other ferrous			**25.0**	**5.0**				
Nonferrous beverage containers			**1.5**	**0.3**				
Other nonferrous			**0.5**	**0.1**				
Remaining waste			**11.0**	**2.2**				
Total			**498.0**	**100.0**				

SOURCE: Resource Planning Associates, Inc.

* Sample not taken due to scheduling error.

Exhibit C.o (continued)

Source-Separated Materials, Summer Season, Marblehead

Sample No.	13		14		15		16	
Housing Units Sampled	7		12		14		13	
	Lb	Percent	Lb	Percent	Lb	Percent	Lb	Percent
Paper								
Newsprint	145.5	50.8	51.5	18.7	180.5	55.1	84.5	32.0
Magazines	11.0	3.8	4.0	1.4	3.5	1.1	32.0	12.1
Corrugated	1.5	0.5	1.5	0.6	8.0	2.4	4.5	1.7
Other paper	7.0	2.5	4.0	1.4	10.0	3.1	7.0	2.7
Subtotal	**165.0**	**57.6**	**61.0**	**22.1**	**203.0**	**61.7**	**128.0**	**48.5**
Glass beverage containers								
Clear	29.5	10.3	50.0	18.1	19.0	5.8	32.5	12.3
Green	17.5	6.1	20.5	7.5	20.5	6.2	9.0	3.4
Brown	17.0	5.9	2.0	0.7	10.0	3.1	8.0	3.0
Subtotal	**64.0**	**22.3**	**72.5**	**26.3**	**49.5**	**15.1**	**49.5**	**18.7**
Other glass								
Clear	20.0	7.1	60.0	21.7	32.0	9.8	40.5	15.3
Green	13.5	4.7	39.5	14.3	20.5	6.2	13.0	4.9
Brown	2.0	0.7	5.5	2.0	4.0	1.2	7.0	2.7
Subtotal	**35.5**	**12.5**	**105.0**	**38.1**	**56.5**	**17.2**	**60.5**	**22.9**
Ferrous beverage containers	**7.5**	**2.6**	**7.5**	**2.7**	**4.0**	**1.2**	**3.5**	**1.3**
Other ferrous	**11.0**	**3.8**	**18.0**	**6.5**	**9.5**	**2.9**	**15.5**	**5.9**
Nonferrous beverage containers	**1.5**	**0.5**	**0.5**	**0.1**	**1.5**	**0.5**	—	—
Other nonferrous	—	—	**1.5**	**0.6**	**1.0**	**0.3**	**0.5**	**0.2**
Remaining waste	**2.0**	**0.7**	**10.0**	**3.6**	**3.5**	**1.1**	**6.5**	**2.5**
Total	**286.5**	**100.0**	**276.0**	**100.0**	**327.5**	**100.0**	**264.0**	**100.0**

SOURCE: Resource Planning Associates, Inc.

Exhibit C.p

Refuse, Summer Season, Somerville

Sample No.	1		2		3		4	
Housing Units Sampled	7		8		7		7	
	Lb	Percent	Lb	Percent	Lb	Percent	Lb	Percent
Paper								
Newsprint	29.0	7.8	21.5	7.8	16.5	5.6	13.5	3.9
Magazines	19.5	5.3	1.5	0.5	1.0	0.3	—	—
Corrugated	9.5	2.6	2.5	0.9	2.5	0.9	2.5	0.7
Other paper	53.0	14.4	58.0	20.9	58.0	19.8	57.0	16.5
Subtotal	**111.0**	**30.1**	**83.5**	**30.1**	**78.0**	**26.6**	**73.0**	**21.1**
Glass beverage containers								
Clear	23.0	6.2	2.5	9.0	51.0	17.4	41.0	11.8
Green	11.0	3.0	9.5	3.4	1.0	0.3	—	—
Brown	30.5	8.3	20.5	7.4	3.0	1.0	2.5	0.7
Subtotal	**64.5**	**17.5**	**55.0**	**19.8**	**55.0**	**18.7**	**43.5**	**12.5**
Other glass								
Clear	19.0	5.2	19.5	7.0	17.0	5.8	19.5	5.6
Green	3.0	0.8	—	—	—	—	4.0	1.2
Brown	1.5	0.4	—	—	5.5	1.9	1.5	0.4
Subtotal	**23.5**	**6.4**	**19.5**	**7.0**	**22.5**	**7.7**	**25.0**	**7.2**
Ferrous beverage containers	**8.5**	**2.3**	**2.0**	**0.7**	**4.0**	**1.4**	**12.0**	**3.5**
Other ferrous	**15.0**	**4.1**	**11.0**	**4.0**	**6.5**	**2.2**	**44.0**	**12.7**
Nonferrous beverage containers	**0.5**	**0.1**	**1.5**	**0.5**	**0.5**	**0.2**	—	—
Other nonferrous	**1.0**	**0.3**	**1.0**	**0.4**	**1.0**	**0.3**	**1.0**	**0.3**
Remaining waste	**144.5**	**39.2**	**104.0**	**37.5**	**126.0**	**42.9**	**148.0**	**42.7**
Total	**368.5**	**100.0**	**277.5**	**100.0**	**293.5**	**100.0**	**346.5**	**100.0**

