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A SOLID WASTE ESTIMATION PROCEDURE: MATERIAL FLOWS APPROACH

by Fred L. Smith, Jr.*

Introduction and Background

Those who formulate policy for managing the Nation's solid waste need to know how much of it there is and what it consists of. This paper will estimate the quantity of household and commercial solid waste for 1971 by material and product source. The methodology for achieving this estimate is based on production and marketing statistics for both products and materials. The data and assumptions used to obtain these results are shown in appendices.

There are two ways to estimate waste quantities and compositions. The first, an output approach, is to examine or measure the solid waste (discard stream). The second, an input approach, is to analyze the flow of materials and products produced and consumed. Most existing estimates of solid waste quantities and composition were obtained through the former approach: by weighing and separating refuse at the disposal site. Estimates based on production and marketing data are less common.+

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+This is not the first such effort. The Midwest Research Institute (MRI) pioneered in estimating waste from material flow data in a series of OSWMP funded reports: The Role of Packaging in Solid Waste Management,[1] (1969); The Role of Nonpackaging Paper in Solid Waste Management,[2] (1971); Salvage Markets for Materials in Solid Wastes,[3] (1972). Resource Planning Associates, Inc. used an approach similar to that presented in this paper in their report, Potential Economic Value of the Municipal Solid Waste Stream,[4] (1972), prepared for the National Center for Resource Recovery. Two contracts performed for EPA by the URS Research Company conceptualized perhaps the most sophisticated production-oriented estimation approach: Methods of Predicting Solid Waste Characteristics,[5] (1971); A Planning Model for the Prediction of Residential and Commercial Solid Wastes,[6] (1972).

The results of a sampling approach are generally specific to the time and place of the sample and, thus, cannot readily be extrapolated. Also, since solid waste is generated by numerous household and commercial sources (apartment buildings, single family homes, drug stores, supermarkets, etc.), a representative sample of all such sources would have to be very large. Most sampling has been restricted to residential waste and provides little information on non-residential municipal waste.

In principle, a material flow approach, based on production and marketing statistics, avoids many of these problems. Attention is given to the material and product categories involved in solid waste rather than to the sources of solid waste. Since production and marketing statistics are regularly collected and published, subsequent estimates require far less effort once the initial methodology has been developed.

A disadvantage of a material flow approach is that you may leave out or incorrectly estimate a waste category, such as lawn waste, that does not pass through the production sector. The two approaches applied in tandem can be used to cross-check each other and should yield a more accurate representation of the waste stream.

Definition and Scope

"Solid waste" refers to everything from the tailings of mine operations to discarded cans. Indeed, solid waste can be defined as: all non-gaseous, non-liquid by-products of production and consumption that, at the time and place of discard, have no economic value. Solid waste thus includes agricultural and forestry residue, animal manure, as well as fly ash, rejected output, slag, and sludge generated in refining, production, and converting operations. Solid waste also includes the dredging spoils generated in waterway maintenance, the debris from construction and demolition operations, and the sludge produced in water and waste treatment operations. Many of these wastes are thought to be large, but data are very limited and widely scattered.

The paper estimates the fraction of solid waste that is most noticeable to the public and that poses the most immediate problem to municipalities: the household and commercial fraction. (The commercial fraction here refers to the waste generated by institutions, business establishments, and other offices.) The following categories are excluded from this discussion: (1) industrial processing waste; (2) construction or demolition waste; (3) street sweepings (except littered product-type waste); (4) heavy or bulky tree and landscape waste (other than lawn-trimming waste accepted in ordinary collection); (5) automobile waste (except tires); (6) sewage sludge.

Since our concern here is with the waste generated by the household and commercial fraction, we will consider the following product end-use categories: newspapers, books, and magazines; containers and packaging; major household appliances; furniture and furnishings; clothing and footwear; other household and commercial products. All materials used in one or more of these product categories will be examined. These include paper, glass, aluminum, iron and steel, other nonferrous metals, plastics, rubber and leather, textiles, and wood. The waste generation estimates are cross-classified by both material and product category. Additional categories--food waste, yard waste, and miscellaneous inorganics--are also included in the household/commercial waste stream and will be discussed later.

METHODOLOGY

The methodology used in making these waste generation estimates is a hybrid one in which the production, or material, flow approach is used to estimate the non-food product solid waste. Food, yard, and miscellaneous non-product wastes are estimated from these results, as well as from data on waste composition. A final adjustment to these estimates is needed to account for the variability introduced by moisture.

Product Waste Categories

The material flow approach requires one to first consider the total production of each raw material and then to systematically trace each material through the production system to its final use in one or more of the product categories, which appear in residential or commercial solid waste. The precise steps in this process differ according to the particular material and product category under consideration.* However, in general, an attempt was made to carry out the following steps:

(1) Production data were obtained for each selected material and were adjusted for imports and exports in order to obtain estimates of apparent domestic "consumption". These statistics are generally reported as apparent bulk consumption e.g., millions of tons of steel, thousands of board feet of lumber, etc;

(2) Apparent consumption of each material was then allotted to each product category e.g., steel consumed in major appliances and wood consumed in packaging;

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*A complete treatment of each basic material is presented in the Appendices.

(3) The raw material quantities for each product category were reduced to include processing losses, and the resulting estimates were adjusted for imports and exports to obtain estimates of the apparent consumption of the finished products;

(4) The estimated quantities of materials consumed in each product category were then adjusted to include any losses in use or diversions from the solid waste stream to obtain an estimate of potential solid waste;*

(5) A time-lag between consumption and discard was introduced where appropriate to account for the durability of various finished products (e.g. furniture and appliances);

(6) For each product material category, potential solid waste was adjusted to account for the quantity of material recovered through recycling;

(7) The resulting final waste disposal estimates for each material and product category were then summed to obtain net product-related solid waste generation.

In order to use this methodology for any specific material, such as paper or aluminum, extensive data must be available from either governmental or industrial sources. Moreover, the estimator must be familiar with the reporting conventions and production stages of that industry. For most materials, there are several processing and distribution steps between bulk raw material production and final goods consumption. Even when data are available for each stage of production, only a fraction of the tonnage involved at any stage of processing may be reported, or the level of detail may make it difficult to distinguish consumption by product category. Moreover, the units of measurement and categories used at one stage are often difficult to reconcile with those used at the next. For example, to trace the amount of wood consumed in making plywood boxes, one finds the data reported successively in board feet of timber, square feet of plywood, and finally, thousands of boxes. Given such problems, tracing material flows requires that the estimator be familiar with both the materials and the products involved.

Our lack of detailed working knowledge of some of the materials under consideration (e.g. nonferrous metals and plastics) and our inability to locate a comprehensive set of production and material flow statistics for some commodities (e.g. glass and leather) forced us sometimes to stray from our methodology. Indeed, for certain materials, our actual estimation procedure resembled the assembly of a jigsaw or crossword puzzle more than the logical tracing-out of material flows,

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*Examples of such adjustments are the exclusion of toilet tissue which is discarded as sewage and of cigarette paper which is dissipated in use.

as described above. The details of our actual calculations for each material are described in the appropriate Appendix.

The upper portion of Table 1 ("as generated" column) summarizes the results of these material flow calculations and provides a breakdown by material and product end-use. Non-food product waste was estimated at 77.1 million tons in 1971. These results will be discussed in a subsequent section of this paper.

Food, Yard, and Other Miscellaneous Inorganic Waste

As mentioned earlier, the household and commercial waste stream is not restricted to product-type waste. Food waste, yard waste, and miscellaneous inorganics (largely dirt and stones) also constitute important waste fractions. This waste is not readily estimated by means of a material flow analysis , and, thus, necessitates an indirect estimation approach: the compositions of collected solid waste samples. Such an approach poses difficulties. We must rely on physical samples of the solid waste stream, which are limited in terms of the number of sources included. Moreover, such samples vary widely in their results. Interpreting and comparing the samples is difficult due to the failure of most sampling studies to report whose waste was sampled (e.g. residential, commercial/ manufacturing, commercial/retailing) and what the moisture content of each waste component was. Also, the material or product categories used for reporting the waste composition vary from study to study.. Finally, most samples fail to account for major compositional differences by region and season.