SOURCE: Resource Planning Associates, Inc.

Exhibit C.p (continued)

Refuse, Summer Season, Somerville

Sample No.	5		6		7		8	
Housing Units Sampled	14		15		13		12	
	Lb	Percent	Lb	Percent	Lb	Percent	Lb	Percent
Paper								
Newsprint	183.5	99.2	252.5	99.0	279.5	79.0	175.0	97.5
Magazines	–	–	–	–	23.0	6.5	–	0
Corrugated	–	–	–	–	6.0	1.7	0.5	0.3
Other paper	1.5	0.8	2.5	1.0	40.5	11.5	4.0	2.2
Subtotal	**185.0**	**100.0**	**255.0**	**100.0**	**349.0**	**98.7**	**179.5**	**100.0**
Glass beverage containers								
Clear								
Green								
Brown								
Subtotal								
Other glass								
Clear								
Green								
Brown								
Subtotal								
Ferrous beverage containers								
Other ferrous								
Nonferrous beverage containers								
Other nonferrous								
Remaining waste					4.5	1.3		
Total	**185.0**	**100.0**	**255.0**	**100.0**	**353.5**	**100.0**	**179.5**	**100.0**

SOURCE: Resource Planning Associates, Inc.

Appendix D

MOISTURE ANALYSIS DATA

Exhibit D.a

Moisture Content-Data Summary*
(Percent H_2O)

Component	Somerville				Marblehead			
	FALL Source-Separated Materials	Refuse	SPRING Source-Separated Materials	Refuse	WINTER Source-Separated Materials	Refuse	SUMMER Source-Separated Materials	Refuse
Newsprint	6.0	21.8	6.6	14.0	9.2	7.8	3.9	8.6
Other paper**	4.5	18.2	11.5	29.8	4.1	14.5	4.6	10.0
Glass beverage containers	0.0	–	–	0.0	0.0	–	0.0	–
Other glass	0.0	–	–	0.1	0.0	–	3.0	–
Ferrous beverage containers	3.6	–	–	6.6	0.1	–	2.2	–
Other ferrous	2.0	–	–	2.8	0.0	–	4.4	–
Nonferrous beverage containers	3.6	–	–	0.6	0.0	–	–	–
Other nonferrous	2.4	–	–	12.8	0.4	–	0.0	–
Remaining waste	17.2	22.9	–	30.9	3.2	22.9	18.1	18.2

SOURCE: Resource Planning Associates, Inc.

* This exhibit lists the results of our laboratory analysis for moisture content for four seasons.
** Includes magazines and corrugated paper.

Moisture Analysis Data Form,
Fall Season, Somerville

Form completed by: Richard Harris

Date: started 10/31/77

Date sample received: 10/31/77

RW - Recycled waste (source-separated materials)
MW - Mixed waste (refuse)

Analysis

Sample name and number	Wet sample weight (g)	Dry sample weight (g)	Weight of moisture loss (g)	Calculated moisture content (percent)	Comments
S-10/25 Label smeared*	1934.9	1573.0	361.5	18.69%	Average Moisture = 18.16% Standard Deviation = 0.92%
S-10/25 Label smeared*	1856.7	1539.2	317.5	17.1%	
S-10/25 Label smeared*	1420.6	1155.0	265.6	18.7%	
Somerville-Non-Ferrous Non-Beverage RW 10/25	1190.6	1162.3	28.3	2.4%	Not used for Heating Value Computation
Somerville-Ferrous Beverage RW 10/25	1162.3	1105.6	56.7	4.88%	Average Moisture = 3.63% Standard Deviation = 1.10% C.V. = 30%
Somerville-Ferrous Beverage RW 10/25	680.4	661.2	19.2	2.82%	
Somerville-Ferrous Beverage RW 10/25	750.2	726.2	24.0	3.2%	
Somerville-Other Paper MW 10/25	2466.4	1899.4	567.0	22.99%	
Somerville Glass-Non Beverage RW 10/25	3373.5	3373.5	-----	<0.1%	Average Moisture = <0.1% Standard Deviation = 0 C.V. = 0
Somerville Glass-Non-Beverage RW 10/25	3061.7	3061.7	-----	<0.1%	

*Later determined to be Somerville-other paper, MW

Exhibit D.b (continued)

Moisture Analysis Data Form, Fall Season, Somerville

Form completed by: Richard Harris

Date: started 10/31/77

Date sample received: 10/31/77

RW - Recycled waste (source-separated materials)
MW - Mixed waste (refuse)

Analysis

Sample name and number	Wet sample weight (g)	Dry sample weight (g)	Weight of moisture loss (g)	Calculated moisture content (percent)	Comments
Somerville News-print MW 10/25	1251.5	959.9	291.6	23.3%	Average Moisture =21.85% Standard Deviation = 1.64% C.V. = 7.5%
Somerville News-print MW 10/25	1475.8	1149.7	326.1	22.1%	
Somerville News-print MW 10/25	1282.3	1024.6	257.7	20.1	
Somerville Newsprint RW 10/25	2182.9	2069.5	113.4	5.20%	Average Moisture = 6.0% Standard Deviation = 1.65% C.V. = 27.5%
Somerville Newsprint RW 10/25	2863.2	2636.5	226.7	7.92	
Somerville Newsprint RW 10/25	1729.3	1644.2	85.1	4.93	
Somerville Glass Beverage RW 10/25	3628.7	3628.7	-----	<0.1	Average Moisture = <0.1% Standard Deviation = 0 C.V. = 0
Somerville Glass Beverage RW 10/25	3231.8	3231.8	-----	<0.1	
Somerville Glass Beverage RW 10/25	2778.2	2778.2	-----	<0.1	
Somerville-Remaining Waste RW 10/25	2069.5	1700.9	368.6	17.81%	Average Moisture = 17.22% Standard Deviation = 1.05% C.V. = 6%
Somerville-Remaining Waste RW 10/25	1190.5	978.0	212.5	17.86%	
Somerville-Remaining Waste RW 10/25	1057.3	888.1	169.1	16.0%	

Exhibit D.b (continued)

Moisture Analysis Data Form, Fall Season, Somerville

Form completed by: Richard Harris

Date: started 10/31/77

Date sample received: 10/31/77

RW - Recycled waste (source-separated materials)
MW - Mixed waste (refuse)

Analysis

Sample name and number	Wet sample weight (g)	Dry sample weight (g)	Weight of moisture loss (g)	Calculated moisture content (percent)	Comments
Somerville-Ferrous Non-Beverage RW 10/25	1474.1	1445.8	28.3	1.92%	Average Moisture = 2.0% Standard Deviation = C.12% C.V. = 6%
Somerville-Ferrous Non-Peverage RW 10/25	1360.8	1332.4	28.4	2.09%	
Somerville-Other Paper RW 10/25	907.2	850.5	56.7	6.25%	Average Moisture = 4.49% Standard Deviation = 1.62% C.V. = 36%
Somerville-Other Paper RW 10/25	935.5	907.2	28.3	3.03%	
Somerville-Other Paper RW 10/25	680.3	651.9	28.4	4.2%	
Somerville-Remaining Waste MW 10/25	1899.4	1417.5	481.9	25.38%	Average Moisture = 22.94% Standard Deviation = 2.18% C.V. = 9%
Somerville-Remaining Waste MW 10/25	1786.0	1389.1	396.9	22.23%	
Somerville-Remaining Waste MW10/25	935.5	737.1	198.4	21.20%	