A composition study prepared by Niessen and Chansky was judged to suffer least from the limitations described above.[7] Their work compared a large number of composition studies and attempted to aggregate them in order to represent the "average municipal solid waste composition" for a number of representative situations. Their figures were the basis for calculations of food and yard waste (Table 2). As shown, food, yard, and miscellaneous inorganics are estimated to represent respectively 18.7, 20.4, and 1.6 percent of the residential and commercial municipal post-consumer solid waste stream.

Our product waste estimate of 77.1 million tons includes major appliances, furniture, and tires. However, it is likely that the Niessen and Chansky results excluded such bulky waste. No precise information exists on the product content of the waste streams they considered, and a sofa or a refrigerator would introduce a large element of variability into any reasonably size sampling efforts. Therefore, before proceeding to estimate the remaining fraction of municipal post-consumer waste, we reduced the 77.1-million-ton estimate to exclude bulky waste. Bulky

TABLE 1

MATERIAL FLOW ESTIMATES OF RESIDENTIAL AND COMMERCIAL SOLID WASTE GENERATION, BY KIND OF MATERIAL AND PRODUCT - SOURCE CATEGORY, 1971*

Kinds of Materials	Product Source Categories "As Generated" Weight Basis (10^6 Tons)						Material Totals					
							"As Generated" Basis			"As Disposed" Basis		
	Newspapers, books, and magazines	Containers and Packaging	Mayor Household Appliances	Furniture & Furnishings	Clothing & Footware	Other Products	10^6 Tons	Lb/Cap/Day+	Per-cent	10^6 Tons	Lb/Cap/Day+	Per-cent
Paper	10.3	20.4	---	tr.	tr.	8.4		1.034	31.3	47.3	1.252	37.8
Glass	----	11.1	tr.	tr.	---	1.0	12.1	0.320	9.7	12.5	0.331	10.0
Metals	----	6.1	1.9	0.1	tr.	3.8	11.9	0.314	9.5	12.6	0.334	10.1
Ferrous	----	5.4	1.7	tr.	---	3.5	10.6	0.281	8.5			
Aluminum	----	0.6	0.1	tr.	000	0.1	0.8	0.021	0.6			
Other Nonferrous	----	0.1	0.1	tr.	---	0.2	0.4	0.041	0.3			
Plastics	tr.	2.5		0.1	0.2	1.3	4.2	0.111	3.4	4.7	0.124	3.8
Rubber & Leather	----	tr.		tr.	0.5	2.7	3.3	0.087	2.6	3.4	0.090	2.7
Textiles	tr.	tr.	---	0.6	0.5	0.7	1.8	0.048	1.4	2.0	0.053	1.6
Wood	----	1.8	---	2.3	tr.	0.5	4.6	0.122	3.7	4.6	0.122	3.7
Non-Food Product Totals	10.3	41.9	2.1	3.2	1.2	8.4	77.1	2.040	61.7	87.2	2.308	69.7
Food Waste							22.0	0.582	17.6	17.7	0.469	14.2
PRODUCT TOTALS, INCL. FOOD							99.1	2.623	79.3	104.9	2.777	83.9
Yard Waste							24.1	0.638	19.3	18.2	.482	14.6
Misc. Inorganics							1.8	0.048	1.4	1.9	.050	1.5
TOTAL WASTE							125.0	3.308	100.0	125.0	3.308	100.0

*Smith, F. A., F. L. Smith, Resource Recovery Division, Office of Solid Waste Management Programs, Sept. 1973.
+Based on a population of 207 million.

TABLE 2

ANNUAL AVERAGE ESTIMATED
MUNICIPAL REFUSE COMPOSITION*
FOR A SEMI-SEASONAL STATE IN 1970+

Refuse Category	Percentage
Paper	35.8
Glass	8.4
Metal	8.2
Plastics	1.3
Leather, rubber	1.4
Textiles	1.9
Wood	2.3
Non-food Product Total	59.3
Food Waste	18.7
Yard Waste	20.4
Miscellaneous	1.6
Total	100.0

*This composition is representative of residential and commercial waste excluding bulky waste.

+Niessen, W. R., and S. H. Chansky. The nature of refuse. In Proceedings; 1970 National Incinerator Conference, Cincinnati, May 17-20, 1970. New York, American Society of Mechanical Engineers. p.14.

waste is assumed to include: major household appliances (2.1 million tons); furniture and furnishings (3.2 million tons); rubber tires (1.7 million tons) (Table 1). These exclusions amount to 7.0 million tons and result in an estimate of 70.1 million tons for "non-bulky" product waste, which represents 59.3 percent of the total municipal post-consumer waste stream according to the Niessen and Chansky study.

Using this procedure, we estimate 22.0 million tons of food waste, 24.1 million tons of yard waste, and 1.8 million tons of miscellaneous inorganic waste. (These statistics are shown in the lower portion of Table 1.)

Moisture Adjustments

An additional refinement was the adjustment of the moisture levels in the various waste stream components to reflect the moisture transfer occurring during storage and collection. For example, paper is discarded on an air-dry basis of about 7 percent moisture, but will generally be measured in composition surveys after it has become a part of mixed refuse and has gained moisture. Niessen and Chansky have estimated both the "as-discarded" and "as-disposed" moisture content of each category (Table 3).[7] Using these figures, the "as-disposed" results shown in the right-hand columns of Table 1 were calculated. These composition percentages correspond more closely to those typically reported in the literature.

DISCUSSION OF RESULTS

The total annual waste generation estimate of 125 million tons per year in 1971 amounts to 3.3 pounds per person per day, assuming a 1971 population of 207 million. This per capita rate is significantly lower than the widely-quoted 190 million tons per year or 5.3 pounds per person per day result that was assumed to hold in 1967. This result was estimated from the 1968 National Survey of Community Solid Waste Practices.[8] Almost two-thirds of this difference is directly explained by the fact that the National Survey included some industrial, demolition, construction, and municipal waste types which are excluded from the present estimates. The National Survey may also have overestimated the household and commercial components of the National solid waste stream. In this regard, it should be noted that, instead of using systematic measurements, the National Survey results were principally based on the estimates of collected tonnage which were prepared by local solid waste agencies.*

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*The difference between various waste generation estimates has been analyzed and discussed in the following report: Smith, F.A. Comparative estimates of post-consumer solid waste. Environmental Protection Publication SW-148. Washington, U.S. Environmental Protection Agency, 1975. 18 p.

TABLE 3

ASSUMED PERCENTAGES MOISTURE CONTENT OF MATERIALS IN MUNICIPAL SOLID WASTE*

	"As Discarded"	"As Disposed"
Paper	7.0	23.1
Glass	0	3.0
Metals	0	5.5
Plastics	2.0	13.0
Rubber and Leather	2.0	13.0
Textiles	7.0	20.0
Wood	15.0	15.0
Food	70.0	63.0
Yard	50.0	34.0
Miscellaneous	2.0	4.0
Weighted Average	0.27	0.27

*Niessen, W. R., and S. H. Chansky. The nature of refuse. In Proceedings; 1970 National Incinerator Conference, Cincinnati, May 17-20, 1970. New York, American Society of Mechanical Engineers. p.14.

Based on the "as-generated" estimates presented in Table 1, several pertinent characteristics of post-consumer solid waste can be inferred. First, 80 percent of the waste stream is organic (including synthetics), and 20 percent inorganic (9.7 percent glass, 9.5 percent metals, 1.4 percent miscellaneous inorganics). Second, of the material fractions recoverable as materials (recyclable), only the paper, glass, and ferrous fractions comprise more than 8 percent of the total municipal post-consumer waste stream. The other individual recyclable materials, taken together, comprise less than 4 percent of the total. Third, about 25 percent of the total weight of municipal post-consumer solid waste is moisture, which originates principally in the food and yard waste fractions.

According to present estimates based on percentage composition studies, about 80 percent of "as-generated" solid waste is derived from market-product sources (as opposed to yard-and garden-type waste). If we exclude food waste, product waste still accounts for about 60 percent of the waste generation. Also, roughly 80 percent of the weight of typical raw municipal refuse is composed of combustible materials.

Container and packaging materials currently contribute about one-third of total post-consumer waste, 42 percent of total product-derived waste, and 54 percent of non-food product waste. The container and packaging fraction currently accounts for about 72 percent of the total mineral (combined glass and metals) fraction. In terms of individual materials, this source category contributes well over 90 percent of the glass, 75 percent of the aluminum, and at least 45 to 55 percent of each of the ferrous metal, paper, and plastic fractions of the municipal post-consumer waste stream. Consumer durable goods, including household appliances, furniture, recreational equipment and the like, account for about 10 to 12 percent of total waste. Newspapers, books and magazines account for about 8 percent.

REFERENCES

1. Darnay, A., and W. E. Franklin. The role of packaging in solid management, 1966 to 1976. Public Health Service Publication No. 1855. Washington, U.S. Government Printing Office, 1969. 205 p.

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4. Resource Planning Associates, Inc. Potential economic value of the municipal solid waste stream. Washington, National Center for Resource Recovery, Inc., September 1972. 19 p.

5. Boyd, G. B., and M. B. Hawkins. Methods of predicting solid waste characteristics. Environmental Protection Publication SW-23c. Washington, U.S. Government Printing Office, 1971. 28 p.

6. Black, R. H., R. R. Fiedler, M. B. Hawkins, and P. O. Strom. A planning model for the prediction of residential and commercial solid wastes; final report. San Mateo, California, Urs Research Company, 1972. 46 p., app.

7. Niessen, W. R. and S. H. Chansky. The nature of refuse. In Proceedings; 1970 National Incinerator Conference, Cincinnati, May 17-20, 1970. New York, American Society of Mechanical Engineers. p. 1-24.

8. Black, R. J., A. J. Muhich, A. J. Klee, H. L. Hickman, Jr., and R. D. Vaughan. The national solid wastes survey; an interim report. [Cincinnati], U.S. Department of Health, Education, and Welfare, 1968. 53 p.

APPENDICES A-I

These appendices present detailed calculations for the waste generation estimates for each material category.

APPENDIX A

Aluminum

Since aluminum discards by product category had already been estimated in a previous report for EPA,[1] material flow tracing for aluminum from production through product end-use was not conducted by EPA (except for containers).

The end-use data obtained from this report are summarized in Table A-1 along with EPA extrapolations. Separate data on aluminum consumed in the container and packaging area were obtained from the Aluminum Association (Table A-2).

In total, .8 million tons of aluminum are in the household and commercial waste stream. The quantities of aluminum discarded from each end-use are as follows: packaging and containers, .6 million tons; major appliances, .2 million tons. These are the results reported in Tables A-1 and A-2.

TABLE A-1

ALUMINUM IN THE WASTE STREAM
(000 tons)

End-Use Category	(A) Est. Quantities Becoming Obsolete in 1969*	(B) Est. Quantity Recycled-1969+	(C) Solid Waste 1969	(D) Fraction in HH/Comm Waste‡	(E) Total 1969 HH/Comm Waste	(F) Annual Expansion Factors‡	(G) Total Est. 1971 HH/Comm Waste
Building & Construction	71	9	62	0	0	-	-
Transportation	329	100	229	0	0	-	-
Consumer Durables	197	25	172	1.0	172	1.03	182
Electrical	7	6	1	0	0	-	-
Machinery & Equipment	61	15	46	0	0	-	-
Container & Packaging	486	2	484	1.0	484	1.14	629
Other	183	18	15	.1	2	1.03	2
Total	1,334	175	1,159		658		813

*Battelle Memorial Institute, Columbus Laboratories. A study to identify opportunities for increased solid waste utilization. v.2. Aluminum report. Environmental Protection Publication SW-40d.2. U.S. Environmental Protection Agency, 1972. Appendix B. (Distributed by National Technical Information Service, Springfield, Va., as PB-212 730.)

+Battelle Memorial Institute, Study to identify opportunities for increased utilization, Table 13.

‡EPA estimates.

TABLE A-2

ALUMINUM CONTAINER AND PACKAGING WASTE - 1971
(000 Tons)

Shipments to Container and Packaging Market*	758
Converting losses @ 0.15+	114
Net consumer purchases and discards	664

*Aluminum statistical review, 1971. New York, Aluminum Association.
+EPA estimate.

REFERENCE FOR APPENDIX A

1. Battelle Memorial Institute, Columbus Laboratories. A study to identify opportunities for increased solid waste utilization. v.2. Aluminum report. v.3. Copper report. v.4. Lead report. v.5. Zinc report. v.6. Nickel and stainless steel report. v.7. Precious metals report. Environmental Protection Publication SW-40d.2. U.S. Environmental Protection Agency, 1972. 608 p. (Distributed by National Technical Information Service, Springfield, Va., as PB-212 730.)

APPENDIX B

Glass

Glass consumption is divided into the major categories shown in Table B-1. The categories likely to enter the household and municipal solid waste stream include containers, table and houseware glass, and electronic glassware. A fraction of flat glass also enters through normal breakage.

Statistics on glass consumed for containers are generally measured after fabrication. Thus, the only loss would be from breakage in transit, and this is assumed to be negligible. Time series for container glass consumption are presented in the Glass Container Manufacturer's Institute (GCMI) Annual Reports. No production series for flat and pressed/blown glass categories were found.

Consumption and discards of container glass is estimated at 11.1 million tons for 1971.[1] Although no source of data for the flat and pressed/blown glass categories was available, a previous EPA report estimated that glass waste from these categories in 1967 was 1.0 million tons.[2, p. 71-1] For lack of better data, this figure was used as a base. No expansion for growth was considered, although the actual 1971 waste is probably somewhat higher. Total glass waste is estimated at 12.1 million tons, of which container and packaging consume 11.1 million tons with other products consuming the remaining 1.0 million tons.

TABLE B-1

GLASS CONSUMPTION CATEGORIES

Category	Uses
Containers	Soft drinks, beer, food
Pressed and Blown	
Table & Houseware, Decorative	Dishes
Electronic Glassware	Light bulbs
Insulation Glass	Appliance & House Insulation
Flat Glass	
Window Glass	Windows
Float Glass	Windows
Laminated Glass	Automobile Glass

REFERENCES FOR APPENDIX B

1. Glass containers; 1972/73. Washington, Glass Container Manufacturers Institute, 1973.

2. Darnay, A., and W. E. Franklin. Salvage markets for materials in solid wastes. Environmental Protection Publication SW-29c. Washington, U.S. Government Printing Office, 1972. Figure 21. Approximate glass industry material flows, 1967.

APPENDIX C

Iron and Steel Products

Since most iron and steel products have long lifetimes, the used production statistics to estimate the amount of ferrous material that will be discarded annually poses a major problem. Therefore, an estimate of waste for any one year requires that the lifetime of each major product category using ferrous material be estimated and that production data for past years corresponding to that lifetime be obtained.

Another chronic problem is that production statistics are collected at the bulk commodity shipment point. Thus, consumption of iron and steel has to be adjusted to account for the loss of scrap from fabricating and conversion operations. One special problem, unique in the steel industry, is that much bulk production is reported as "consumed" by distribution centers which receive steel in various shapes and forms and then retail it to miscellaneous small metal-working establishments. The end-use as well as the nature of the waste problem cannot be determined without a detailed study of the markets served. To our knowledge, no such study has been performed.