Exhibit D.c

Moisture Analysis Data Form, Winter Season, Marblehead

Form completed by: Richard Harris

Date: 4/3/78

Date sample received: 2/24/78

Analysis

Sample name and number	Wet sample weight (g)	Dry sample weight (g)	Weight of moisture loss (g)	Calculated moisture content (percent)	Comments
Mixed Refuse	2,352.97	1,559.20	793.77	33.7	Average Moisture = 29.1% Standard Deviation = 3.88% C.V. = 13%
Remaining Waste	1,332.40	1,008.91	323.49	24.2	
2/23	1,445.80	1,020.56	425.24	29.4	
Marblehead	85.05	85.05	------	0	Average Moisture = 0.4% Standard Deviation = 0.56% C.V. = 14.1%
2/23 Recycled	56.70	56.70	------	0	
Non-Ferrous Other	85.05	84.00	1.05	1.20	
Mixed Refuse	368.54	340.19	28.35	7.70	Average Moisture = 7.8% Standard Deviation = 1.19% C.V. = 15.26%
News	283.49	256.79	26.70	9.42	
2/23	113.40	106.00	7.40	6.53	
Marblehead	1,304.05	1,275.71	28.34	2.16	Average Moisture = 3.2% Standard Deviation = 1.6% C.V. = 52.0%
Recycled 2/23	1,020.56	1,001.02	19.54	1.91	
Remaining Waste	510.28	481.93	28.35	5.56	

Exhibit D.c (continued)

Moisture Analysis Data Form, Winter Season, Marblehead

Form completed by: Richard Harris

Date: 4/3/78

Date sample received: 2/24/78

Analysis

Sample name and number	Wet sample weight (g)	Dry sample weight (g)	Weight of moisture loss (g)	Calculated moisture content (percent)	Comments
Recycled	2,296.27	2,296.27	-----	0	Average Moisture = 0% Standard Deviation = 0% C.V. = 0%
2/23	2,154.52	2,154.52	-----	0	
Glass, Other	2,211.22	2,211.22	-----	0	
Marblehead	1,304.05	1,162.31	141.74	10.87	Average Moisture = 9.2% Standard Deviation = 1.81% C.V. = 19.7%
Recycled 2/23	566.98	510.28	56.70	10.01	
News	425.24	396.89	28.35	6.67	
Marblehead	595.33	595.33	-----	0	Average Moisture = 0% Standard Deviation = 0% C.V. = 0%
Recycled 2/23	510.28	510.28	-----	0	
Non-Ferrous Beverage	510.28	510.28	-----	0	
Marblehead	1,020.56	999.22	21.34	2.0	Average Moisture = $<0.1\%$ Standard Deviation = $<0.01\%$ C.V. = $<10\%$
Recycled 2/23	878.82	878.82	-----	0	
Ferrous - Beverage	595.33	595.33	-----	0	

Exhibit D.c (continued)

Moisture Analysis Data Form, Winter Season, Marblehead

Form completed by: Richard Harris

Date: 4/3/78

Date sample received: 2/24/78

Analysis

Sample name and number	Wet sample weight (g)	Dry sample weight (g)	Weight of moisture loss (g)	Calculated moisture content (percent)	Comments
Marblehead	311.84	246.79	65.05	20.86	Average Moisture = 14.5% Standard Deviation = 4.6% C.V. = 32%
Mixed Refuse	566.98	510.28	56.70	10.01	
Other Paper 2/23	453.58	396.89	56.69	12.50	
Marblehead	1,389.10	1,389.10	-----	0	Average Moisture = 0% Standard Deviation = 0% C.V. = 0%
Recycled 2/23	1,672.59	1,672.59	-----	0	
Ferrous - Other	1,190.66	1,190.66	-----	0	
Recycled	2,381.32	2,381.32	-----	0	Average Moisture = 0% Standard Deviation = 0% C.V. = 0%
2/23	1,474.15	1,474.15	-----	0	
Beverage - Glass	963.87	963.87	-----	0	
Marblehead	301.80	283.49	18.31	6.60	Average Moisture = 4.1% Standard Deviation = 1.4% C.V. = 34.3%
Paper - Other	1,105.61	1,077.26	28.35	2.69	
2/23	737.07	708.73	28.34	3.84	

Exhibit D.d

Moisture Analysis Data Form, Spring Season, Somerville

Form completed by: Richard Harris

Date: 6/23/78

Date sample received: 5/11/78

Analysis

Sample name and number	Wet sample weight (g)	Dry sample weight (g)	Weight of moisture loss (g)	Calculated moisture content (percent)	Comments
Other Non Ferrous	765.42	680.38	85.04	11.11	Average Moisture = 12.81% Standard Deviation = 1.29% C.V. = 10%
Refuse	652.03	566.98	85.05	13.04	
	369.89	340.19	56.70	14.29	
Other Paper	425.24	285.14	140.10	32.96	Average Moisture = 29.76% Standard Deviation = 4.76% C.V. = 16%
Refuse	737.07	566.98	170.09	23.08	
	425.24	283.49	141.75	33.33	
Non Ferrous Beverage	230.14	226.79	3.35	1.70	Average Moisture = 0.57% Standard Deviation = 0.73% C.V. = 140%
Refuse	198.44	198.44	-----	0	
	198.44	198.44	-----	0	
Other Paper	301.84	265.14	36.70	12.19	Average Moisture = 11.54% Standard Deviation = 1.85% C.V. = 16%
Recovered Materials	311.84	283.49	28.35	9.09	
	425.24	368.54	56.70	13.33	

Exhibit D.d (continued)

Moisture Analysis Data Form, Spring Season, Somerville

Form completed by: Richard Harris

Date: 6/23/78

Date sample received: 5/11/78

Analysis

Sample name and number	Wet sample weight (g)	Dry sample weight (g)	Weight of moisture loss (g)	Calculated moisture content (percent)	Comments
Other Ferrous Recovered Materials	56.70	56.70	------	0	Average Moisture = 0 Standard Deviation = 0 C.V. = 0
	56.70	56.70	------	0	
	28.35	28.35	------	0	
Other Ferrous Refuse	1162.31	1133.96	28.35	2.44	Average Moisture = 2.76% Standard Deviation = 0.36% C.V. = 13%
	907.17	878.82	28.35	3.13	
	680.38	662.03	18.35	2.70	
Newsprint Refuse	566.98	481.93	85.05	15.00	Average Moisture = 14.01% Standard Deviation = 2.10% C.V. = 15%
	510.28	453.58	56.70	11.11	
	471.93	396.89	75.04	15.93	

Exhibit D.d (continued)

Moisture Analysis Data Form, Spring Season, Somerville

Form completed by: Richard Harris

Date: 6/23/78

Date sample received: 5/11/78

Analysis

Sample name and number	Wet sample weight (g)	Dry sample weight (g)	Weight of moisture loss (g)	Calculated moisture content (percent)	Comments
Glass Beverage Refuse	2891.60	2891.60	-----	0	Average Moisture = 0 Standard Deviation = 0 C.V. = 0
	2494.71	2494.71	-----	0	
	2296.27	2296.27	-----	0	
Remaining Waste Refuse	1871.03	1417.45	453.58	24.75	Average Moisture = 30.91% Standard Deviation = 4.80% C.V. = 16%
	1359.20	953.52	423.28	31.14	
	1615.89	1020.56	595.33	36.84	
Other Glass Refuse	1984.43	1984.43	------	0	Average Moisture = 0.12% Standard Deviation = 0.17% C.V. = 141%
	2296.27	2287.92	8.35	0.36	
	1842.69	1842.69	------	0	

Exhibit D.d (continued)

Moisture Analysis Data Form, Spring Season, Somerville

Form completed by: Richard Harris

Date: 6/23/78

Date sample received: 5/11/78

Analysis

Sample name and number	Wet sample weight (g)	Dry sample weight (g)	Weight of moisture loss (g)	Calculated moisture content (percent)	Comments
Newsprint Refuse	273.49	255.14	18.35	6.72	Average Moisture = 6.59% Standard Deviation = 0.53% C.V. = 8%
	481.93	453.58	28.35	5.90	
	396.89	368.54	28.35	7.14	
Ferrous Beverage Refuse	935.52	935.52	-----	0	Average Moisture = 0 Standard Deviation = 0 C.V. = 0
	538.63	538.63	-----	0	
	595.33	595.33	-----	0	