For these reasons, the waste estimates in our analysis are not based on the extensive annual series reported by the American Iron and Steel Institute in their Annual Statistical Report. Rather, we relied on a Battelle Memorial Institute report prepared for EPA, which attempted to estimate the quantity of ferrous materials that entered the waste stream in 1970.[1]

Portions of this data are reproduced in Table C-1. It is assumed that the steel categories most likely to be found in the residential and commercial solid waste stream are consumer durables and containers. For lack of better data, it is also assumed that 1.9 million tons of miscellaneous ferrous waste finds its way into this solid waste stream (Table C-1). Thus, a rough estimate of total residential and commercial ferrous solid waste from non-automotive sources in 1971 is 11.4 million tons (Table C-1). It is assumed that no iron and steel castings are included in household and commercial solid waste.

More complete data were available for the packaging waste category, and an improved waste estimate for this category was possible. Using shipments by steel mills as an approximation for consumption by the container industry, the situation is shown in Table C-2. It is assumed that only a small portion of packaging materials other than cans and closures enters the household and commercial waste stream. (These adjustments are shown in the table.) The resulting 5.4 million tons is our packaging waste figure.

TABLE C-1

FERROUS MATERIALS
IN
HOUSEHOLD/COMMERCIAL SOLID WASTE*

	Bulk Consumption		Conversion	1970		1971
	Time Period	Tonnage (000 Tons)	Losses‡ (000 Tons)	Ferrous Waste (000 Tons)	Expansion Factor	Ferrous Waste (000 Tons)
Consumer Durables	1954-1956	4000	800	3200	1.03	3300
Containers	1969-1970	7400	1500	5900	1.05	6200
Miscellaneous+	1949-1951	2200	400	1800	1.03	1900

*Regan, W. J., R. W. James, and T. J. McLeer. Identification of opportunities for increased recycling of ferrous solid waste. U.S. Environmental Protection Agency, 1972. 391 p. (Distributed by National Technical Information Service, Springfield, Va., as PB-213 577.) Table IV-26.

+This row is determined by taking 10 percent of the "All Other" category in Table IV-26 of the report.

‡Conversion losses are assumed to be 20 percent of production.

TABLE C-2

FERROUS PACKAGING WASTE - 1971
(000 Tons)

	Shipments*	Less Converting Loss+	Less Diverting Fraction‡
Cans and Closures	5808	5111	5111
Barrels, Drums and Shipping Pails	732	644	129
All Other	672	591	118
TOTALS	7212	6346	5358

*Annual statistical report, 1971. Washington, American Iron and Steel Institute, 1972. p.26.

+Converting losses are assumed to be 12 percent of bulk consumption.

‡All cans and closures are assumed to enter the designated waste stream; however, only 20 percent of the other categories are assumed to do so.

Ferrous waste, attributable to major household appliances (1.7 million tons), was calculated from data presented in a National Industrial Pollution Control Council report.[2] (This figure is reported separately in the body of this report.)

A residual category of ferrous waste, referred to as "other" waste, was calculated by subtracting the 1.7 million tons of waste of major household appliances from the consumer durables category in Table C-1 and then adding this figure to the miscellaneous category in this table.

To conclude, the residential and commercial ferrous waste figures are as follows: total ferrous waste equals 10.6 million tons, which can be broken down into containers and packaging (5.4 million tons); major household appliances (1.7 million tons); other products (3.5 million tons).

REFERENCES FOR APPENDIX C

1. Regan, W. J., R. W. James, and T. J. McLeer. Identification of opportunities for increased recycling of ferrous solid waste. Environmental Protection Agency, 1972. 391 p. (Distributed by National Technical Information Service, Springfield, Va., as PB-213 577.)

2. National Industrial Pollution Control Council. The disposal of major appliances. Washington, U.S. Government Printing Office, June 1971. 22 p.

APPENDIX D

Nonferrous Metals

Nonferrous metals represent a broad range of materials used in our economy. However, with the exception of aluminum, most of these metals are found in only trace quantities in the household and commercial waste stream. Since aluminum is reported separately, the nonferrous category represents our estimates of the remaining material. Copper and lead are assumed to represent the bulk of these materials.

Instead of tracing material flows, we obtained data on copper from a previous report for EPA by the Battelle Memorial Institute.[1] (The resulting data are shown in Table D-1.) Total copper waste is estimated at 200 thousand tons, of which approximately 100 thousand tons are discarded in major appliances.[2]

Direct estimates were available for the tin and lead consumed in tin can manufacture (containers and packaging), which resulted in a .1-million-ton contribution.[3] The total nonferrous estimate was then arbitrarily increased by .1 million tons in order to reflect other nonferrous metals likely to be found in solid waste.

These figures are reported in the body of this report as follows:

Total Nonferrous Waste	400 Thousand Tons
Containers and Packaging	100 thousand tons
Major Household Appliances	100 thousand tons
Other Products	200 thousand tons

TABLE D-1

COPPER IN HOUSEHOLD/COMMERCIAL WASTE STREAM*

Categories+	Quantity Not Recycled (000 Tons)	Fraction in Residential/Commercial Waste Stream	Copper Waste (000 Tons)
El. Wire and Tube	152	.25	38
Magnet Wire	145	.25	36
Other Cast/Wrought Brass	489	.25	122
Copper Alloy Additives	97	.10	10
TOTAL			206

*Battelle Memorial Institute, Columbus Laboratories. A study to identify opportunities for increased solid waste utilization. v.3. Copper report. Environmental Protection Publication SW-40d.2. U.S. Environmental Protection Agency, 1972. Table 14. (Distributed by National Technical Information Service, Springfield, Va., as PB-212 730.)

+The categories used here are a subset of those used by Battelle. Copper consumed in three categories--cartridge brass, automobile radiators, and railroad car boxes--is assumed not to enter the household and commercial waste stream.

REFERENCES FOR APPENDIX D

1. Battelle Memorial Institute. Columbus Laboratories. A study to identify opportunities for increased solid waste utilization. v.2. Aluminum report. v.3. Copper report. v.4. Lead report. v.5. Zinc report. v.6. Nickel and stainless steel report. v.7. Precious metals report. Environmental Protection Publication SW-40d.2. U.S. Environmental Protection Agency, 1972. 608 p. (Distributed by National Technical Information Service, Springfield, Va., as PB-212 730.)

2. National Iudustrial Pollution Control Council. The disposal of major appliances. Washington, U.S. Government Printing Office, June 1971. 22 p.

3. Hill, G. A. Steel can study; an interim report on resource recovery and conservation opportunities for the ferrous fraction of the municipal solid waste stream. [Washington], U.S. Environmental Protection Agency, Office of Solid Waste Management Programs, Resource Recovery Division, June 1973. 83 p., app. (Unpublished report.)

APPENDIX E

Paper

Table E-1 summarizes the calculations used to estimate paper waste. It is important to note that building paper and board are excluded from these calculations.* Column 1 shows "Apparent Consumption," that is, production adjusted for imports and exports. (These statistics are reported by the American Paper Institute.[1])

The categories used in Table E-1 are those conventionally used to report bulk paper and board statistics. Containerboard+ is equal to the sum of unbleached kraft linerboard, semi-chemical paperboard, and combination shipping board. "Other virgin board" is a residual category and equals total virgin board less linerboard, semi-chemical medium, and bleached packaging and converting board. "Other Combination Board" is also a residual category and equals combination board less combination bending board and combination shipping board.

The scrap losses shown in Column 2 were obtained from estimates made by the Midwest Research Institute as well as an industry spokesman (Table E-2). These converting losses are deducted, and the resulting final consumption is regrouped in Column 3.

Column 4 indicates the estimated fraction of each use category that either: (1) is dissipated in use, such as sand paper; (2) does not enter the solid waste stream, such as toilet tissue; (3) is stored permanently, such as archive material. The diversion estimates are based on a report for EPA by Midwest Research Institute.[2] (Since the MRI estimates include both permanent and temporary diversions, the quantity diverted was revised downward for this report diverted was revised downward for this report to reflect only permanent diversions.) In principle, one should account for the fact that some paper products are discarded several years after production. However, since most paper products have relatively short-use lives, this time-lag adjustment was neglected in this report.

Column 5 summarizes the amount of paper to be discarded. The data is again regrouped to allow use of MRI estimates of the fraction of each grade consumed in the household.[3] (The figures used are shown in Table E-3.)

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*Their exclusion is based on the fact that these products rarely enter the household/commercial waste stream.

+Containerboard is often referred to as corrugated board. The two terms are used interchangeably in this report.

TABLE E-1

Paper in the Waste Stream - 1971*
(000 Tons)

Grade	1 Apparent Consumption	2 Scrap Losses Percent	2 Scrap Losses Tonnage	3 Final Consumption		4 Diverted Percent	4 Diverted Tonnage	5 Net Discards		6 Household Sector Discards	7 Household Sector Recovered	8 Household Sector Waste	9 Non-Household Sector Discards	10 Non-Household Sector Recovered	11 Non-Household Sector Waste
Newsprint	10,002	2.5	250	9752	9752	.5	49	9703	9703	9218	2234	6984	496	0	496
Groundwood Paper Uncoated	1,371	15.0	206	1165											
Coated Printing & Converting	3,209	15.0	481	2728	6248	7	437	5811							
Book Paper Uncoated	2,771	15.0	416	2355					9248	5826	0	5826	3422	1100	2322
Writing & Related	2,923	5.0	146	2777	3656	6	219	3437							
Bleached Bristols	977	10.0	98	879											
Unbleached Kraft Packaging & Converting	3,597	5.0	180	3417	4620	0	0	4620	4620	2310	0	2310	2310	742	1568
Packaging & Converting except Bl. Kr.	1,266	5.0	63	1203											
Special Industrial	362	10.0	36	326	326	45	147	179	179	0	0	0	179	0	179
Tissue	3,681	5.0	184	3497	3497	31	1099	2398	2398	1463	0	1463	935	0	935
Containerboard	14,282	12.0	1714	12568	12568	0	0	12568	12568	1005	0	1005	11563	2603	8960
Bleached Packaging & Converting Bd.	3,348	19.0	636	2712	2712	0	0	2712							
Other Virgin Board	856	15.0	128	728	728	0	0	728	7798	5615	0	5615	2183	717	1466
Combination Bending Bd.	2,477	19.0	471	2006	2006	0	0	2006							
Other Combination Bd.	2,767	15.0	415	2352	2352	0	0	2352							
TOTAL	53,889	10.1	5424	48465	48465	3.9	1951	46514	46514	25437	2234	23203	21088	5162	15926

*See text for source.

TABLE E-2

ESTIMATED LOSS FACTORS BY PAPER GRADE

Paper Grade	Estimated Converting Loss Factor
Newsprint*	.025
Printing & Converted*	.150
Writing & Related*	.050
Bleached Bristol*	.100
Packaging & Converting*	.050
Special Industrial*	.100
Tissue+	.050
Containerboard*	.120
Folding Boxboard*	.190
Other Boxboard‡	.150

*Personal communication. W. Franklin, Midwest Research Institute, to F. L. Smith, Jr., Office of Solid Waste Management Programs.

+Personal communication. W. Driscoll, American Paper Solid Waste Management Programs.

‡EPA estimates.

TABLE E-3

SOURCE OF DISCARDED PAPER*

	Household (Percent)	Non-Household (Percent)
Newsprint	95	5
Printing and Publishing	63	27
Converting and Packaging	38	62
Sanitary	61	39
Bags	76	24
Corrugated Containers	8	92
Other Board Packaging	72	28

*Darnay, A., and W. E. Franklin. Salvage markets for materials in solid wastes. Environmental Protection Publication SW-29c. Washington, U.S. Government Printing Office, 1972. 187 p.

Note: The categories used in Table E-3 differ slightly from those used in Table E-1, column 5. In particular, "Converting and Packaging" and "Bags" are combined in Table E-1; household and non-household uses are each assumed to consume one-half of the combined tonnage.

To obtain the amount of paper recovered from this waste stream, it was assumed that the recovery rate observed in 1970 (12.021 of 53.325 million tons or 22.4 percent) still holds in 1971. MRI estimates that the split between industrial (i.e. converting) and post-consumer waste is 39:61.[4] Total consumption in 1971 was 53.18 million tons and, using the assumption above, 22.4 percent, or 12.125 million tons, of this paper is recovered. Using the 61:39 split, 4.729 million tons* is assumed recovered from industrial waste and 7.396 million tons from post-consumer waste.

The post-consumer recovery figure of 7.396 million tons is distributed between the three major post-consumer wastepaper types, in the proportions recorded in another report by MRI.[5] Post-consumer waste recovery is broken down as follows: newsprint, 30.2 percent; pulp substitutes and high grades, 9.0 percent; mixed paper, 25.6 percent. Applying these percentages to the total post-consumer waste figure of 7.396 million tons results in 2.603 million tons of recovered containerboard and 2.559 million tons of recovered mixed and high grades.

Recovered news is assumed to be recovered solely from household sources (Column 4 of Table E-1). Recovered corrugated is assumed to be recovered solely from non-household sources (Column 10 of Table E-1). Both mixed and high grades are also assumed to be recovered solely from non-household sources. The paper categories from which the latter two grades are recovered are assumed to be: printing and related; packaging and converting; other boxboard. Recovery from these categories is assumed to be proportional to their production. Since mixed and high grades together account for 34.6 percent of the 7.396 million tons of post-consumer waste recovered, a total of 2.559 million tons is assumed recovered from these categories. The resulting allocations are shown in Table E-4 and are indicated in Columns 7 and 10 of Table E-1. Columns 8 and 11 then indicate the residual waste by source.

To obtain a better understanding of the product categories under which paper waste may be classified, paper was broken down into three end-use categories: packaging; magazines and newspapers; other. Table E-5 shows the resulting breakdown. The grade categories are those used in Column 5 of Table E-1.

To obtain the amount of paper initially discarded from any one of these end-use categories, the post-consumer waste that is recovered must be added to these figures. Similarly, to obtain total bulk consumption by end-use, converting waste must be included. For example, using the information shown in Table E-1 and using ratios where appropriate, one finds that total discarded packaging paper equals 24.3 million tons and apparent consumption of packaging paper was 27.7 million tons.

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*Since total converting waste is estimated at 5.424 million tons in Column 2, our estimate of the industrial waste recovery rate is 87 percent.

TABLE E-4

ALLOCATED WASTEPAPER RECOVERY*
(000 Tons)

	Production Tonnage	Percent	Allocated Recovery
Printing & Related	3422	43	1100
Packaging & Converting	2310	29	742
Other Boxboard	2183	28	717
TOTAL	7915	100	2559

*See text for source.

TABLE E-5

PAPER IN THE WASTE STREAM BY SOURCE
1971
(000 Tons)

Category	Waste Quantity*	Packaging	Magazines & Newspapers	Other
Newsprint	7480	--	7480	--
Printing & Writing	8148	748+	2815‡	4549
Packaging Paper	3878	3878	--	--
Special Industrial	179	--	--	179
Tissue Paper**	2398	240	--	2158
Containerboard	9965	9965	--	--
Other Board	7081	5535	--	1546xx
TOTAL	39129	20412	10295	8432

*This column is the sum of columns 8 and 11 from Table E-1.