Exhibit D.e

Moisture Analysis Data Form, Summer Season, Marblehead

Form completed by: R. Harris

Date: 9/6/78

Date sample received: 7/21/78

Analysis

Sample name and number	Wet sample weight (g)	Dry sample weight (g)	Weight of moisture loss (g)	Calculated moisture content (percent)	Comments
Mixed News	680.37	625.32	55.05	8.09	Average Moisture = 8.6% Standard Deviation = 1.1% C.V. = 12%
Mixed News	852.47	775.42	65.05	7.63	
Mixed News	453.58	406.88	46.70	10.15	
Mixed Remaining	510.28	425.23	85.05	16.67	Average Moisture = 18.16% Standard Deviation = 1.1% C.V. = 5.8%
Mixed Remaining	907.16	737.07	170.09	18.75	
Mixed Remaining	595.32	481.93	113.39	19.05	
Recycled Remaining	1105.61	907.17	198.44	17.95	Average Moisture = 18.153% Standard Deviation = 3.24% C.V. = 17.85%
Recycled Remaining	1020.56	793.77	226.79	22.22	
Recycled Remaining	595.33	510.28	85.05	14.29	
Recycled Ferrous Bev.	595.32	576.98	18.34	3.08	Average Moisture = 2.21% Standard Deviation = 0.65% C.V. = 29%
Beer Cans	510.28	500.00	10.28	2.02	
	396.18	390.10	6.08	1.53	

Exhibit D.e (continued)

Moisture Analysis Data Form, Summer Season, Marblehead

Form completed by: R. Harris

Date: 9/6/78

Date sample received: 7/21/78

Analysis

Sample name and number	Wet sample weight (g)	Dry sample weight (g)	Weight of moisture loss (g)	Calculated moisture content (percent)	Comments
Recycled News	1020.56	982.22	38.34	3.76	Average Moisture = 3.89% Standard Deviation = 0.1% C.V. = 2.56%
Recycled News	1389.10	1332.40	56.70	4.08	
Recycled News	850.47	817.12	33.35	3.92	
Recycled Glass Bev.	1842.69	1842.69	-----	----	Average Moisture = 0 Standard Deviation = 0 C.V. = 0
Recycled Glass Bev.	1502.50	1502.50	-----	----	
Recycled Glass Bev.	878.82	878.82	-----	----	
Recycled Glass Other	1672.89	1615.89	56.70	3.39	Average Moisture = 3.0% Standard Deviation = 0.38% C.V. = 12.8%
Recycled Glass Other	1559.20	1509.00	50.20	3.22	
Recycled Glass Other	1332.40	1294.05	38.35	2.5	
Recycled Ferrous Bev.	425.24	425.24	-----	----	Average Moisture = 0 Standard Deviation = 0 C.V. = 0
Recycled Ferrous Bev.	368.54	368.54	-----	----	
Recycled Ferrous Bev.	255.14	255.14	-----	----	

Exhibit D.e (continued)