+The figure is the 13.5 percent of the Printing Paper portion of Printing and Writing. This percentage was derived from data shown in Table 4, Role of Nonpackaging Paper.

‡This figure is 56 percent of all non-packaging printing paper. The percent is derived from Table 10 of Role of Nonpackaging Paper.

**All non-sanitary tissue is classified as packaging paper.

xxThis figure is 9 percent of all board as indicated in Table 4, Role of Nonpackaging Paper.

REFERENCES FOR APPENDIX E

1. The statistics of paper. New York, American Paper Institute, 1972. Table XXVII. (This is Bureau of Census-based data and is not readily compatible with similar production, import, and export data reported in Tables II, IV, and V in the main body of The Statistics of Paper.)

2. Franklin, W. E., and A. Darnay. The role of nonpackaging paper in solid waste management, 1966 to 1976. Public Health Service Publication No. 2040. Washington, U.S Government Printing Office, 1971. 76 p.

3. Midwest Research Institute. Unpublished data. More recent and detailed results are shortly to be published as a result of present contract work. The MRI data assigned each paper grade to a final use area after the recovered fraction of that grade had been deducted; however, the same data is used to allocate grade here before recovery.

4. Darnay, A., and W. E. Franklin. Salvage markets for materials in solid wastes. Environmental Protection Publication SW-29c. Washington, U.S. Government Printing Office, 1972. 187 p.

5. Franklin, W. E. Paper recycling--the art of the possible, 1970-1985. New York, American Paper Institute, 1973. 181 p.

APPENDIX F

Plastics

Plastics are one of the more difficult materials to trace since numerous producers manufacture numerous grades of plastic resins, the bulk form of plastics. Statistics are maintained for only the more important resins: low density polyethylene, high density polyethylene, polystryrene, polyvinyl chloride, and polypropylene. These "big-five" polymers are estimated to comprise 67 percent of all plastics.[1, p. III-57] Estimates of the quantities of these polymers that are to be discarded in various end-use categories are given in a report by Arthur D. Little for EPA.[1] Table F-1 summarizes this information, excluding those end-use categories not included in household and commercial solid waste. The excluded categories include transportation, construction and agricultural film, construction plastics, and wire and cable. Unfortunately, there are no data on end-use consumption for these categories.

Estimating the breakdown by source of plastic household-commercial waste allows the comparison of estimates with those reported in composition studies. An illustration of such a cross-check is the finding by Staudinger that packaging comprised 76 percent of all household plastic waste.[2] The corresponding percentage shown in Table F-1 is 60 percent.

Table F-1 estimates were for the base year 1970; these were adjusted for the year 1971. Moreover, the data were regrouped to show the product categories used in the body of the report. These calculations are shown in Table F-2. The results are that total plastic waste is 4.300 million tons, of which containers and packaging are 2.500 million tons, major appliances are 100 thousand tons, furniture and furnishings are 100 thousand tons, clothing and footwear are 200 thousand tons, and other products are 1.500 million tons.

TABLE F-1

"BIG-FIVE" PLASTICS IN THE WASTE STREAM - 1970

Product Groups	Estimated Waste* (000 tons) (1)	(2)	Estimated Household Percentage+ (3)	Household Waste (000 tons) (4)	(5)
	Big-Five	Total		Big-Five	Total
Packaging‡	1,963	2,930	90	1,767	2,637
Rigid	1,079	1,610	90	971	1,449
Flexible	883	1,318		795	1,187
Consumer Durables	528	788			
Appliances	50	75			
Furniture	30	45	90	475	709
Other*	448	669			
Clothing	68	101			
Apparel	23	34	100	68	101
Footwear	45	67			
Novelties, Disposables	50	75	60	30	45
TOTAL	2,609	3,894		2,340	3,493

*Milgrom, J. Incentives for recycling and reuse of plastics. Environmental Protection Agency, 1972. Tables 36, 39. (Distributed by National Technical Information Service, Springfield, Va., as PB-214 045.)

+EPA estimate.

‡Milgrom, Incentives for recycling and reuse of plastics, Table 42.

*This category includes housewares, toys, sporting goods, luggage, and records.

Note: The total waste columns 2 and 5 are obtained by assuming that all other plastics are consumed in the same proportion as are the "big-five." Thus, columns 2 and 5 are simply columns 1 and 4 divided by .67.

TABLE F-2

TOTAL PLASTIC WASTES
(000 tons)

Product Groups	"Big-Five" Thermo Plastics (1970)	Expand for Thermosets and Coatings	Expand to 1971	
Packaging	1,963	x 1.14* = 2,224	1.12**	2,491
Major Appliances	25	x 2.59‡ = 65	1.11**	72
Furniture	30	x 2.59‡ = 78	1.19**	93
Apparel & Footwear	68	x 2.59‡ = 176	1.05**	185
Other	523	x 2.59‡ = 1,355	1.10**	1,491
TOTAL	2,608	x 1.49+ = 3,897	--	4,332
TOTAL, Non-packaging	696	x 2.59‡ = 1,670	--	1,841

*Midwest Research Institute. Plastic packaging. (Unpublished note.) It stated that the "big-five" represent 88 percent of all packaging plastics: 1÷88=1.14.

+The "big-five" represent 67 percent of all plastic: 1÷.67=1.49 (Milgrom, Incentives for recycling and reuse of plastics, p.III-57).

‡These factors were obtained by subtracting the packaging figure in column 3 (2,224) from the total-plastics-consumed figure of 3,897 and then calculating the expansion factor required to balance the nonpackaging categories.

**EPA estimates.

REFERENCES FOR APPENDIX F

1. Milgrom, J. Incentives for recycling and reuse of plastics. Environmental Protection Publication SW-41c. U.S. Environmental Protection Agency, 1972. 316 p. (Distributed by National Technical Information Service, Springfield, Va., as PB-214 045.)

2. Staudinger, J. J. P. Disposal of plastics waste and litter. S.C.I. Monograph No. 35. London, Society of Chemical Industry, 1970. 100 p.

APPENDIX G

Rubber

Two approaches were used to estimate the rubber fraction in the household/commercial waste stream. The first relied on 1968 data presented by Pettigrew and Ronninger in a report, Rubber Reuse and Recycling.[1] The details of their calculation are indicated in Table G-1. The second approach relied on several additional data sources and is detailed in Table G-2.

The first method yields a total post-consumer rubber waste estimate of 3.75 million tons, while the second yields 2.70 million tons. The methods are very close on tire rubber, assuming 80 percent by weight of a tire is rubber. The main difference is in non-tire rubber where the estimates are 1.04 and 2.15 million tons. Part of the difference is the result of product category definitions; part is the inclusion of non-rubber components in shoes and other goods.

In our judgement, the best compromise is a rubber figure of 3.3 million tons, composed of 1.7 million tons tire rubber and 1.6 million tons non-tire rubber (including tire tubes).

TABLE G-1

1968 RUBBER POST-CONSUMER WASTE*

(000 tons)

Tire production less wear allowance	3000
Tire tonnage diverted from waste+	1000
Net tire discards	2000
Rubber discarded in tires‡	1600
Other rubber waste	2150
Total waste	3750

*Pettigrew, R. J., F. H. Roninger, W. J. Markiewicz, and M. J. Gransky. Rubber reuse and solid waste management. [Public Health Service Publication No. 2124.] Washington, U.S. Government Printing Office, 1971. pt.1.

+Most diversions are for retread purposes; minor portions are used for reclaim, dock bumpers, etc.

‡The exact rubber content of tires varies but is assumed here at 80 percent.

TABLE G-2

RUBBER POST-CONSUMER WASTE

(000 tons)

	Tire and Tire Products	Non-Tire Products	Total
U.S. Rubber Consumption, 1969 New plus reclaimed*	2100	1097	3197
Converting losses†			
Tires, @ .03	- 63		-118
Other products @ .05		- 55	
	2037	1042	3079
Diversions from Waste Stream‡			
Tire tread wear	215		
Reclaimer use	135		
Retreading ⁑	---		
Tire-Splitting	13		
Diversion for other reuse (@ 1% of tires)	21		
Total Diversions	384		
Post-Consumer Waste Rubber	1653	1042	2695

*Total consumption from Rubber Manufacturers Association, Rubber Industry Facts, Table 18, p. 20. Net imports are neglected although, in fact, tire imports substantially exceed exports. Allocated between tires and non-tire products on basis of percentages from Table 22, p. 20.

†Based on Gordian Associates unpublished data, and: Pettigrew and Ronninger, Rubber Reuse and Solid Waste Management.

‡Values in this list based on W. J. Markiewizc and M. J. Gransky, "Waste Rubber and Its Reuse: 1968" in Rubber Reuse and Solid Waste Management.

⁑This assumes that retreading involves no net diversion since retreading supplies a quantity of tires that were not counted as part of consumption in the first line.

REFERENCE FOR APPENDIX G

1. Pettigrew, R. J., F. H. Roninger, W. J. Markiewicz, and M. J. Gransky. Rubber reuse and solid waste management. pt.1-2. [Public Health Service Publication No. 2124.] Washington, U.S. Government Printing Office, 1971. 120 p.

APPENDIX H

Textiles

No general statistical series on textile use were found during this study. However, two recycling studies contained data on textile waste.[1,2] The report by Midwest Research Institute stated that total end-use consumption of textiles in 1968 was 4.83 million tons while bulk consumption was 5.67 million tons.[3, Table 47, p.70-2; Table 48, p. 79-3] This implies a factor of 15 percent for converting loss and this figure is used throughout Table H-1 to convert bulk production into final consumption statistics. Much discarded clothing is also recovered for reuse in rags. Although no accurate data are available on this subject, Midwest Research Institute did estimate that from .8 to 1.8 million tons of old clothes are recovered annually.[1, p. 75] In this report, one million tons of old clothes are assumed to be recovered from the waste stream.

Production data for three end-use categories--apparel, home furnishings, and miscellaneous--were obtained from a Battelle Memorial Institute report.[2, p. 241] The time-lag between production and discard for Apparel and the Miscellaneous category is assumed to be five years. Home furnishings are assumed to last ten years. It is estimated that only 80 percent of the Miscellaneous category becomes household waste.

The waste estimates based on these assumptions are summarized in Table H-1. The data sources permitted waste to be estimated for the year 1970; these results are expanded to represent 1971 textile waste.

TABLE H-1

TEXTILE WASTE*
(000 tons)

End-Use Category	Production Period	Production Tonnage	Converting Loss	Discards	Recovered Textiles	1970 Waste	Expansion Factor	1971 Waste
Apparel	1965	1,780	267	1,513	1,000	513	1.03	528
Home Furnishings	1960	650	98	552	---	552	1.03	569
Miscellaneous	1965	648	97	551	---	551	1.03	568
Total	--	3,240	962	2,616	1,000	1,616	--	1,665

*Battelle Memorial Institute, Columbus Laboratories. A study to identify opportunities for increased solid waste utilization. v.9. Textile report. Environmental Protection Publication SW-40d.3. U.S. Environmental Protection Agency, 1972. p. 241. (Distributed by National Technical Information Service, Springfield, Va., as PB-212 731.) Converting losses were calculated using the 15 percent factor developed in the text. The recovery estimates were developed and discussed in the text. The expansion factors are EPA estimates.

REFERENCES FOR APPENDIX H

1. Darnay, A., and W. E. Franklin. Salvage markets for materials in solid wastes. Environmental Protection Publication SW-29c. Washington, U.S. Government Printing Office, 1972. Ch. VIII.

2. Battelle Memorial Institute, Columbus Laboratories. A study to identify opportunities for increased solid waste utilization. v.9. Textile report. Environmental Protection Publication SW-40d.3. U.S. Environmental Protection Agency, 1972. p. 241-339. (Distributed by National Technical Information Service, Springfield, Va., as PB-212 731.)

APPENDIX I

Wood

The Forest Service has developed an excellent time series for wood consumed in a variety of end-use categories.[1] The 1970 consumption data are shown in Table I-1. Table I-2 estimates the likelihood that each category will enter several designated waste streams. It is important to note that several wood-use categories (e.g. railroad ties) enter none of these waste streams. In this report, wood waste entering the household and commercial solid waste stream is estimated as that produced by the following use categories: Household Furniture, Commercial and Industrial Furniture, Consumer Goods, and all Shipping categories.

To estimate the waste tonnages for each of these categories, production data from The Outlook for Timber were used.[1] These data seem to be available only for the years 1945, 1960, 1965, and 1970. Considering the expected lifetimes of the products in each major category: 1960 production data were used for Furniture; 1970 data were used for Shipping; 1965 data were used for Consumer Goods, and other categories.

These statistics are for bulk consumption rather than for wood actually embodied in the finished product. The data were adjusted for converting losses, using information shown in Table I-3. To convert wood use into weight terms, the factors shown in Table I-4 were used. Since the weights for hardwood and softwood products differ, the fraction of hardwood and softwood lumber and plywood used in each category were estimated. These are shown in Table I-5. The resulting tonnages are summarized in Table I-6. Contributions by each wood type are reported separately and then summarized in the right-hand column.

Wood used in the Shipping end-use category was handled somewhat differently in order to reflect our belief that much wood packing and shipping materials are used solely in industrial applications. The work sheets used for the adjusted waste from the shipping category are shown in Tables I-7 and I-8. These readjustments indicate our estimates of the fraction of shipping materials likely to be discarded from industrial rather than household/commercial uses. Table I-9 finally summarizes the wood estimates and adjusts them to the 1971 base year.

I-1

1970 SOLID WOOD CONSUMPTION BY END-USE*

Categories	Lumber (Mil.Bd. Feet)	Plywood (Mil.sq.ft. 3/8"basis)	Building Board Categories: Hardboard (Mil.sq.ft.) (1/8" basis)	Particle Bd. (Mil.sq.ft.) (3/4" basis)	Insulation Bd. (Mil.sq.ft.) (1/2" basis)	Total (Mil.sq.ft.) 1/2"basis)[8]
Residential Housing[1]	12,270	6,330	NES	NES	NES	2,070
Residential Upkeep[2]	4,690	2,510	NES	NES	NES	1,060
Other Construction[3]	2,610	1,700				720
Commercial	380	170				155
Non-commercial	970	900	NES	NES	NES	500
Utilities	660	180				20
Highway	270	360				15
Other	330	90				30
Manufacturing[4]	4,670	1,656	1,361	669	-	
HH Furniture	2,961	838	663	427	-	
Commer/Inst. Furniture	271	227	127	179	-	
Consumer Goods	621	303	48	14	-	?
Comm.Industrial Machinery	620	179	49	19	-	
Other	197	109	474	30		
Shipping[5]	5,725	591	58	-	-	
Containers	1,755	437	26	-	-	
Pallets	3,150	140	28	-	-	?
Dunnages	820	14	4	-	-	
Railroad Construction[6]	880	25	-	-	-	-
Other[7]	8,160	5,636	NES	NES	NES	2,683

NOTES:
1) Residential data from Table 5-9. This data is estimated annually from consumer expenditures.
2) Residential upkeep data from Table 5-11.
3) Other construction totals from Table 5-13. Lumber, plywood, and building board breakdowns from Tables 5-14, 5-15, and 5-16 respectively. New surveys for this end use category are now in progress.
4) Manufacturing totals from Table 5-15, Detailed lumber, plywood, hardboard and particle board breakdown from Appendix II, Tables 18, 19, 20 and 21. These were based on a special census survey for the USDA, Forest Service, in 1965.
5) Shipping data from Table 5-18.
6) Railroad data from Table 5-14 and page 5-73. This information is collected by the Association of American Railroads.
7) Other data from Table 5-23.
8) The conversion to 1/2 inch basis requires that the hardboard figure be divided by 4 and the particle board figure be multiplied by 1.5.