Moisture Analysis Data Form, Summer Season, Marblehead

Form completed by: R. Harris

Date: 9/6/78

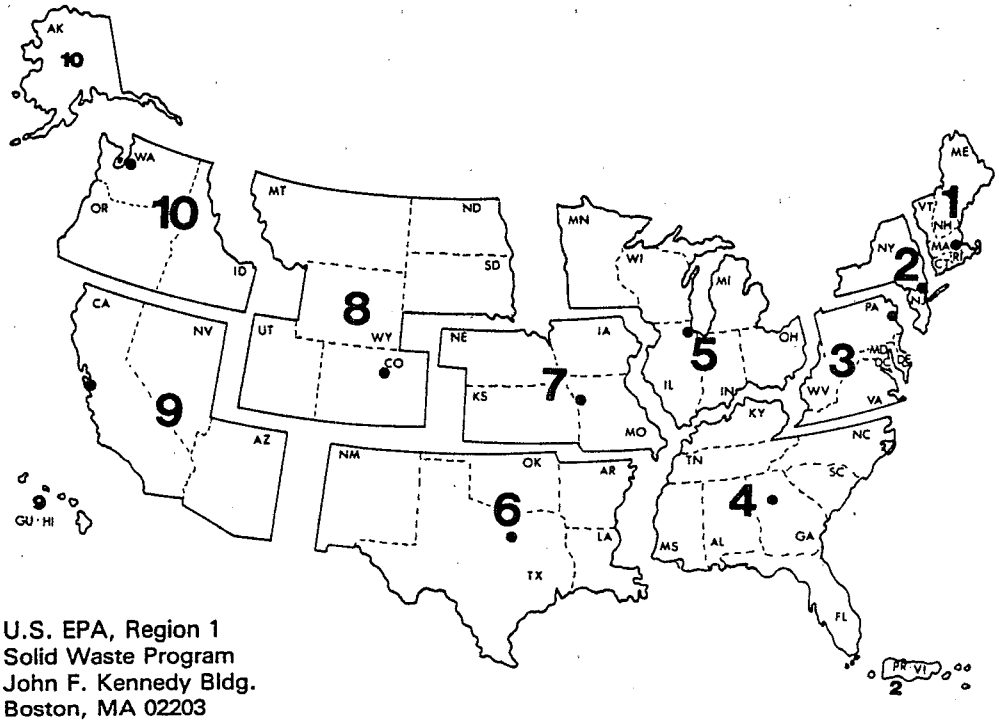
Date sample received: 7/21/78

Analysis

Sample name and number	Wet sample weight (g)	Dry sample weight (g)	Weight of moisture loss (g)	Calculated moisture content (percent)	Comments
Recycled Non-Ferrous Other	113.40	113.40	----	----	Average Moisture = 0 Standard Deviation = 0 C.V. = 0
	85.05	85.05	----	----	
	56.70	56.70	----	----	
Recycled Paper Other	1020.56	972.22	48.34	4.74	Average Moisture = 4.6% Standard Deviation = 0.38% C.V. = 8.34%
Recycled Paper Other	1389.10	1332.40	56.70	4.08	
Recycled Paper Other	1065.30	1012.20	53.10	4.99	
Recycled Ferrous Other	1360.75	1302.40	58.35	4.29	Average Moisture = 4.37% Standard Deviation = 0.27% C.V. = 6.3%
Recycled Ferrous Other	963.87	963.87	-----	----	
Recycled Ferrous Other	907.17	907.17	-----	----	
Mixed Paper (label smeared)	725.0	638.1	86.90	12.9	Average Moisture = 10.0% Standard Deviation = 1.328% C.V. = 13.29%
	681.7	619.2	62.5	9.17	
	720.3	655.4	64.9	9.0	

ra1882.2
SW-823

EPA REGIONS



U.S. EPA, Region 1
Solid Waste Program
John F. Kennedy Bldg.
Boston, MA 02203
617-223-5775

U.S. EPA, Region 2
Solid Waste Section
26 Federal Plaza
New York, NY 10007
212-264-0503

U.S. EPA, Region 3
Solid Waste Program
6th and Walnut Sts.
Philadelphia, PA 19106
215-597-9377

U.S. EPA, Region 4
Solid Waste Program
345 Courtland St., N.E.
Altanta, GA 30308
404-881-3016

U.S. EPA, Region 5
Solid Waste Program
230 South Dearborn St.
Chicago, IL 60604
312-353-2197

U.S. EPA, Region 6
Solid Waste Section
1201 Elm St.
Dallas, TX 75270
214-767-2734

U.S. EPA, Region 7
Solid Waste Section
1735 Baltimore Ave.
Kansas City, MO 64108
816-374-3307

U.S. EPA, Region 8
Solid Waste Section
1860 Lincoln St.
Denver, CO 80295
303-837-2221

U.S. EPA, Region 9
Solid Waste Program
215 Fremont St.
San Francisco, CA 94105
415-556-4606

U.S. EPA, Region 10
Solid Waste Program
1200 6th Ave.
Seattle, WA 98101
206-442-1260