*U.S. Forest Service. The outlook for timber in the United States. Dec. 1972. Draft report.

TABLE I-2

WOOD IN THE SOLID WASTE STREAM *

	Domestic Waste		Commercial Institutional Waste		Construction & Demolition	Other
	Regular	Bulky	Regular	Bulky		
Residential Housing	S	S	S	S	X	-
Residential Upkeep	S	M	S	M	X	-
Other Construction						
Commercial	-	-	S	S	X	-
Non-Commercial	-	-	S	S	X	-
Utilities	-	-	S	S	X	-
Highways	-	-	-	-	X	-
Other	?	?	?	?	?	?
Manufacturing						
Household Furniture	S	X	-	-	-	-
Commercial/Industrial Furniture	-	-	S	X	-	-
Consumer Goods	X	X	-	-	-	-
Commercial, Industrial, & Machinery	-	-	S	?	-	X
Other	?	?	?	?	?	?
Shipping						
Containers	-	S	-	X	-	-
Pallet	-	-	-	X	--	-
Dunnage et al	-	-	-	X	-	-
Railroad	-	-	-	-	-	X
Other	?	?	?	?	?	?

S - Slight
M - Moderate
X - Large
? - Unknown

*All intersection notations are judgmental. The wood categories are are from: U.S. Forest Service, The Outlook for Timber in the United States, Dec. 1972, review draft.

TABLE I-3

CONVERSION LOSS FACTOR*

	Lumber Products	Panel Products
Residential Housing	NE	NE
Residential Upkeep	NE	NE
Other Construction	NE	NE
Commercial		
Non-Commercial		
Utilities		
Highway		
Other		
Manufacturing	+	.10
Household furniture	.6	+
Commercial/Institutional Furniture	.6	+
Consumer Goods	.6	+
Commercial, Industrial, & Machinery	.3	+
Other	.3	+
Shipping	.25	.10
Containers	+	+
Pallets	+	+
Dunnage	+	+
Railroad Construction	NE	NE
Ties		
Other		
Other	NE	NE

NE - Not estimated.

*Gill, T., U.S. Forest Service. Unpublished data.
+Not estimated separated.

TABLE I-4

HARDWOOD/SOFTWOOD RATIOS BY END-USE CATEGORY*

Sector	Lumber Percentages		Plywood Percentages	
	HW	SW	HW	SW
Manufacturing	+	+	+	+
Household Furniture	82	18	69	31
Comm/Ind Furniture	82	18	69	31
Consumer Goods	49	51	74	26
Commercial	55	45	86	14
Other	51	49	24	76
Shipping	+	+	33	67
Containers	40	60	+	+
Pallets	58	42	+	+
Dunnage	53	47	+	+

*Gill, T., U.S. Forest Service, Unpublished data.
+Not separately estimated.

TABLE I-5

WEIGHT CONVERSION UNITS*

Lumber

One Softwood Board Foot-dressed = 1.92 pounds

One Hardwood Board Foot-rough = 3.34 pounds

Panel Products

Plywood (3/8" basis)

Softwood - One Square Foot = 1.07 pounds

Hardwood - One Square Foot = 1.31 pounds

Building Board

Hardboard (1/8" basis) - One Square Foot = .679 pounds.

Insulating board (1/2" basis) - One Square Foot = .766 pounds.

Particle board (3/4" basis) - One Square Foot = 2.95 pounds.

*Gill, T., and J. Micklewright, U.S. Forest Service, Unpublished data.

TABLE I-6

WOOD IN WASTE STREAM: 1970*
(000 tons)

	Time Period	Consumption Total	Consumption Hard Wood	Consumption Soft Wood	Tonnage Total	Tonnage Hard Wood	Tonnage Soft Wood	Pipeline Loss	Waste Tonnage
Household Furniture	1960	--	--	--	3969	--	--	2149	1820
Lumber (MMBF)		2116	1735	381	3263	2897	366	1958	--
Veneer & Plywood (MMSF)		877	605	272	543	397	146	91	--
Hardboard (MMSF)		231	--	--	78	--	--		--
Particleboard (MMSF)		58	--	--	85	--	--		--
Other Furniture	1960	--	--	--	757	--	--	325	432
Lumber (MMBF)		289	237	52	446	396	50	278	--
Veneer & Plywood (MMSF)		342	236	105	212	155	57	47	--
Hardboard (MMSF)		145	--	--	49	--	--		--
Particleboard (MMSF)		34	--	--	50	--	--		--
Consumer Goods	1965	--	--	--	878	--	--	436	442
Lumber (MMBF)		518	254	264	677	424	253	406	--
Veneer & Plywood (MMSF)		273	202	71	171	133	38	30	--
Hardboard (MMSF)		43	--	--	15	--	--		--
Particleboard (MMSF)		10	--	--	15	--	--		--
Shipping	1970	--	--	--	7941	--	--	1936	6005
Lumber (MMBF)		5725	2964	2761	7601	4950	2651	19000	
Veneer & Plywood (MMSF)		591	195	395	340	128	212	36	
Hardboard (MMSF)		58	--	--	20	--	--		

*Consumption data from U.S. Forest Service, Outlook for Timber in the United States, 1972, Table 5-15 and 5-18. The other data are from this section: The hardwood/softwood split from Table I-4. Pipeline losses estimated from Table I-3. Table I-5 provided the factors to convert to tons.

TABLE I-7

WOOD USED IN SHIPPING APPLICATIONS, 1970*

	Total Wood		Hardwood		Softwood	
	Quantity (Units as Noted)	Tonnage (000 tons)	Quantity (Units as Noted)	Tonnage (000 tons)	Quantity (Units as Noted)	Tonnage (000 tons)
Containers						
Lumber (bd. ft.)	1755	2183	702	1172	1053	1011
Veneer & Plywood (sq. ft.)	437	251	144	94	293	157
Hardboard (sq. ft.)	26	9	---	---	---	---
Pallets						
Lumber (bd. ft.)	3150	4321	1827	3051	1323	1270
Plywood (sq. ft.)	140	80	46	30	94	50
Hardboard (sq. ft.)	28	9	---	---	---	---
Dunnage						
Lumber (bd. ft.)	820	1096	435	726	385	370
Plywood (sq. ft.)	14	8	5	3	9	.005
Hardboard (sq. ft.)	4	1	---	---	---	---

*The quantity data is from Table I-1. Tonnages are calculated from Table I-5.

TABLE I-8

Adjusted Household/Commercial Wood Waste*

(000 tons)

Category	Total Wood Consumed	Pass-Through Factor	Total Wood Waste	Estimated Fraction in Solid Waste	Household/ Commercial Solid Waste
Containers					
Lumber	2183	.75	1637	.5	936
Panel Products	260	.90	234		
Pallets					
Lumber	4321	.75	3241	.2	664
Panel Products	89	.90	81		
Dunnage					
Lumber	1096	.75	822	.2	166
Panel Products	9	.90	8		

*Total wood consumed from Table I-7. Pass-through factor from Table I-3. The fractions in the solid waste stream are EPA estimates.

TABLE I-9

FINAL WASTE*

(000 tons)

	1970	Expansion Factor	1971
Containers & Packaging	1766	1.03	1819
Furniture & Furnishing (Household & Other)	2252	1.05	2320
Other (Consumer Goods)	442	1.03	455

*1970 estimates from Table I-8. Expansion factors estimated by EPA.

REFERENCE FOR APPENDIX I

1. U.S. Forest Service. The outlook for timber in the United States. December 1972. (Draft report; now available as Forest Resource Report No. 20. Washington, U.S. Government Printing Office, October 1973. 367 p.)

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